I-69 EVANSVILLE TO INDIANAPOLIS

Tier 2 Studies

***DRAFT* Karst Feature and Groundwater Flow Investigation Report**

Section 5, SR 37 south of Bloomington to SR 39

October 2012

CONFIDENTIAL MATERIAL ENCLOSED

Prepared for

Federal Highway Administration and
Indiana Department of Transportation

DRAFT

EXECUTIVE SUMMARY

This study was conducted to support the I-69 Tier 2, Section 5 Environmental Impact Statement (EIS) and address Items 1 through 4 of the 1993 Memorandum of Understanding (MOU) as entered into by the Indiana Department of Transportation (INDOT), the Indiana Department of Natural Resources (IDNR), the Indiana Department of Environmental Management (IDEM), and the U.S. Fish and Wildlife Service (USFWS) to delineate guidelines for construction of transportation projects in karst regions of the state. A copy of the 1993 MOU is presented in **Appendix A**. The study was prepared by Ozark Underground Laboratory (OUL) of Protem, Missouri and Philip Moss, PG of Waterloo, Illinois with additional data provided by Michael Baker, Jr. Inc. (Baker) of Indianapolis, Indiana, and Lewis and Associates, LLC of Borden, Indiana.

This study focused on characterizing karst features and related groundwater flowpaths relevant to Section 5, and identifying caves, springs, sinkholes, and other karst features that could be impacted by construction and use of the proposed interstate highway.

This document is an update to and replacement of the July 2006 I-69 Tier 2 Studies Section 5 Draft Karst Feature and Groundwater Flow Investigation Report (2006 Draft Karst Report). Updates to the 2006 Karst Report include:

- The 2006 Karst Report was provided to the Karst MOU signatory agencies and the U.S. Environmental Protection Agency (USEPA) for review and comment on September 22, 2006, and comments received were incorporated into the updated 2012 Karst Report.

- Additional field reconnaissance and dye tracing was conducted to determine the approximate recharge area for two overlapping cave systems (known as Cave and Cave) in the vicinity of the Section 5 corridor, based on agreement between INDOT, FHWA, and USEPA.

- Updated land cover, land use, population growth, planned development, and setting as part of the Section 5 DEIS evaluations, subsequent to the 2006 Draft Karst Report.

- Monroe County geographic information system (GIS) files such as the 2010 aerial photography and 2-foot contours were reviewed to identify potential additional or adjust 2006 Section 5 karst features. The Monroe County data included topography from Light Detection And Ranging (LiDAR) that can measure beneath leaf canopy, increase reproducibility between surveys, and provide increased precision over standard aerial photography based mapping. Karst feature additions and adjustments from this data were incorporated following field check confirmations.

- Geologic mapping and descriptions were updated with publications by the Indiana Geological Survey such as the Monroe and Bloomington quadrangle bedrock mapping (Thompson 2007) and Bedrock Geologic Map of Monroe County, Indiana (Hasenmueller 2008).

DRAFT

- Data from the I-69 Tier 2 Studies Section 4 Survey of Karst Features Report (2010) and Addendum No. 1 (2011) was reviewed and incorporated where appropriate.

These updates, additional field data, and evaluations resulted in increases in the number of identified karst features and flowpaths included in this 2012 Karst Report.

Section 5 Karst Setting

- The Section 5 EIS Corridor is a 2,000-foot wide area centered on State Road 37 (SR 37) from southwest of Bloomington in Monroe County, Indiana to just south of Martinsville in Morgan County, Indiana. The karst study area included both the I-69 Tier 1 and Tier 2 karst data that was determined to be relevant to Section 5, and extended from the southern terminus of Section 5 north along SR 37 to roughly Chambers Pike. The study area included the 2,000 ft. corridor and appropriate areas outside the corridor based on geologic information and mapping for the area. Relevant karst is the portion of karst within the 21-mile length of Section 5 Corridor and associated areas outside of the corridor: that has been demonstrated to have corridor derived water passing through it; or is linked by logical inference based on the best available geographic, geologic, and hydrologic data, including the Tier 2 investigation. It does not necessarily include areas outside the corridor that contribute water to the corridor. Three distinctive karst areas were recognized based on bedrock substrate, sinkhole characteristics, and drainage features.

- Karst Areas:

    - Bloomington Karst extends from approximately Clear Creek along SR 37, south of the Section 5 corridor, northward along SR 37 to approximately Arlington Road. It is primarily developed in the Lower St. Louis Limestone above the contact with the underlying Salem Limestone.

    - Bloomington North Karst extends from about Arlington Road north to the approximately Kinser Pike on the southern slope of the Beanblossom Creek Valley and is developed in the Ramp Creek and Harrodsburg Limestones.

    - Simpson Chapel Karst extends from approximately Wayport Road on the northern slope of the Beanblossom Creek Valley and continues north to just south of Chambers Pike and is developed in the Ramp Creek and Harrodsburg Limestones.

- Land Use: Land use within the Bloomington area has been affected by both historic and recent development. Approximately 55% of land use within the relevant karst area - as mapped inside the corridor and including associated areas outside the corridor - is currently developed, while 45% remains undeveloped (e.g., 36% upland/wetland habitat, 9.5% agricultural, and, 0.5% water), based on field reviews and updates of a GIS land use layer provided by the Monroe County Planning Department. Local planners anticipate development of an additional 20% of the karst area by 2035, based on only those specific areas of development identified by the local planning staffs (City of Bloomington and

DRAFT

Monroe County tax increment financing [TIF] Districts); this development is anticipated to occur independent of the proposed Section 5 project.

- The Section 5 physiography consists of limestone plateaus dissected by many deeply entrenched stream systems, areas of karst development, and generally rugged topography with relatively flat uplands. Both the Bloomington and Bloomington North Karst are located within the Mitchell Plateau while the Simpson Chapel Karst is located in the Norman Upland portion of the of the Southern Hills and Lowlands Physiographic Region (Gray, 2000).

- The non-karst portion of the Section 5 corridor extends from Chambers Pike to the northern terminus with Section 5 just south of Martinsville. Historical data and field checks for karst features were conducted in this area without the identification of any karst features.

- The bedrock in Section 5 is typically shallow with thin overlying soils, except in some of the larger stream valleys. The study area is within the Illinois Basin structure, with the bedrock gently dipping to the southwest and west, younger formations to the south and west, and older formations to the north and east.

- Monroe County mining has been limited mainly to limestone and includes dimension stone (Salem Limestone), high calcium-rich limestone, crushed stone for construction, agricultural lime and livestock feed. A natural gas storage dome is located under SR 37 in the Simpson Chapel Karst area.

- Groundwater supplies are limited in the karst portion of Section 5 with the majority of the local water supply coming from man-made surface water reservoirs (such as Lake Monroe Reservoir). Well production is typically low, generally ranging from less than 10 gallons per hour (gph) to 10 gallons per minute (gpm).

- The main hydrogeologic unit in the Bloomington Karst is the St. Louis Limestone, while the Ramp Creek and Harrodsburg Limestones act as a single hydrogeologic formation in the Bloomington North and Simpson Chapel Karst areas.

Methodology

The karst investigations reported herein are consistent with the requirements for such investigations from the 1993 MOU, Items 1 through 4, and included:

- Public and private research sources.

  The Project Team compiled existing information on local karst features from a number of sources. These sources included: the Indiana Geological Survey, Indiana Cave Survey, and karst experts knowledgeable about the area. Specific karst studies and mapping for the Section 4 corridor examined and field checked for this study included I-69 Tier 1 and Tier 2 public comments, including cave maps and other karst feature data and mapping, as well as all previous I-69 related karst study data.

DRAFT

Additional resources included high resolution aerial photography, planimetric and topographic mapping in the corridor as well as USGS topographic maps.

- Karst feature field check (sinkholes, springs, karst flowpaths, caves, and others).

  Field checks were conducted to verify and map previously recorded karst features along the length of the Section 5 corridor. In addition, a field reconnaissance was conducted to determine the presence of, and map previously unrecorded karst features within the 11.5-mile length of karst crossed by the Section 5 corridor and appropriate areas outside of the corridor to identify potentially related karst features that may be associated with the corridor via karst groundwater flowpaths or surface run-off. Cave entrance research and field survey was conducted concurrently by Indiana Geological Survey personnel for cave accessibility and potential bat habitat research.

- Dye tracing/drainage patterns.

  Drainage areas, drainage patterns, and land use specifically related to the karst features were determined and mapped. Additionally, dye tracing tests were conducted on selected karst features within the karst study area in order to determine and map the subsurface flow from recharge features (caves, sinkholes, swallets, and sinking streams) to discharge features (springs and gaining streams) and establish groundwater flow patterns within the study area.

- Annual pollutant load estimates.

  The pollutant loads were calculated for each karst feature within the right-of-way (ROW) but outside (or with portions outside) the construction limits of the I-69 preferred alternative. Pollutant loads were calculated for pre and post construction conditions. The calculation procedures are based upon models developed to predict pollutant loads without field measurements presented in a Federal Highway Administration (FHWA) training course.

- Biological survey of caves.

  Accessible caves and related springs with hydraulic or physical connection with the alternatives being advanced were surveyed for biological fauna. During the study, coordination was maintained among the Project Team to review and exchange new information discovered by other project related studies. These included ongoing studies regarding caves as potential Indiana bat habitat, as well as karst studies and other field evaluations being conducted for the I-69 corridor within adjacent sections and within Section 5. This included cross referencing all previous mapping collected with the field investigations and the IGS cave entrance surveys conducted in support of the Project Team's Section 7 Consultation with the USFWS for this project.

- Agency coordination and mitigation measures.

DRAFT

The Project Team has conducted ongoing coordination with the Karst MOU signatory agencies. The karst survey methodology and updates on survey results were discussed with resource agencies during the karst studies. Any future agency concerns or questions relating to the findings or recommendations presented in this report, or any other karst related issues will be addressed through ongoing coordination relative to addressing the Karst MOU.

Results

The Section 5 karst investigation produced the following results (2006 data and 2012 updates[1]), specific to conditions identified in the Section 5 study area:

- Three distinct areas of karst (Bloomington Karst, Bloomington North Karst, and Simpson Chapel Karst) were identified for a total of approximately 11.5 linear miles of karst along SR 37.
- 446 sinkholes, five losing/sinking stream basins, and 21 filled or appreciably modified sinkholes were documented within or adjacent to the 2,000 foot corridor.
- The drainage area and land use corresponding to each feature was determined.
- Field investigations revealed 169 springs, 143 had not been previously reported; 131 were determined to be relevant to Section 5.
- Fourteen karst flowpaths were shown to cross under at least one lane of SR 37.
- One previously unreported cave was found.
- Three karst windows relevant to the Section 5 Corridor were identified and documented.
- The karst relevant to the Section 5 Environmental Impact Study was determined. The relevant karst is the portion of karst within the I-69 Section 5 corridor, and associated areas outside of the corridor, that has been demonstrated to have corridor-derived water passing through it, or is linked by logical inference based on the best available geographic, geologic, and hydrologic data, including the Tier 2 investigation. It does not include areas outside the corridor that contribute water to the corridor.
- Dye Tracing:

[1] Updates to the 2006 Karst Report include: MOU signatory agencies and USEPA 2006 Karst Report comments, additional field reconnaissance and dye tracing for and Cave recharge area(s), data from the Tier 2 Studies Section 4 Survey of Karst Features Report (2010) and Addendum No. 1 (2011), and post 2006 Section 5 DEIS updates (such as land cover, land use, population growth, planned development, setting, bedrock, Monroe County 2010 aerial photography and 2-foot contours) (see page i). These updates, additional field data, and evaluations resulted in increases in the number of identified karst features and flowpaths included in this 2012 Karst Report.

- A total of 205 dye trace sampling stations were established, and over 3,800 samples were analyzed. Forty-one dye introductions were made that demonstrated 59 karst groundwater flowpaths, and 20 relevant dye traces from other sources were included for a total of 83 groundwater flowpaths evaluated in this report.

- Groundwater flow was characterized in the Section 5 relevant karst areas; flow velocities ranged from 10 feet per day (0.42 feet per hour) to over 48,000 feet per day (2,000 feet per hour), and flowpaths ranged from 243 feet to over one mile in length. The flowpath data presented in this report are diagrammatic; the lines representing the flowpaths are *not* meant to represent the actual location or distribution of the conduits.

- Fourteen groundwater flowpaths illustrated transfer across sub-watershed boundaries.

- The Illinois Central Spring recharge area was revised and the recharge area for the Cave system was delineated.

- No federally listed species were identified in Section 5 caves; however, two state listed threatened/endangered species were identified from cave biological surveys at and caves.

- Four areas of special concern for Section 5 were identified: Lemon Lane and Bennett's Dump Superfund sites, 2nd Street Interchange, and Cave.

- Annual Pollutant Load Estimates for pre/post construction were completed for the preferred alternative.

- Potential measures to offset impacts to karst include the 1993 MOU preferences for avoidance, alternative drainage, mitigation/treatment, and operations and maintenance.

Summary and Conclusions

The report study results are specific to conditions identified within the Section 5 study area. Land use within the Bloomington area has been affected by both historic and recent development. Approximately 55% of land use within the relevant karst area is currently developed, while 45% remains undeveloped (e.g., 36% upland/wetland habitat, 9.5% agricultural, and 0.5% water), based on field reviews and updates of a GIS land use layer provided by the Monroe County Planning Department. Local planners anticipate development of an additional 20% of the karst area by 2035, based on only those specific areas of development identified by the local planning staffs (City of Bloomington and Monroe County tax increment financing TIF Districts).

Although some particular karst features may be avoided, since Section 5 is essentially the upgrade of the existing four-lane divided highway SR 37 to a new four- to six-lane divided

DRAFT

interstate I-69, karst geology cannot be avoided within the Section 5 corridor. Therefore, the focus of alignment and design should be on minimizing impacts via alternative drainage, mitigation/treatment, and operations and maintenance.

Only three of the dye traces demonstrated discrete recharge from insurgence features without surface expression and where no buried sinks have been identified. Some rapid movement of water into karst groundwater systems could also occur in areas where the landscape has been modified, or where sinkholes have been filled or altered.

In general terms, existing SR 37 is situated near both the topographic drainage and groundwater divides; thus, the general trend is for water to flow away from SR 37 through relatively short pathways (from hundreds of feet to about one mile) to springs on either side of the roadway. While karst flowpaths cross under SR 37, it was generally the headwaters of these systems that passed under SR 37.

The Section 5 karst groundwater systems tend to be small and relatively isolated; therefore, a single spill along the roadway, even if uncontained, would generally impact a single, relatively small groundwater system. The only significant cave system linked hydrologically to the Section 5 corridor is the Cave System that receives water from a relatively small part of the corridor. South of the Cave recharge area to the Section 5 southern terminus with Section 4, the flowpaths are longer and shared recharge areas become more common.

About 80% of the springs in Section 5 were found at or near geologic contacts. Spring discharges varied by at least two orders of magnitude. During the study, the mean daily discharge at the Illinois Central Spring (ILCS) was 257 gpm, but ranged from 18 to 3,916 gpm; two orders of magnitude variation in discharge appears to be representative of springs in Section 5. Hydrologic characteristics by area are as follows:

- *Bloomington Karst*: Recharge to springs generally includes the grade of SR 37, and springs were being impacted from road use, maintenance, and development along SR 37. The Bloomington Karst has longer and slower groundwater flowpaths than the other karst areas, with velocities ranging from hundreds to thousands of feet per day. Water tended to go from the surface to a spring in one to two days.

- *Bloomington North Karst*: About half of the insurgence features and some of the springs in the corridor were at higher elevations than the SR 37 grade. Sinkholes and springs were smaller on average than those found in the other two karst areas and reflected the thin nature of the karst that terminated at the edge of the ridge tops.

- *Simpson Chapel Karst:* Most insurgence features were above the SR 37 grade; therefore, many springs were not receiving road runoff. SR 37 was cut into the limestone through most of this area and essentially has been redirecting runoff to other, lower elevation karst features or off the karst entirely.

The flowpaths in the Bloomington North Karst and Simpson Chapel Karst tended to be relatively short and faster than those in the Bloomington Karst, with velocities over 48,000 feet per day

DRAFT

(9.1 miles/day) and typical travel times ranging from minutes to a single day for water to run off the surface and discharge at the springs.

Areas of Special Concern

- The Lemon Lane Landfill Superfund site is approximately 800 feet from existing SR 37 pavement and adjacent to the eastside of the Section 5 corridor. Drainage from the site is treated at the ILCS facility. Peak flows have historically exceeded the treatment and storage capacities and have the highest concentrations of contaminants. Parties involved in the ongoing treatment operations for the site requested that planning and design of I-69 find ways to reduce the volume of water entering the ILCS recharge area. The revised recharge area shows that minimal amounts of SR 37 are located in the ILCS recharge area.

- The Bennett's Dump Superfund site is located approximately 1,400 feet from existing SR 37 pavement and adjacent to the Section 5 corridor in the northwest corner of the interchange of SR 37 and SR 46. While it is not hydrologically connected to SR 37 or Section 5, parties involved in ongoing remedial design and mitigation measures at the site have requested that the planning and design of I-69 consider redirecting highway runoff around the site.

- The intersection of 2nd Street and SR 37 is an area of special concern due to the presence of a reported former cave and numerous sinkholes that were filled as part of SR 37 construction and other local development. Many of these sinkholes have had roadway and development runoff culverts installed in or nearby and since have reopened, resulting in the potential to destabilize the roadbed and adjacent lands.

- Cave and nearby Cave are areas of special concern due to the biological significance of diverse troglobitic (obligate cave dwelling) fauna, and state-listed threatened and endangered species.
    - No federally listed species were identified.
    - The cave's biological community appeared to be in relatively good health at the time of the field investigation despite historical and current aquatic impacts from SR 37. However, there is ongoing development in the recharge area unrelated to this I-69.
    - The mapped cave passage extend under SR 37, and the recharge area of the cave extend across SR 37 and the Section 5 corridor. Since the cave passages are at relatively shallow depths, there also may be a problem of bedrock competency over the cave passage.

DRAFT

General Environmental Concerns

- Karst systems are capable of transporting sediment and contaminants quickly into caves and to springs that may be relatively far from their source.

- Interbasin transfer of water is common in karst and in Section 5. If a spill containment failure were to occur, the location for an effective response might not be obvious.

- Redirection of runoff may be perceived as aggravating existing flooding downstream of SR 37.

General Engineering Concerns

- Collapse of filled sinkholes can threaten adjacent or overlying structures. These failures can result without surface expression prior to the collapse in areas where loess-derived soils overlie karst. There are sinkholes that have been filled or otherwise modified by people or natural processes throughout Section 5.

- Impervious surfaces, such as roads, can change patterns of runoff and infiltration. Concentrated or redirected water can destabilize sinkholes (with or without current surface expression) as they equilibrate with the new water input conditions. Unlined water detention or retention structures can increase the hydraulic head (i.e., saturate) in the supporting earthen materials and possibly lead to failure of such structures.

- Impervious surfaces, such as roads, can sever recharge features from the groundwater system. This can result in decreased spring discharges and alteration of habitat for any biological communities within the karst system

- Potential alteration of existing groundwater flow/quality and bedrock competency concerns are associated with groundwater flow within the Section 5 karst. The flowpaths demonstrated in this investigation are naturally occurring conduits in bedrock and are not meant to represent the actual location or distribution of the conduits. While these conduits are large enough to have turbulent flow, they are unlikely to have spans of more than a few feet, based on the relatively small groundwater systems of which they are components.

- There are hydrologically active drainage systems (such as culverts) to sinkholes and from springs under SR 37. Roadways can be eroded by passing over a spring with drainage and structural fill that is not properly engineered.

- Numerous instances of reopening sinkholes and soil piping were observed that had formed under concrete-lined ditches along SR 37. Many of these instances had been caused by wheel ruts from vehicles accidentally leaving the roadway, or by tractor tire ruts resulting from mowing the right-of-way when the ground was soft.

DRAFT

Recommendations

Best Management Practices

- Construction within the karst areas should be planned with effective erosion and sediment control measures. Procedures to reduce the impacts to karst will be implemented in accordance with INDOT's Standard Specifications and the 1993 Karst MOU between the INDOT, IDNR, IDEM and the USFWS. Stormwater runoff protection measures will be installed at all karst features in the right-of-way at the initiation of construction and maintained until all stormwater drainage has been diverted away from the feature, or final permanent stormwater treatment measures are in place. Erosion control measures will be put in place as a first step in construction and maintained throughout construction. Temporary erosion control devices such as silt fencing, check dams, sediment basins, inlet protection, sodding and other appropriate BMPs will be used to minimize sediment and debris in tributaries within the project area. Timely revegetation after soil disturbance will be implemented and monitored. Any riprap used will be of a large diameter in order to allow space for habitat for aquatic species after placement. Prior to construction, heavy equipment parking and turning areas will be located outside the construction limits but within the right-of-way to minimize soil erosion. Soil bioengineering techniques for bank stabilization will be considered where appropriate.

- The staging of equipment and materials should occur outside of karst areas or at a minimum on impervious material with drainage controlled. Same-season re-vegetation of disturbed land during construction, repairs and maintenance should be used, when feasible.

- Road maintenance should include posted low salt/no spray areas to prevent contaminants from entering karst systems. Mowing should be restricted to appropriate times, and repairing damaged vegetation and drainages should be required

- Some of the channels that cross the corridor may be under-drained in karst areas and appear to transmit water infrequently. Culverts and bridge openings must be sized to accommodate the required rainfall events as defined by the INDOT Drainage Design Manual. Unique backwater conditions created by sinking streams and other insurgence features will require further evaluation during subsequent design stages to assure that adequate detention storage volume is available.

- The roadway project needs to convey surface water runoff with as much natural treatment for water quality as is feasible. This treatment is best accomplished by dispersing the runoff through at least 100 feet of vegetation filter swale or passing it through an engineered treatment system (sediment basin) before it reaches the invert elevation for a sinkhole.

- Where possible, the road prism (structures, base, and pavement) should not restrict flow into a sinkhole or other insurgence feature. Use of filters, buffers, containment structures, reinforced soil, void grouting, compaction grouting, concrete caps, reinforced bridging slabs (land bridges), deep foundations, etc. are potentially effective mitigation measures, but will not be determined until subsequent detailed design stages.

DRAFT

- Utilization of lined ditches designed to prevent erosion to the outfall discharge points are recommended within the karst areas. Water flow within the roadway ditches will need an analysis for lining requirements. Culvert outlets should be designed to discharge water to at grade terrain. This design will reduce erosion scour and sediment transport into the karst and other environments. Design of ditches and culverts should be based on INDOT's Drainage Design Manual and be appropriate to the specific karst feature.

- The drainage design for I-69 should provide for proper energy dissipation devices at the culvert and storm sewer system outlet locations to prevent erosion to existing channels. Energy dissipater devices include such items as scour holes, riprap linings and stilling basins. Design of energy dissipater devices and ditch linings should be based on INDOT's Drainage Design Manual.

- The roadway drainage system should be incorporated into the Operations and Maintenance Plan for inspection and repair to prevent disturbance of karst drainage patterns and undercutting observed along SR 37. The karst areas will require monitoring to identify roadway slopes and ditches and repair of off-road disturbances. Mowing should be restricted to periods of dry weather/firm soil conditions to avoid rutting from vehicles. Reseeding/drainage repair should be required following accidents that disrupt vegetative cover. Installation of guardrails could be utilized to prevent vehicles from leaving paved roadway surfaces. Roadway maintenance should include posted low salt/no spray areas to prevent chemicals from entering the karst system.

- Excavation into bedrock below the current SR 37 roadway grade, which could potentially expose cave passages and other karst conduits, should be avoided where possible. Roadway grading constructed with embankment fill is preferable to cuts in bedrock.

- Implementation of hazardous waste traps will conducted by INDOT (or their designated contractors) to protect karst features against hazardous materials spills per Step 7 of the Karst MOU. Spill response equipment should be readily available during construction and subsequent use of the road. Due to the high flow rate within karst systems, response times are critical for prevention/reduction of impacts to karst ecologic communities, groundwater resources, and surface water. The first priority must be to prevent contaminants from entering the karst groundwater system at the location of the release, or at the location of overflow where treatment/mitigation measures are present. Once contaminants have entered the karst system, use of preventive or mitigation measures at appropriate resurgence points for both surface water and sediment are time critical due to the high water velocities (depending on the particular conduit system), precipitation, and other flow conditions.

- In the event that a sinkhole disturbance cannot be avoided, the sinkhole should be capped. A special design of the roadway subgrade and pavement structure should be considered in these areas to avoid the hazards of sinkhole instability and reallocated water runoff. The special design may include special subgrade treatment and/or increased structural design of roadway pavement and anchoring of pavement slabs crossing the sinkhole area(s) to underlining bedrock.

- In the event that disturbance of a spring cannot be avoided, a spring box and culvert should be constructed to discharge the flow to an appropriately designed outfall to prevent undercutting of the pavement and/or subgrade. A special design of the roadway

DRAFT

subgrade and pavement structure should address potential undermining of the roadbed due to excess pressure head discharging from the spring or potential water leakage from the spring boxes and culverts over time. The special design may include special subgrade treatment and/or increased structural design of roadway pavement and an anchoring of pavement slabs crossing the spring areas to underlining bedrock.

- In the event that disturbance to a karst flowpath cannot be avoided, the top of the karst flowpath should be capped, but still allow for natural flow within the flowpath. A special design of the roadway subgrade and pavement structure should be considered in these areas to ensure that the natural conduit does not collapse and threaten the integrity of the roadbed. The special design could include special subgrade treatment and/or increased structural design of roadway pavement and an anchoring of pavement slabs crossing the karst conduits to underlining bedrock.

- If caves are exposed during construction, karst experts should be consulted to determine their project significance. Drainage and treatment alternatives will be considered concurrently so as to not impede drainage in recharge areas and having potentially harmful impacts to cave biota.

- Per the 1993 MOU, in the event that Federal and/or State listed species are encountered during construction that were not previously reported/evaluated, construction should be halted until an evaluation can be performed.

Areas of Special Concern

- Control of construction water runoff, post construction roadway water runoff and alternative drainage to either surface water systems or drains are recommended in the vicinity of the Bennett's Dump and Lemon Lane Landfill Superfund sites, where alterations in surface runoff and groundwater flow have the potential to flush existing contaminants or increase treatment volumes.

- Design and Construction of the SR 45/Second Street interchange will require karst feature engineering to mitigate impacts on buried sinkholes.

- Impacts to the Simpson Chapel Karst area may be reduced where SR 37 generally follows the karst groundwater divide and numerous nearby valley heads drain below the karst bedrock.

- The Cave and Cave recharge areas are of special concern due to the presence of State listed threatened and endangered species. Additional measures may be required or installation of alternative drainage at Cave and Cave. In order to maintain the existing base flow levels in the system, surface treatment of runoff water may be required. Treatment options include:

    - Engineered wetland sediment and contaminant reduction systems.

    - Linear peat sand filters and/or vegetated swales along the roadway or at the terminus of lined storm water control structures.

DRAFT

- Sinkhole sediment and contaminant traps.
- Runoff and storm water detention/retention systems, treatment, and infiltration galleries.
- Control of "first flush" volumes with designed overflow into natural drainage system.

DRAFT

TABLE OF CONTENTS

EXECUTIVE SUMMARY I

Section 5 Karst Setting ii
Methodology iii
Results v
Summary and Conclusions vi
Areas of Special Concern viii
General Environmental Concerns ix
General Engineering Concerns ix
Recommendations x
Best Management Practices x
Areas of Special Concern xii

1.0 INTRODUCTION 1

1.1 Purpose of the Study 1
1.2 The Study Area 4
1.3 Land Use Setting 4
1.4 Physiographic Setting 10
1.5 Geologic Setting 11
1.5.1 Bloomington Karst 12
1.5.2 Bloomington North and Simpson Chapel Karst 12
1.5.3 Mining/Quarry Operations 13
1.5.4 Hydrogeologic Setting 13

2.0 METHODOLOGY 20

2.1 Public and Private Research Sources 20
2.2 Karst Feature Field Check Methodology 20
2.2.1 Sinkholes 21
2.2.2 Springs 22
2.2.3 Karst Flowpaths 23
2.2.4 Caves 23
2.2.5 Others 24
2.3 Dye Trace Methodology 25
2.3.1 Dye Trace Program 25
2.3.1.1 Quality Assurance/Quality Control 27
2.3.2 Sampling Stations 28
2.3.3 Dye Introductions 29
2.4 Tracer Dyes Sampling and Analysis Methodologies 30
2.4.1 Activated Carbon Samples 30
2.4.2 Water Samples 31
2.5 Annual Pollutant Load Estimates 32
2.5.1 Pollutant Loads from Highway and Right-of-Way 32
2.6 Review of IDNR Water Well Data 32
2.7 Cave Biology 33

3.0 RESULTS 35

3.1 Karst Features 35
3.1.1 Sinkholes and Other Insurgence Features 35
3.1.1.1 Drainage Area 37
3.1.2 Springs 43

DRAFT

3.1.3 Karst Flowpaths ... 49
3.1.4 Caves ... 49
3.1.5 Others ... 50
3.2 Dye Tracing Results ... 53
3.2.1 Previous Dye Tracing Results ... 53
3.2.2 Groundwater Tracing Results by Individual Traces ... 55
3.3 Summary of Dye Tracing Results ... 64
3.4 Recharge Area Delineations ... 70
3.4.1 Illinois Central Spring Recharge Area ... 70
3.4.2 Cave Recharge Area ... 71
3.5 Cave Biology Results ... 74
3.6 Annual Pollutant Load Estimates ... 76
3.6.1 INDOT's Previous Karst Study on SR 37 ... 76
3.6.2 Kentucky's Previous Karst Study on I-65 at Mammoth Cave ... 77
3.6.3 Karst Features to Analyze ... 77
3.6.4 FHWA Highway Runoff Water Quality Training Course ... 78
3.6.4.1 Part 1: Pollutant Loadings from Highway Runoff ... 78
3.6.4.2 Part 2: Pollutant Concentrations from Highway Runoff ... 79

4.0 POTENTIAL MEASURES TO OFFSET IMPACTS TO KARST ... 81

4.1 Avoidance ... 81
4.2 Alternative Drainage ... 81
4.3 Mitigation/Treatment ... 81
4.4 Operations and Maintenance ... 82

5.0 SUMMARY AND CONCLUSIONS ... 83

5.1 Karst Settings Description and Distribution ... 83
5.1.1 Bloomington Karst ... 83
5.1.2 Bloomington North Karst ... 84
5.1.3 Simpson Chapel Karst ... 84
5.2 Drainage Patterns and Land Use ... 85
5.3 Dye Tracing ... 88
5.4 Characterization of Karst Groundwater Flowpaths ... 88
5.5 Cave Biology ... 89
5.6 Areas of Special Concern ... 90
5.6.1 Lemon Lane Landfill ... 90
5.6.2 Bennett's Dump ... 95
5.6.3 SR 45/2nd Street – SR 37 Interchange ... 98
5.6.4 Cave Recharge Area ... 100
5.7 General Environmental Concerns ... 103
5.8 Engineering Concerns ... 103

6.0 RECOMMENDATIONS ... 105

6.1 Best Management Practices ... 105
6.2 Areas of Special Concern ... 107

7.0 REFERENCES ... 110

DRAFT

TABLES

Table 1 Karst Effects by Land Use 10
Table 2 Bedrock and Karst Area Groupings 11
Table 3 Relevant Karst Land Use for Section 5 Study Area 37
Table 4 Spring Relevance 44
Table 5 Estimated Discharge for Relevant Springs 46
Table 6 Summary of Dye Trace Parameters 65
Table 7 Dye Traces and Detection Stations 67
Table 8 Obligate Subterranean Species Summary 74
Table 9 Summary of Karst Features Exceeding Water Quality Standards for Preferred Alternative 8 80

DRAFT

FIGURES

Figure 1 Section 5 Location Map……..6
Figure 2 Location of Section 5 Karst Areas 7
Figure 3a 2000 Population Density for Relevant Karst Areas 8
Figure 3b Monroe County Population Density Trend 9
Figure 4a Section 5 Mineral Resources – Limestone Reserves and IDNR Water Wells 18
Figure 4b Section 5 Mineral Resources – Abandoned Quarries, Sand/Gravel Deposits, Natural Gas Wells and Storage Dome 19
Figure 5a Sinkholes/Insurgence Features and Land Use – Bloomington and part of Bloomington North Karst 39
Figure 5b Sinkholes/Insurgence Features on Aerial Background – Bloomington and part of Bloomington North Karst 40
Figure 6a Sinkholes/Insurgence Features and Land Use - part of Bloomington North and Simpson Chapel Karst..... 41
Figure 6b Sinkholes/Insugence Features on Aerial Background - Simpson Chapel Karst..... 42
Figure 7 Locations of Springs – Bloomington and N. Bloomington Karst..... 51
Figure 8 Locations of Springs – Bloomington N. and Simpson Chapel Karst 52
Figure 9 Previous Relevant Dye Traces and Spring Locations..... 54
Figure 10 Locationof Sampling Stations - Bloomington and Bloomington North Karst 62
Figure 11 Location of Sampling Stations – Bloomington North and Simpson Chapel Karst . 63
Figure 12 Summary of Dye Tracing for the Bloomington and Bloomington North Karst..... 68
Figure 13 Summary of Dye Tracing for the Simpson Chapel Karst 69
Figure 14 Revised Illinois Central Spring Recharge Area 72
Figure 15 Recharge Area of Cave..... 73
Figure 16 Adjustment of Sub-Watershed Boundaries Resulting from Dye Tracing (Bloomington and Bloomington North Karst)..... 85
Figure 17 Adjustment of Sub-Watershed Boundaries Resulting from Dye Tracing (Simpson Chapel Karst) 87
Figure 18 Area of Special Concern: Lemon Lane Landfill..... 94
Figure 19 Area of Special Concern: Bennett's Dump..... 97
Figure 20 Area of Special Concern: Second Street – SR 37 Interchange 99
Figure 21 Area of Special Concern: Cave Recharge Area..... 102

DRAFT

APPENDICES

APPENDIX A Memorandum of Understanding
APPENDIX B Tabular results for activated carbon and water samples
APPENDIX C Ozark Underground Laboratory Procedures and Criteria
APPENDIX D Sampling Station Index and Karst Feature Index
TableD-1 Sampling Station Index
Table D-2 Karst Insurgence Feature Index
APPENDIX E Sampling Station and Select Feature Photographs (on CD)
APPENDIX F Individual Dye Trace Reports, Summary Table, and Figures
Table F-1 Individual Dye Trace Summary Table
Figure F-1 Trace 04-01:
Figure F-2 Trace 04-02:
Figure F-3 Trace 04-03:
Figure F-4 Trace 04-04:
Figure F-5 Trace 04-05:
Figure F-6 Trace 04-06:
Figure F-7 Trace 04-07:
Figure F-8 Trace 04-08:
Figure F-9 Trace 04-09:
Figure F-10 Trace 04-10:
Figure F-11 Trace 04-11:
Figure F-12 Trace 05-12:
Figure F-13 Trace 05-13:
Figure F-14 Trace 05-14:
Figure F-15 Trace 05-15:
Figure F-16 Trace 05-16:
Figure F-17 Trace 05-17:
Figure F-18 Trace 05-18:
Figure F-19 Trace 05-19:
Figure F-20 Trace 05-20:
Figure F-21 Trace 05-21:
Figure F-22 Trace 05-22:
Figure F-23 Trace 05-23:
Figure F-24 Trace 05-24:
Figure F-25 Trace 05-25:
Figure F-26 Trace 05-26:
Figure F-27 Trace 05-27:
Figure F-28 Trace 05-28:
Figure F-41 Cave Recharge Area; previous and 13 additional individual traces

- *F-29 Trace 08-01:*
- *F-30 Trace 08-02:*
- *F-31 Trace 08-03:*
- *F-32 Trace 09-04:*
- *F-33 Trace 09-05:*
- *F-34 Trace 09-06:*
- *F-35 Trace 09-07:*
- *F-36 Trace 09-08:*
- *F-37 Trace 09-09:*

DRAFT

- *F-38 Trace 09-10:*
- *F-39 Trace 09-11:*
- *F-40 Trace 09-12:*
- *F-41 Trace 09-13:*

APPENDIX G Documentation Graphs for All Analyzed Samples (on CD)
APPENDIX H Precipitation and Discharge Data from Illinois Central Spring
APPENDIX I CONFIDENTIAL Data (on CD)
Figure I-1 Cave Entrance and Passage Locations) CONFIDENTIAL
APPENDIX J Cave Fauna of the Section 5 Corridor of I-69
APPENDIX K Indiana Bat Hibernacula Cave Reconnaissance
APPENDIX L Pollutant Loading Estimate Tables and FHWA Methodology
APPENDIX M IDNR Water Well Data
APPENDIX N Detail Maps of Preferred Alternative and Resources

DRAFT

GLOSSARY OF KEY TERMS

(As defined for this report)

General Terms

Corridor	A 2,000 foot wide area centered on existing SR 37. The I-69 Tier 2 Section 5 Corridor extends from just south of Bloomington in Monroe County, Indiana, to the southern edge of Martinsville in Morgan County, Indiana.
Section 4	The study area south of Section 5, where the proposed I-69 corridor departs from SR 37 and heads to the west on new alignment.
Section 6	The study area to the north of Section 5. This study area extends along SR 37 from Martinsville north to Indianapolis, Indiana.

Biological Terms

Commensal	A species that benefits from the association with a host species, which is substantially unaffected.
Troglobite	An obligate cave dweller.
Stygobite	An aqueous obligate subterranean dweller.

Karst Terms

Bloomington Karst	The portion of relevant karst from just south of Bloomington to the SR 37/SR 46 interchange.
Bloomington North Karst	The portion of relevant karst from the SR 37/SR 46 interchange to the south side of the Beanblossom Creek valley.
Cave	A naturally occurring void in earth materials that can be entered by a human for an appreciable distance.
Cave System	An assemblage of karst features that may contain multiple caves, water inlets, and springs that are all related. For management purposes, the cave system is generally the category of interest since fauna and water movement in a cave system are rarely restricted in areas where humans cannot enter.

DRAFT

Drainage Area	Drainage area (as informally used in the MOU) is used in this report synonymously with recharge area (i.e., "the land surface that contributes at least some water under some flow conditions to a particular karst feature.")
Dye Trace	A dye trace for this project consisted of the following actions: 1) the introduction of dye into an insurgence feature with either existing water flow and/or with potable water, 2) travel of the dye through the karst groundwater system, 3) detection of the dye in the elutant from an activated carbon sampler or from a grab sample of water.
Epikarst	The weathered upper surface of karst consisting of a network of fissures and cavities that can store and redistribute water into the main karst conduits.
Insurgence Feature	A surface feature that directs surface water into the karst groundwater system (i.e. sinkholes, swallet, losing and sinking streams).
Interference peak	A peak from a fluorescent dye or other compound, detected at sampling stations that is not associated with dye introduced as part of the Section 5 studies.
Karst	A three-dimensional landscape underlain by soluble rocks and having appreciable groundwater flow through solutionally enlarged openings (internal drainage) in the rock.
Karst Conduit	A tubular opening created by dissolution of the bedrock, which carries, can carry, or has carried water flow.
Karst Groundwater System	Includes water in both the saturated and unsaturated zones, the conduits through which the water flows and the springs at which groundwater is discharged.
Karst Valley	A valley that is like an ordinary valley on the upper slopes, but has sinkholes in the bottom draining it. The sinkholes are often aligned along the valley bottom.
Karst Window	For this study, a karst window is a sinkhole that provided limited access to a submerged karst conduit.
Loess	Calcareous silt associated with windblown dust of Pleistocene age.

DRAFT

Losing Stream	A surface stream from which a portion of the flow enters into a subterranean groundwater system.
Recharge Area	The land surface that contributes at least some water under some flow conditions to a particular karst feature.
Resurgence Feature	Discrete opening(s) in the bedrock where water is discharged to the earth's surface (i.e. springs, seeps, and gaining streams).
Relevant Karst	The relevant karst is the portion of karst within the I-69 Section 5 corridor and associated areas outside of the corridor; that has been demonstrated to have corridor-derived water passing through it; or is linked by logical inference based on the best available geographic, geologic, and hydrologic data, including the Tier 2 investigation. It does not include areas outside the corridor that contribute water to the corridor.
Sampling Station	Sampling stations for this project generally consisted of two anchored carbon packets in water flow at a spring, stream or pool. GPS locations were obtained and the station marked with identifying flagging. Grab samples of water would generally be collected at the sampling stations.
Simpson Chapel Karst	The portion of relevant karst from the north side of the Beanblossom Creek valley to just south of Chambers Pike in Monroe County, Indiana.
Sinking Stream	A stream that leaves the surface and enters into a subterranean groundwater system.
Sinkhole	A natural, closed depression in the surface of the earth which recharges groundwater (internal drainage). All land draining into a sinkhole is part of the sinkhole. The boundaries of sinkholes with surface expression in Section 5 were mapped based on 2-foot contour data which were derived from 2010 LiDAR data along with field checking of sink points (swallets).
Spring	A discrete point for water discharging from a karst groundwater system. Springs have discernable channels that may carry perennial flow or only flow as storm response.

DRAFT

Swallet	The location where a stream sinks underground, often associated with a stream flowing into a sinkhole or cave entrance.
Karst Flowpath	Groundwater flow through a karst conduit within a karst groundwater system.

Land Use Terms

The following land use terms used for relevance to karst within Section 5 and are based upon a consolidation of the land use terms used in other Tier 2 documents.

Agricultural	Includes row crops, pasture, orchards, groves, nurseries, specialty crops, and agricultural operations.
Nonresidential/Industrial	Includes commercial and industrial developments, churches, and cemeteries.
Planned Development	Ranges from parcels with approved site plans to areas targeted by local comprehensive plans to absorb future residential or commercial growth. Specific sites of planned development were identified during the coordination process with planners from the City of Bloomington and Monroe County and placed in the project GIS. This development is anticipated to occur independent of the proposed project.
Public and Institutional	Public use and institutional land uses include schools, libraries, soccer fields, parks, hospitals, fire and police stations, communally owned civic facilities (Masonic lodges, rotary clubs, etc.) or other public facilities.
Mines/Quarries	Includes areas of extractive mining activities (but not reclaimed mine areas).
Residential	Includes single-family, multi-family, and mobile home parks.
Water	Includes surface hydrologic features such as streams, rivers, lakes, reservoirs, and ponds.
Transportation, Utilities, and Communications	Includes infrastructure such as roads, road right-of-ways, railroads, utility right-of-ways, and power substations.
Upland/Wetland Habitat	Includes wetland and upland habitat ranging from forested to herbaceous cover.

DRAFT

1.0 INTRODUCTION

1.1 Purpose of the Study

This study was conducted to support the I-69 Tier 2, Section 5 Environmental Impact Statement (EIS) and address Items 1 through 4 of the 1993 Memorandum of Understanding (MOU) as entered into by the Indiana Department of Transportation (INDOT), the Indiana Department of Natural Resources (IDNR), the Indiana Department of Environmental Management (IDEM), and the U.S. Fish and Wildlife Service (USFWS) (INDOT et al, 1993) to delineate guidelines for construction of transportation projects in karst regions of the state. A copy of the 1993 MOU is presented in **Appendix A**.

This report documents reviews of karst information relevant to the Section 5 corridor, field checks of previously recorded karst features, field investigations to identify previously unrecorded karst features, dye tracing of karst features, and recommendations for karst feature avoidance, impact minimization, and mitigation of unavoidable impacts. The study was prepared by Ozark Underground Laboratory, Inc. (OUL), Protem, Missouri and Philip Moss, PG of Waterloo, Illinois with additional data provided by Michael Baker, Jr. Inc. (Baker), Crown Point, Indiana.

This document is an update to and replacement of the July 2006 I-69 Tier 2 Studies Section 5 Draft Karst Feature and Groundwater Flow Investigation Report (2006 Draft Karst Report). Updates to the 2006 Karst Report include:

- The 2006 Karst Report was provided to the Karst MOU signatory agencies and the U.S. Environmental Protection Agency (USEPA) for review and comment on September 22, 2006, and comments received were incorporated into the updated 2012 Karst Report.

- Additional field reconnaissance and dye tracing was conducted to determine the approximate recharge area for two overlapping cave systems (known as Cave and Cave) in the vicinity of the Section 5 corridor, based on agreement between INDOT, FHWA, and USEPA.

- Updated land cover, land use, population growth, planned development, and setting as part of the Section 5 DEIS evaluations, subsequent to the 2006 Draft Karst Report.

- Monroe County geographic information system (GIS) files such as the 2010 aerial photography and 2-foot contours were reviewed to identify potential additional or adjust 2006 Section 5 karst features. The Monroe County data included topography from Light Detection And Ranging (LiDAR) that can measure beneath leaf canopy, increase reproducibility between surveys, and provide increased precision over standard aerial photography based mapping. Karst feature additions and adjustments from this data were incorporated following field check confirmations.

- Geologic mapping and descriptions were updated with publications by the Indiana Geological Survey such as the Monroe and Bloomington quadrangle bedrock mapping

DRAFT

(Thompson 2007) and Bedrock Geologic Map of Monroe County, Indiana (Hasenmueller 2008).

- Data from the I-69 Tier 2 Studies Section 4 Survey of Karst Features Report (2010) and Addendum No. 1 (2011) was reviewed and incorporated where appropriate.

These updates, additional field data, and evaluations resulted in increases in the number of identified karst features and flowpaths included in the 2012 Karst Report

Items 1 through 4 of the 1993 MOU are quoted as follows:

1. *INDOT in cooperation with the IDNR, IDEM and USFWS shall determine the location of sinkholes, caves, underground streams and other related karst features and their relationship prior to proposed alterations or construction in karst regions of the State. A consultant with expertise in karst geology/hydrology may assist in the identification and characterization of the karst features. The choice of the consultant retained by INDOT will be subject to the review of IDNR, USFWS and IDEM.*

2. *Tasks to accomplish this work will include:*

    - *Research available from public and private sources for information relative to karst features.*

The Project Team compiled existing information on local karst features from a number of sources. These sources included: the Indiana Geological Survey, Indiana Cave Survey, and karst experts knowledgeable about the area. Specific karst studies and mapping for the Section 4 corridor examined and field checked for this study included I-69 Tier I and Tier II public comments, including cave maps and other karst feature data and mapping, as well as all previous I-69 related karst study data. Additional resources included high resolution aerial photography, planimetric and topographic mapping in the corridor as well as USGS topographic maps.

During the study, coordination was maintained among the Project Team to review and exchange new information discovered by other project related studies. These included ongoing studies regarding caves as potential Indiana bat habitat, as well as karst studies and other field evaluations being conducted for the I-69 corridor within adjacent sections and within section 5. This included cross referencing all previous mapping collected with the field investigations and the IGS cave entrance surveys conducted in support of the Project Team's Section 7 Consultation with the USFWS for this project. Accessible caves related springs with hydraulic or physical connection with the alternatives being advanced were surveyed for biological fauna.

    - *Field check karst and cave features that appear from the first task and identify any additional karst features.*

Field checks were conducted to verify and map previously recorded karst features along the length of the Section 5 corridor. In addition, a field reconnaissance was conducted to determine the presence of, and map previously unrecorded karst features within the 11.5-mile length of karst crossed by the Section 5 corridor and appropriate areas outside of the corridor to identify

DRAFT

potentially related karst features that may be associated with the corridor via karst groundwater flowpaths or surface run-off.

- *Prepare a draft report with photographs and maps, drainage areas, and land use of that drainage area for each sinkhole or karst feature. Dye-tracing and/or other geotechnical information to determine subsurface flow of water in the project area and surface water drainage patterns of the area. Calculations of estimates of annual pollutant loads from the highway and drainage within the right-of-way will be made, including prior to, during and post construction estimates. The design of the treatment of the karst features will take into consideration treatments necessary to meet the standards of the monitoring and maintenance plan.*

Drainage areas, drainage patterns, and land use specifically related to the karst features were determined and mapped. Additionally, dye tracing tests were conducted on selected karst features within the karst study area in order to determine and map the subsurface flow from recharge features (caves, sinkholes, swallets, and sinking streams) to discharge features (springs and gaining streams) and establish groundwater flow patterns within the study area.

- *That report will be used as a tool to assist in determining the proposed highway alignment. The intent of INDOT is to avoid karst areas and use alternate drainage where possible.*

3. *IDNR, IDEM and USFWS will be requested to review and comment on the findings at the early coordination phase of project development.*

The Project Team has conducted ongoing coordination with the agencies signatory to the Karst MOU (signatory agencies). The karst survey methodology and updates on survey results were discussed with resource agencies during the karst studies. Any future agency concerns or questions relating to the findings or recommendations presented in this report, or any other karst related issues will be addressed through ongoing coordination relative to addressing the Karst MOU. In addition, this draft report will be distributed to the signatory agencies and other appropriate review agencies for their review and comments as part of the Draft Environmental Impact Statement (DEIS).

4. *INDOT, using the input for IDNR, IDEM, and USFWS, will begin to formulate appropriate measures to offset unavoidable impacts to the karst features. It is understood by all parties that some of the methods proposed at this time will be generic and could be applied throughout the length of the corridor. Other methods may be specific to a particular cave or karst feature. Some of the approaches may require additional investigations to determine their necessity and/or their feasibility. A revised draft report will be prepared by INDOT'S consultant and provided to the IDNR, IDEM and the USFWS as part of the design review process.*

The Project Team will determine the appropriate measures to offset unavoidable impacts to karst features through coordination with the signatory agencies and any other appropriate review agencies. Any future agency concerns or questions relating to the findings or recommendations

DRAFT

presented in this report, or any other karst related issues will be addressed by the Project Team through ongoing coordination relative to addressing the Karst MOU.

1.2 The Study Area

The Section 5 Corridor (Figure 1) is a 2,000-foot wide area centered on State Route 37 (SR 37) from southwest of Bloomington in Monroe County, Indiana approximately 21 miles north to just south of Martinsville in Morgan County, Indiana. The karst study area encompasses the I-69 Tier 1 and Tier 2 karst feature data, and extends from Clear Creek, south of Section 5, northward along SR 37 to roughly Chambers Pike. Relevant karst is the portion of karst within the 21-mile length of Section 5 Corridor and associated areas outside of the Corridor: that has been demonstrated to have Corridor derived water passing through it; or is linked by logical inference based on the best available geographic, geologic, and hydrologic data, including the Tier 2 investigation (2006 data and 2012 updates[2]). It does not necessarily include areas outside the Corridor that contribute water to the Corridor. The relevant karst is shown on Figure 2 and was divided into three areas as follows:

- Bloomington Karst – begins at the southern terminus at approximately That Road (just north of the Section 4 SR 37 interchange) and continues north to approximately Arlington Road (old SR 46) within the Mitchell Plateau Physiographic Region.

- Bloomington North Karst - the relevant karst begins at approximately Arlington Road and continues to Kinser Pike at the southern slope of the Beanblossom Creek Valley within the Mitchell Plateau Physiographic Region.

- Simpson Chapel Karst - the relevant karst begins approximately Wayport Road at the northern slope of the Beanblossom Creek Valley and continues north to just south of Chambers Pike within the Norman Upland physiography.

1.3 Land Use Setting

The relevant karst portion of Section 5 is located within the Bloomington area of Monroe County. Like most of Indiana, agriculture was the primary early source of development in Monroe County and continues to play a vital role outside the greater Bloomington area. Bloomington itself has been a commercial and residential center since the 1830's. Much of the city's development has been, and is currently, based on Indiana University and the national and international demand for the high quality limestone available from local quarrying operations. Concurrent commercial, industrial, and residential growth has expanded to urban and suburban land use patterns now prevalent in the relevant karst areas[2].

[2] Updates to the 2006 Karst Report include: MOU signatory agencies and USEPA 2006 Karst Report comments, additional field reconnaissance and dye tracing for and Cave recharge area(s), data from the Tier 2 Studies Section 4 Survey of Karst Features Report (2010) and Addendum No. 1 (2011), and post 2006 Section 5 DEIS updates (such as land cover, land use, population growth, planned development, setting, bedrock, Monroe County 2010 aerial photography and 2-foot contours) (see page i). These updates, additional field data, and evaluations resulted in increases in the number of identified karst features and flowpaths included in this 2012 Karst Report.

DRAFT

Generally, the City of Bloomington has more urbanized land uses at higher densities than surrounding areas of Monroe County, which display a mix of suburban and rural land uses. However, Monroe County on the whole has experienced, and is projected to continue to experience, steady population growth. The 2010 Population Density for relevant karst areas (compiled from 2010 census block data) and Monroe County Population Density Trend (Figure 3a and Figure 3b) illustrate the overall densities that have resulted from residential and other non-residential uses (i.e., commercial and industrial land uses) and the density increase projected for the area.

DRAFT

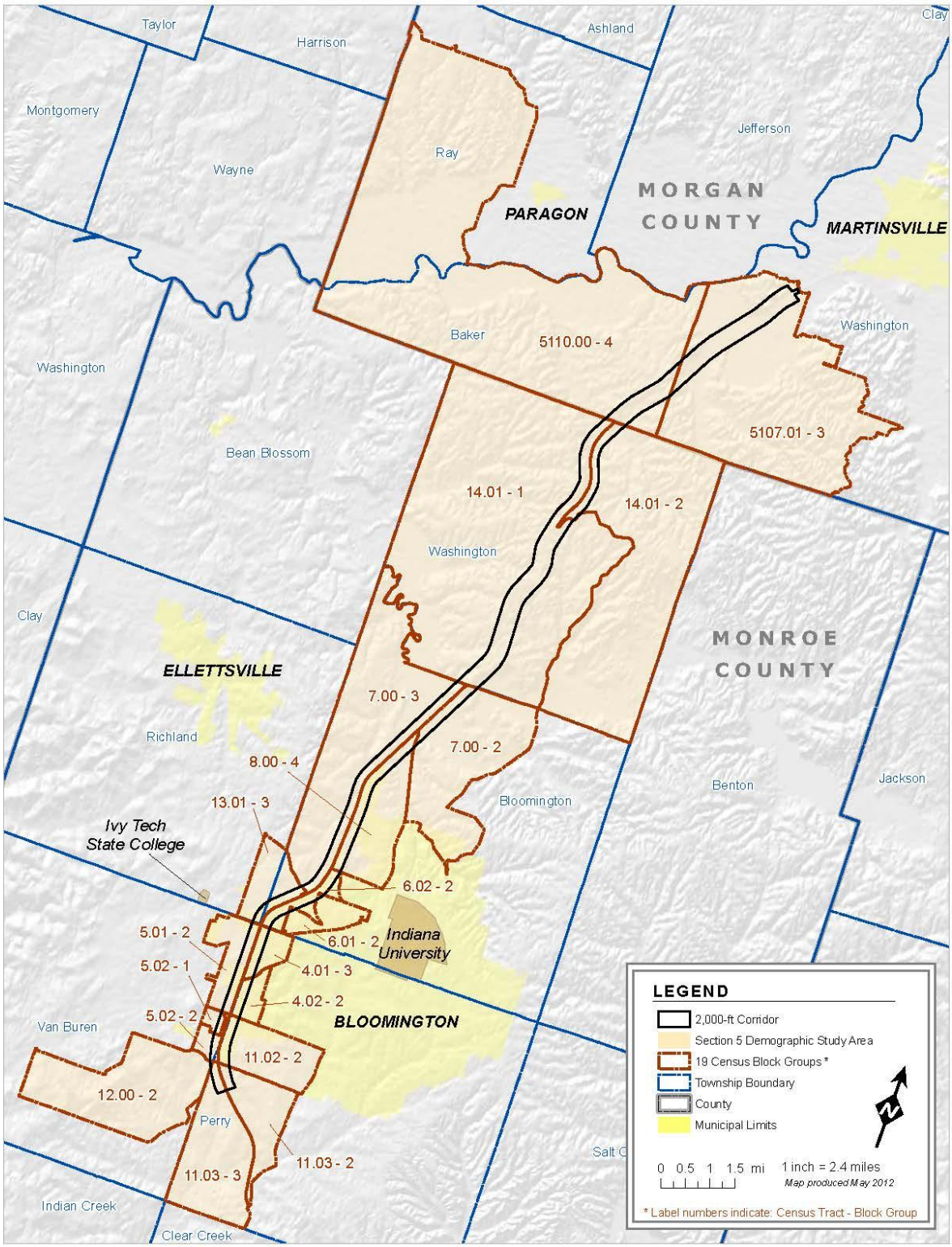


Figure 1 Section 5 Location Map

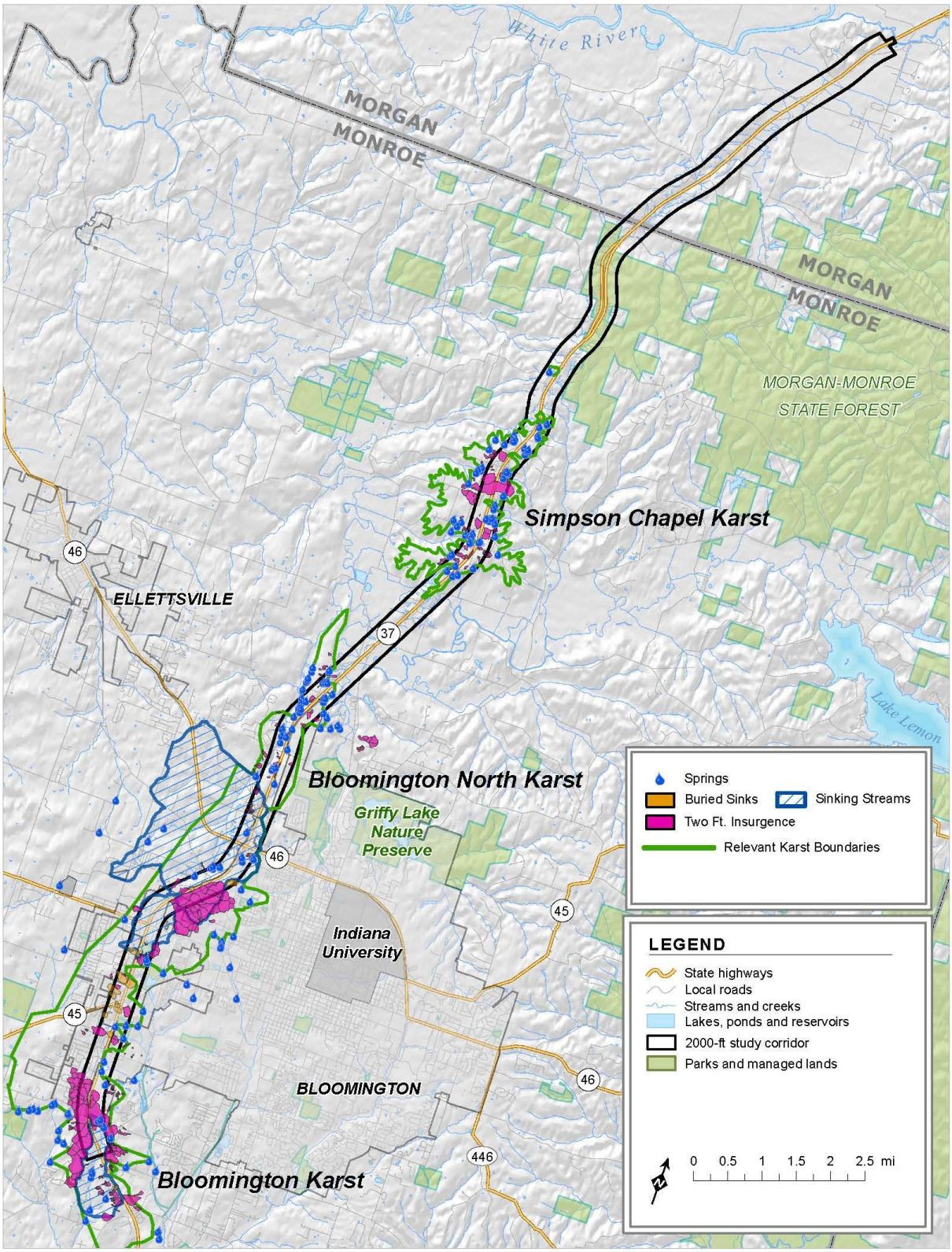


Figure 2 Location of Section 5 Karst Areas

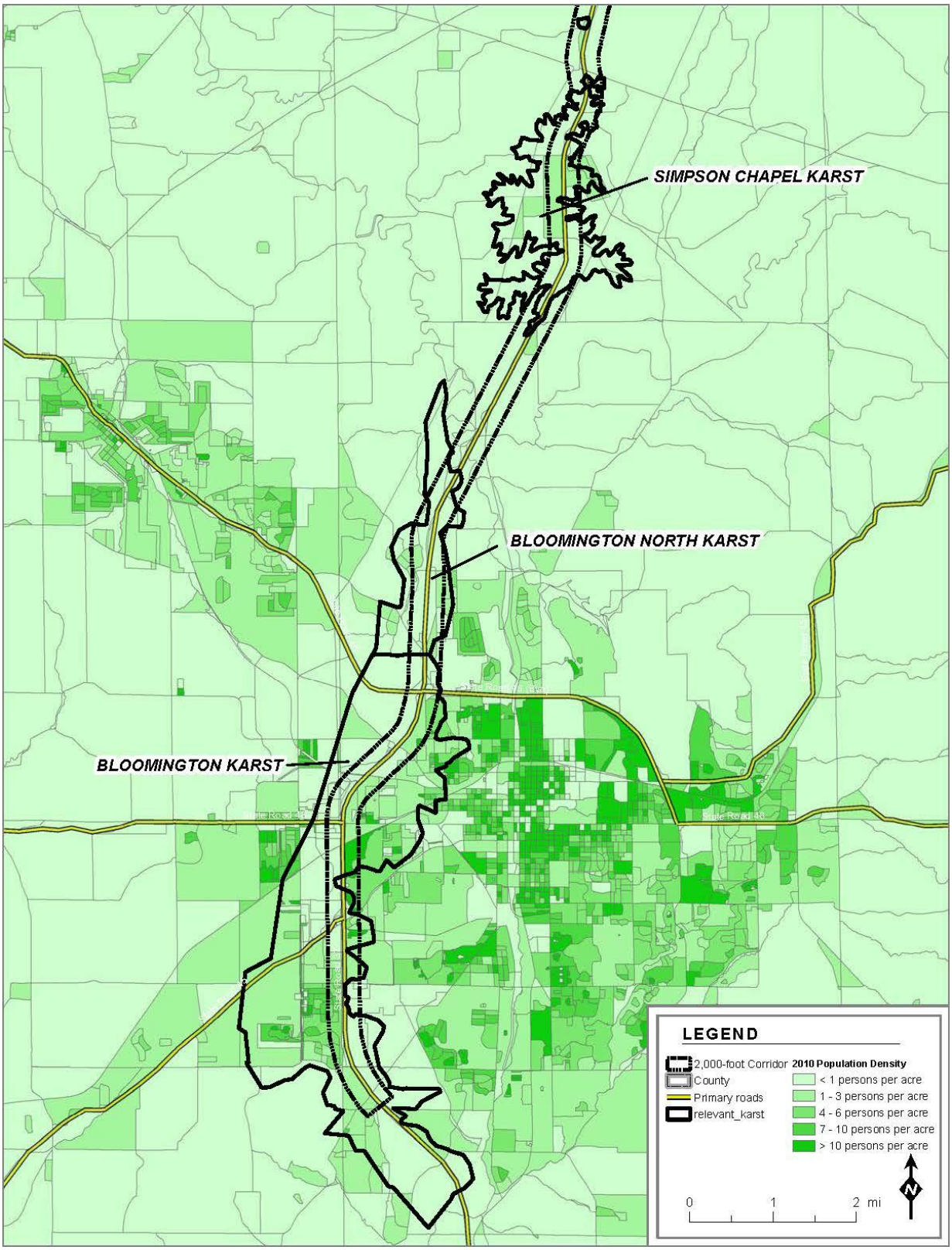


Figure 3a 2010 Population Density for Relevant Karst Areas

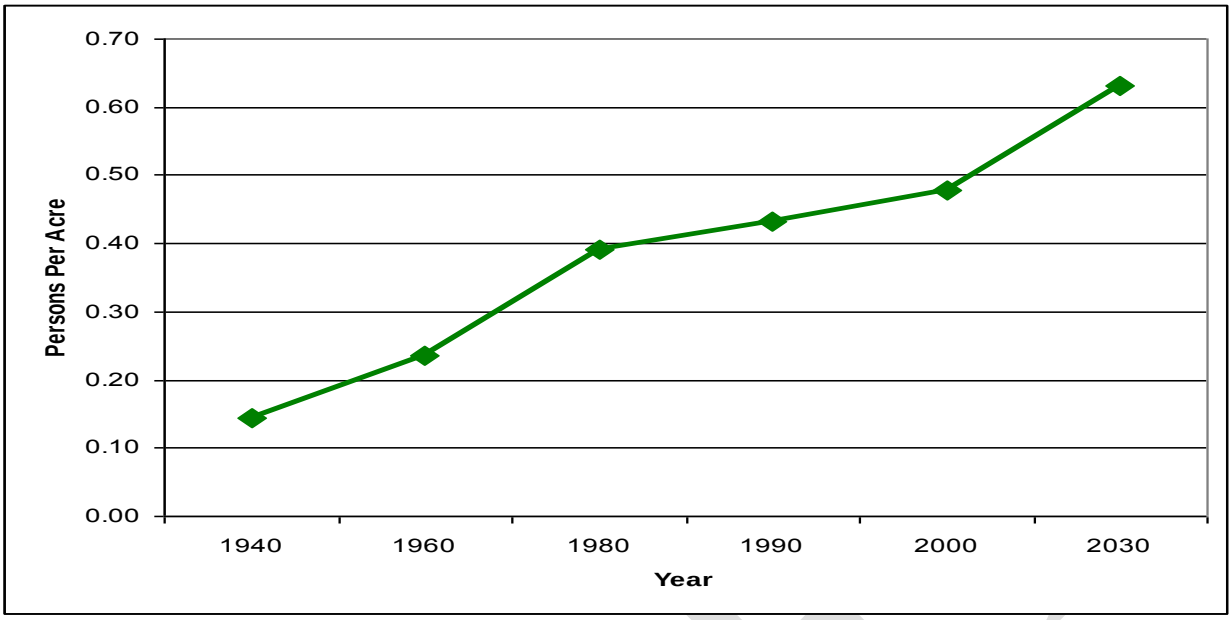


Figure 3b Monroe County Population Density Trend

Different land use types result in different hydrological and ecological implications for karst environments. To assess this impact, existing (2010) land uses were identified based on field reviews and updates of a GIS land use layer provided by the Monroe County Planning Department received to date (2006 data and 2012 updates[3]). According to a GIS analysis of this layer, 55% of existing land use within the relevant karst areas was classified as developed (e.g., residential, non-residential/industrial, public use/institutional, transportation/communication/utilities, and/or mines/quarries), 36% was upland/wetland habitat, 9.5% was agricultural, and 0.5% was water.

Additional development is likely to occur within the Bloomington region by 2035. Over time, this development would result in the conversion of undeveloped land uses such as agricultural and upland/wetland habitat to developed land uses. For the purposes of this analysis, only those specific areas of development identified by the local planning staffs (City of Bloomington and Monroe County) are being considered. The Project Team created a GIS layer based on the sites identified by the local planning staff. These sites are primarily based upon tax increment financing (TIF) districts, and additional information for developments with preliminary or approved site plans, and consistency with the local comprehensive plan. Based on this GIS analysis, an additional 20% of the relevant karst area, is planned for development by 2035.

Historically, much of the development in Section 5 has been linked to the presence of karst, including: limestone quarries, cutting mills, abandoned quarries, use of sinkholes as drainage, historical landfills/dumps in sinkholes and quarries, springs used as water supply for both human and livestock consumption, and disposal of lawn cuttings or trash in sinkholes. Incidental relationships with the relevant karst areas include hazardous waste spills, over-fertilization,

[3] Updates to the 2006 Karst Report include data from the Tier 2 Section 5 DEIS updates (such as land cover, land use, population growth, planned development, setting, bedrock, Monroe County 2010 aerial photography and 2-foot contours) (see page 1).

herbicide releases, sewage leaks from both septic and sanitary sewers, disruption of natural flow by ongoing development, and pavement runoff. Table 1 describes specific implications of different land use types to karst areas. The table was derived from a variety of sources, including: "Living with Karst, a Fragile Foundation" (Veni et al. 2001).

Table 1 Karst Effects by Land Use

Land Use	Impervious Surface	Potential Runoff Contaminants	Other concerns or benefits
Agricultural	Low	Sediment, animal waste, fertilizers, pesticides	The lack of consistent vegetation/ground cover, presence of animal waste, and use of fertilizers and pesticides have a greater potential to increase the sediment load, pH, and biological oxygen demand (BOD) than other land use through both chronic releases and acute episodes .
Nonresidential/ Industrial	High	Salt, petroleum based contaminants and some heavy metals	Nonresidential/industrial land uses pose elevated risks due to the potential for releases of materials used or stored on site including a wide range of chemicals, raw materials, byproducts, and wastes.
Public Use and Institutional	Varies	Salt, petroleum based contaminants and some heavy metals.	NA
Mines and Quarries	Varies	Suspended solids and petroleum based products	Elevated sediment load, pH and temperature impacts and potential direct impact to the karst formations and groundwater flow patterns.
Residential	Low Moderate	Pesticides and fertilizers	While residential uses have lower runoff/impervious surface than other developed uses, sewage/septic system and water service leaks are endemic to human occupation in a karst area, and such conditions were observed during the field studies.
Water	Low	NA	Lakes and ponds may provide natural attenuation of runoff contaminants, storm water storage, and trapping of suspended matter. Streams, lakes, and ponds may act as suspended load catchments and contaminant sinks.
Transportation, Communication and Utilities	Varies	Heavy metals, petroleum products, PCBs, chemicals, and wood preservatives	Transportation and communication land uses are characterized by high levels of impervious surface coverage; however, impacts related to these land uses are less frequent and more diffuse than those related to other developed land uses.
Upland and Wetland Habitat	Low	NA	Forest, shrub, and herbaceous cover serve to attenuate storm events and trap sediment and other particulate matter. Wetlands provide natural attenuation of runoff contaminants, storm water storage, and trapping of suspended matter.

1.4 Physiographic Setting

The physiographic setting consists of the geographic area with similar geologic structure, climate and geomorphology, and is usually part of a larger region of similar characteristics. Section 5 is

DRAFT

located in the Southern Hills and Lowlands Physiographic Region, a portion of Indiana that was not glaciated during the Wisconsin Glacial Episode and is characterized by hills and valleys in bedrock formations. Although a significant portion of the study area was glaciated during the Pre-Wisconsin glacial events, the area was not significantly altered. The Section 5 study area crosses three of the 10 Southern Hills and Lowlands Physiographic Region divisions. These include from south to north: the Mitchell Plateau, the Norman Upland, and the non-karst terrain Martinsville Hills (Gray, 2000; 2001).

- The Mitchell Plateau extends from south of Section 5 to the Beanblossom Creek valley. It is comprised of a limestone plateau dissected by many deeply entrenched major stream systems, and exhibits extensive karst features.

- The Norman Upland begins at the Beanblossom Creek valley and continues north to about the Morgan/Monroe County line. It is characterized by high relief and generally rugged topography with relatively flat uplands (such as the Simpson Chapel Karst area) among a maze of dendritic ridges.

- The Martinsville Hills start at about the Morgan/Monroe County line and extend northward through Section 5 to Martinsville. They are distinguished from the other divisions due to modification by pre-Wisconsin glaciations and the presence of a relatively thin layer of pre-Wisconsin glacial drift.

1.5 Geologic Setting

The bedrock in Section 5 is typically fairly shallow with thin overlying soils, except in some of the larger stream valleys (Thomas et al., 1981). Structurally, the study area is within the Illinois Basin, with the bedrock dipping to the southwest and west (at approximately 30 feet per mile) with younger formations to the south and west and older bedrock formations located to the north and east (Melhorn, 1959; Rupp, 1991). The divisions occur as follows:

Table 2 Bedrock and Karst Area Groupings

Bedrock Group	Geologic Formations	Outcrop Area
Blue River Group	Paoli	South and west of Section 5
	Ste Genevieve	
	St. Louis	Bloomington Karst
Sanders Group	Salem	
	Harrodsburg	Bloomington North and Simpson Chapel Karst
	Ramp Creek	
Borden Group	Edwardsville	North of Simpson Chapel Karst to north of Section 5
	Spickert Knob Formation (or Carwood and Locust Point)	
	New Providence Shale	

The karst in Section 5 is formed on and in Mississippian age limestones, which are shown on Figure 2. The eastern and western edges are not necessarily the limits of karst development, but are often simply the limits of the existing karst studies (Shaver 1986).

DRAFT

1.5.1 Bloomington Karst

The Bloomington Karst area consists of St. Louis Limestone as the dominant karst-forming limestone, with some karst development in the underlying Salem Limestone. Formations below the Salem Limestone are not relevant to this investigation, since they are well below the water table and are not part of the karst groundwater system(s) associated with caves and springs of the study area.

The St. Louis Limestone, at the base of the Blue River Group, can be subdivided into upper and lower formations. The upper portion consists of largely thin beds of medium to dark gray-brown micritic, pellatal, and skeletal limestone with very thin beds of gray shale. The lower portion is predominantly composed of pellet-micritic limestone, calcareous shale, and silty dolomite. The thickness of the St. Louis Limestone is approximately 250 feet (Rupp, 1991; Gates, 1962).

Under the St. Louis Limestone and at the top of the Sanders Group, is the Salem Limestone, a medium to coarse grained crossbedded calcarenite that occurs in exceptionally thick beds and is used as building stone (dimension stone). The Sanders Group is predominantly composed of carbonate rocks with an occasional shale and siltstone layer typically ranging from 50 to 85 feet in thickness (Gates, 1962).

1.5.2 Bloomington North and Simpson Chapel Karst

The Bloomington North and Simpson Chapel Karst consist of the Ramp Creek and Harrodsburg Limestones with the divide between these members occurring roughly at Arlington Road. The rock immediately below the Ramp Creek Limestone is insoluble shale (Edwardsville) that provides a barrier to the downward formation of karst. Much of the Harrodsburg Limestone and all of the formations above it have been removed by erosion (Rupp, 1991).

The Ramp Creek Formation is at the base of the Sanders Group. It predominantly consists of a carbonate unit formed from interbedded very fine grained dolomite and limestone with small amounts of siltstone and shale. In addition, chert and geodes are common, especially in the dolomite. The Ramp Creek formation is fairly uniform and generally ranges from 20 to 25 feet in thickness. Above the Ramp Creek is the Harrodsburg Limestone, a dominantly well-cemented and, at times, bioclastic limestone that includes some dolomite, shale, very argillaceous limestone, and minor amounts of chert (Gates, 1962). The top of the Group (Salem Limestone) has been eroded in this area and is no longer present (Thompson 2007, Hasenmueller 2008).

Underlying and to the north of the Bloomington North and Simpson Chapel Karst is the Borden Group, comprised of gray argillaceous siltstone and shale commonly with fine-grained sandstone and the occasional limestone formation. The New Providence Shale is dominantly a greenish gray, blue gray or dark lead gray shale bordering on claystone, with minor amounts of sandstone, ironstone, limestone, and silty dolomite. The Borden Group is approximately 600 to 800 feet thick (Rupp, 1991).

DRAFT

Overlying the karst-forming rocks is a wind-deposited silt called loess. The loess was deposited during the Pleistocene Age (Gates, 1962) and is highly erodible and prone to the formation of soil pipes.

1.5.3 Mining/Quarry Operations

Mining in the study area is largely limited to limestone and includes dimension stone, high calcium-rich limestone, crushed stone for construction, agricultural lime and livestock feed. With the famous Salem Limestone at or near the surface, Monroe County has become well known for dimension stone. In addition to being used for building material, dimension stone has a high calcareous content and its waste limestone may be used for chemical limestone. From the Blue River group, primarily Paoli and Salem Limestone have been quarried for crushed stone or gravel. In addition to dimension stone, high calcium limestone including the Harrodsburg, Salem, Paoli and Ste. Genevieve have been quarried for use primarily as flux in steel production, agricultural lime and glass manufacturing (Gates, 1962). See Figure 4a for Limestone Reserves.

Other mineral sources include shale, quartz sand, clay, sandstone, gypsum, anhydrite and gas producing/storage domes along the Leesville Anticline. The most northern of these is the Hindustan Dome, which is located in the study area and used for storage of natural gas. Although minor oil and coal fields are present in Monroe County, they are of limited economic importance and do not exist in the study area (Droste Bulletin 63). See Figure 4b for Section 5 abandoned quarries, sand/gravel deposits, natural gas wells and the storage dome.

1.5.4 Hydrogeologic Setting

Groundwater supplies are limited in the karst portion of Section 5 with the majority of the local water supply coming from man-made surface water reservoirs (such as Lake Monroe Reservoir). Public water services that utilize these sources in Section 5 karst areas include:

- The City of Bloomington Utilities Department,
- Town of Ellettsville Utilities,
- Van Buren Water Inc.,
- Southern Monroe Water Company,
- Washington Township Water Corporation

Water wells installed in unconsolidated materials are typically limited to the larger valley fill and terrace areas. Bedrock wells are installed in the Salem, Harrodsburg, St. Louis and Ste. Genevieve limestone formations, primarily along joints, fractures and bedding planes (Gates, 1962). Well production is typically low, ranging from less than 10 gallons per hour (gph) to 10 gallons per minute (gpm) and small areas of greater than 10 gpm (Harke and Gray, 1998). See Figure 4a for IDNR water well locations included in **Appendix M**.

Karst groundwater movement within the limestones includes both slow-flow and fast-flow regimes. Slow flow groundwater velocities are typically on the order of 0.00001 cm/s and have uniform flow directions known as laminar flow (Freeze and Cherry, 1979). Fast flow velocities,

DRAFT

typically greater than 1,000 meters per day, are in the turbulent flow regime, and have a greater potential to transport material into and through the karst groundwater system.

The main hydrogeologic unit in the Bloomington Karst is the St. Louis Limestone. The underlying Salem Limestone appears to support its own hydrogeologic unit. The springs draining the St. Louis Limestone are at or very near the contact with the underlying Salem Limestone, indicating that there is a hydrogeologic boundary near the contact. An exception to this association between Bloomington Karst springs and the Salem Limestone contact is Spring, which discharges from the Salem Limestone and is a relatively large spring (for this study area).

In both the Bloomington North and Simpson Chapel Karst, the Ramp Creek and Harrodsburg Limestones act as a single hydrogeologic formation. The springs draining these formations are usually above a thick, fossiliferous limestone bed that is underlain by non-karst forming Edwardsville Shale. The basal limestone bed also seems to act as an aquitard in addition to the underlying shale aquitard.

DRAFT

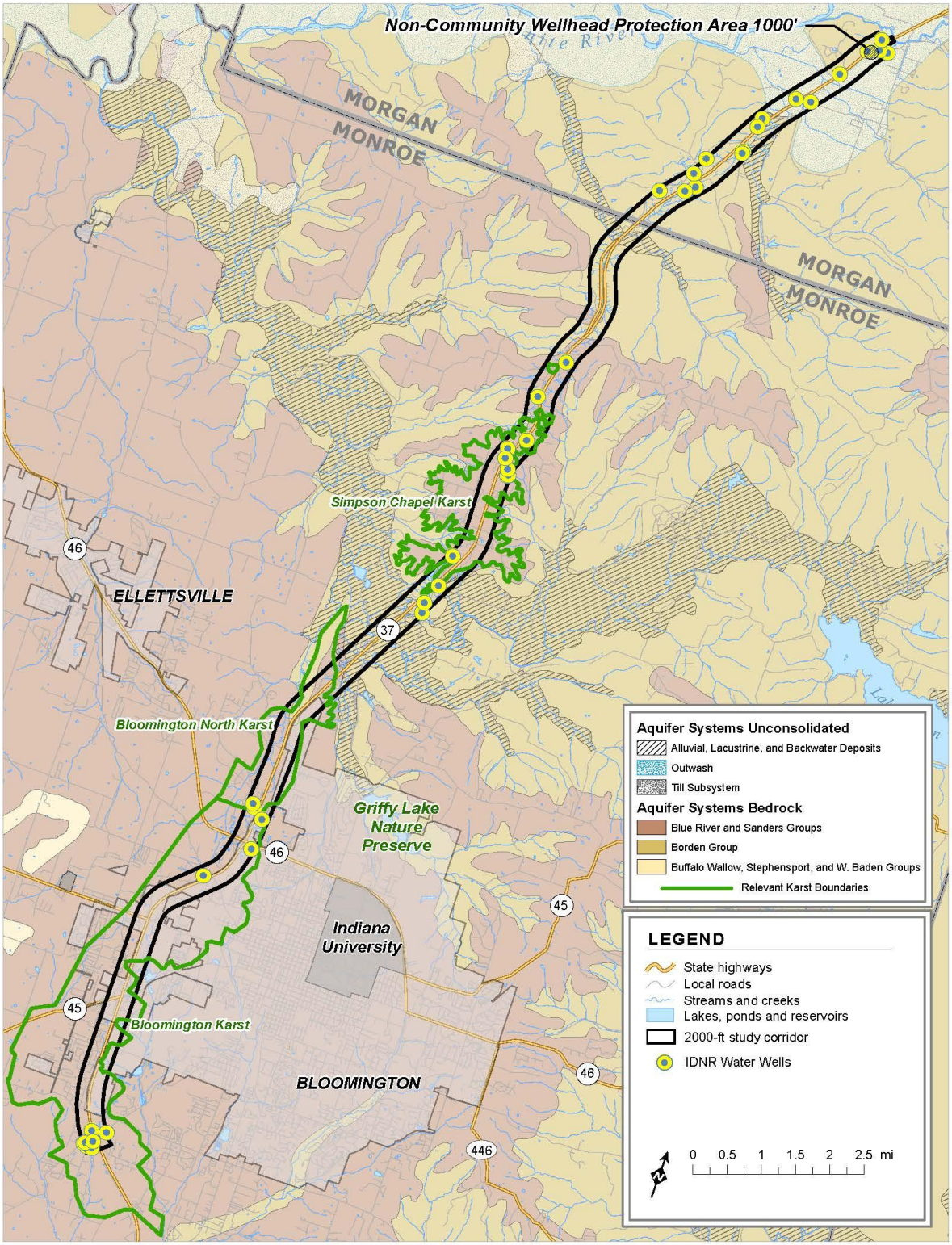


Figure 4a **Section 5 Mineral Resources – Limestone Reserves and IDNR Water Wells**

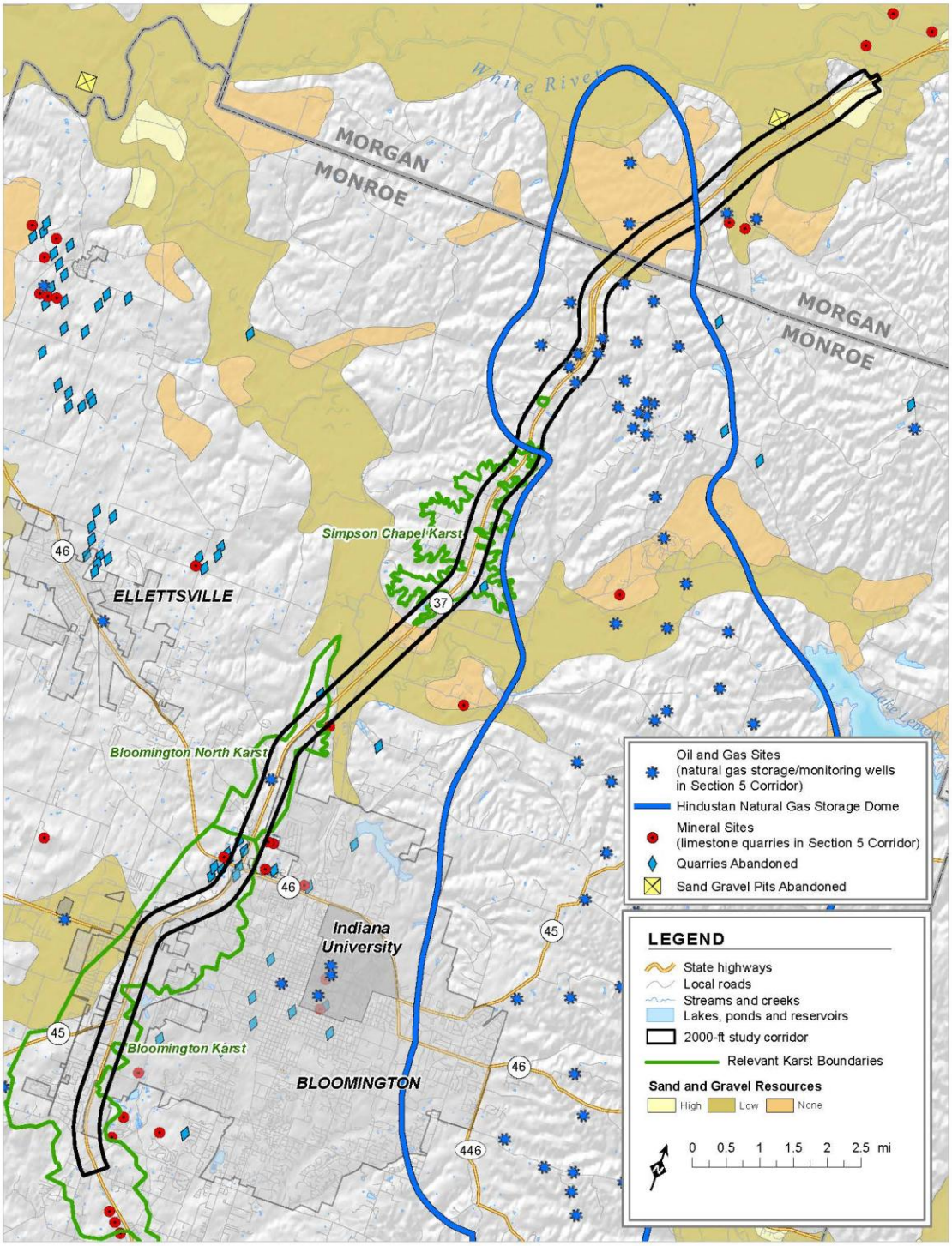


Figure 4b **Section 5 Mineral Resources – Abandoned Quarries, Sand/Gravel Deposits, Natural Gas Wells and Storage Dome**

2.0 METHODOLOGY

The karst study was conducted to support the Tier 2 EIS and address Items 1 through 4 of the 1993 MOU for the I-69 Section 5 Corridor and Relevant Karst.

2.1 Public and Private Research Sources

Documents regarding previous karst investigation in and around Bloomington were gathered, including: general mapping of spring and cave locations and karst areas from the Indiana Geological Survey (IGS); development or hazardous waste mitigation documents conducted by various consultants; and academic research studies and identification of significant numbers of karst features by cavers, as recorded by the nongovernmental Indiana Cave Survey (ICS).

Interviews were conducted with knowledgeable local karst professionals, including Dr. Noel Krothe (principal with Hydrogeology, Inc.), Sam Frushour (IGS at the time and data custodian for the ICS), John Bassett (Earth Tech), Mike McCann (Viacomm), and several cavers and agency employees.

INDOT supplied GIS data, INDOT personal communications, related reports (Earth Tech 1996, 2002), and "as-built" files and City of Bloomington drainage infrastructure files along existing SR 37 were reviewed and incorporated into the data set and utilized during the karst evaluations.

Indiana University, IGS, and Bloomington repositories/libraries were researched for relevant local literature, master and doctorial theses, USEPA documents, and karst feature studies. The ICS database showing relevant cave entrances, City of Bloomington two-foot contour and 2010 Monroe County two-foot contours derived from light detection and ranging (LiDAR) data, and storm water management mapping, six-inch resolution aerial photography, 1939 and 1980 stereo pair aerial photographs from the USDA, and previous INDOT studies were obtained and incorporated as part of the data set.

2.2 Karst Feature Field Check Methodology

Karst features include sinkholes, springs, karst flowpaths, caves, and other landforms (e.g., losing streams and sinking streams) (see Glossary of Key Terms). In accordance with the 1993 MOU, the location, type, area, and significant characteristics of karst features were researched, field checked, documented and imported into a geographic information system (GIS) for evaluation relative to SR 37 and Section 5.

The field checks included walking the Corridor and adjacent areas of interest for karst features not noted in the pre-screening information sources. Field checks were conducted by teams of 1 to 3 professional geologists utilizing global positioning systems (GPS) capable of sub-meter accuracy and performed during periods when the vegetation was reduced (late fall, winter, and early spring). Features and springs that were encountered at any time during the field work were documented and mapped regardless of the time of year. In areas where a feature was not

DRAFT

accessible to GPS (due to landowner objection, locked facilities, buried or too expansive features, etc.), the location was determined via the best available data source (e.g., 6-inch resolution aerial photographs).

The results were imported into GIS, displayed on project mapping/aerial photographs and checked by the field personnel in comparison to one or more of the following: 6-inch resolution aerial photographs, USGS quadrangle mapping, and two-foot contour mapping. The areas that were field checked were also tracked/planned utilizing the GIS database. Insurgence boundaries were adjusted to encompass the drainage area, based upon contour mapping (two-foot interval) and best professional judgment, for use in alternative evaluations, annual pollutant loading calculations, avoidance, alternative drainage, and treatment/mitigation planning.

2.2.1 Sinkholes

Potential sinkhole and other insurgence feature locations were determined based on the following screening methods (from sources gathered throughout the duration of the study):

- IGS state and county geologic and karst feature maps were reviewed for areas and bedrock units prone to formation of karst.
- Current USGS topographic maps were examined for sinkholes and other insurgence features.
- Historic USGS topographic maps were examined for insurgence features that might not be represented on current USGS topographic maps or may have been obscured or buried by development in the study area.
- Two-foot contour interval topographic mapping along the Section 5 Corridor was compared to the USGS mapping to look for features that were not apparent on the larger contour intervals.
- Stereo photography from flight lines flown in 1980 and 1939 were examined to locate insurgence features as a check on the USGS topographic mapping and as an additional source of data on historically modified or filled sinkholes.
- Six-inch resolution aerial photography of the Section 5 Corridor was examined for indications of potential insurgence features.
- Information provided by local karst professionals and volunteered by local residents was compiled and included in field checks.
- Review of I-69 Tier 1 comments.

Potential sinkholes were field checked to verify the accuracy of reported locations and interpretations. The field checks also included walking the Corridor and adjacent areas of interest for karst features not noted in the above information sources. Field checks consisted of the following steps:

DRAFT

1. The locations, types of feature, photographs (of select features or areas), estimates of flow (if present) and other significant characteristics were inventoried.

2. Locations were determined via a Trimble® global positioning system (GPS), capable of sub-meter accuracy. In areas where a feature was not accessible via the GPS (due to landowner objection, locked facilities, buried or too expansive features, etc.), the location was determined via the best available data source (e.g., 6-inch resolution aerial photographs).

3. Field checked data was imported into GIS and displayed on project mapping and aerial photographs. Quality control consisted of review by the field personnel and comparison to one or more of the following: 6-inch resolution aerial photographs, USGS quadrangle mapping, and two-foot contour mapping.

4. Insurgence boundaries were adjusted to encompass the drainage area, based upon two-foot contour mapping and best professional judgment, for use in alternative evaluations, annual pollutant loading calculations, avoidance, alternative drainage, and treatment/mitigation planning.

Multiple field checks were conducted during periods when the vegetation was reduced (late fall, winter, and early spring). Large features and springs that were encountered at any time during the field work were documented and mapped regardless of the time of year. The relevant karst areas may include small/buried sinkholes that did not have surface expression at the time of the field checks due to the dynamic nature of these systems, especially as related to development, tree clearing, and earthmoving in the Bloomington area that may cover, alter or expose features, as compared to the conditions at the time of the field checks. In addition, some very small features may have been obstructed by vegetation even during leaf off conditions of reduced vegetation. This does not mean that karst features or potential karst areas were omitted or not identified but rather that a small feature may have been included in larger features/areas or groups of features or via identification based on additional sources such as historical stereo paired aerials photographs, 2-foot topographic mapping, previous karst mapping, or interpretation by the karst professional.

Future investigations may reveal somewhat different sinkhole distribution than documented at the time of this study. Determinations of areas in which sinkholes are present versus areas with no sinkholes were used to differentiate hydrology and evaluate potential engineering hazards. A bias was placed upon the presence of karst, rather than its absence.

2.2.2 Springs

Springs (or resurgence features) are often the first point accessible to groundwater flow in karst terrain and are natural sampling points for tracer dyes and groundwater quality assessments. Spring locations were determined from the following sources:

- Review of the I-69 Tier 1 database.

- IGS database research.

DRAFT

- Literature search.
- Interviews of local karst professionals.
- Review of I-69 Tier 1 comments.

Potential springs were field checked to verify the accuracy of reported locations and interpretations. The field checks included walking local creeks and geologic formation contacts for springs not noted in the above information sources. Field checks were conducted in a similar manner as sinkholes (Section 2.2.1) with the addition of the following:

1. Features were assigned names and serial numbers, and labeled flagging was placed to ensure accurate sample collection.
2. Sampling stations were established, carbon packet anchors were secured, and photographs were taken of the station areas (for springs determined to be relevant to the study).
3. Discharge rates were estimated: the volume of water discharged is roughly proportionate to the area recharging a given spring, assuming that the geologic setting and climatic conditions are comparable.

2.2.3 Karst Flowpaths

Karst flowpaths (or conduits) are the links between insurgence features (i.e., sinkholes and losing/sinking streams) and resurgence features (springs). Karst flowpaths are difficult to locate unless the passage is large enough to be considered a cave (defined as large enough for human traverse) and has an entrance. Karst flowpath locations for this study were approximated by connecting each dye introduction point with each spring at which the associated dye was detected.

2.2.4 Caves

Potential cave and cave entrances were determined based on the following sources:

- ICS and IGS databases.
- Cave entrance research and field survey was conducted concurrently by Indiana Geological Survey personnel for cave accessibility and potential bat habitat research.
- Interviews with local cavers and knowledgeable individuals.
- Review of I-69 Tier 1 comments.

Potential caves and cave entrances were field checked to verify the accuracy of reported locations and interpretations. The field checks included walking the Corridor and adjacent areas

DRAFT

of interest for caves not noted in the above information sources. Field checks consisted of the following steps:

1. The locations, types of features, photographs (of select features or areas), estimates of water flow (if present) and other significant characteristics were inventoried.

2. Cave entrance locations were determined via a Trimble® GPS, capable of sub-meter accuracy. In instances where an entrance was no longer open and therefore could not be field checked and a GPS location obtained, the location was determined via the best available data source (for example, ICS records).

3. Research and field check data were imported into the CONFIDENTIAL GIS layer for use in alternative evaluations, annual pollutant loading calculations, avoidance, alternative drainage, and treatment/mitigation planning.

Cave entrances were field checked and included as part of the sinkhole and spring field checks, since cave entrances are typically located in sinkholes or at springs. IGS reported several historic cave entrances that had been filled or buried.

2.2.5 Others

The majority of karst features to fall into the "Others" category in this study are losing and sinking streams. Losing streams are streams where a portion of the flow enters the subsurface drainage system, and under low flow conditions may disappear from the surface. Sinking streams are those streams that flow directly into a swallet (or sink point). Losing streams, as well as some sinking streams, often have the same general geomorphology as streams that are not in karst, which can make them difficult to identify during field checks. Sinking or losing streams are important to the karst studies since they can transport significant amounts of water and other material directly into the karst groundwater system.

Because of their lack of distinctive geomorphology, seasonally sinking or losing streams seldom appear as such on topographic maps or aerial photography. Sinking streams were identified in this study by multiple observations of streams and dry channels downstream of flowing water during various flow events (high, base, and low). While potential losing streams also were identified by these limited field checks, confirmation was made via evaluation of dye trace results. Dye introduced into streams at the surface, but detected at springs, demonstrated that some or all of the water from the surface stream was "lost" into the karst groundwater system. The difference between a sinking stream and a losing stream is often solely dependent on the volume of water flowing at the time of observation. That is, a stream that loses some of its flow at high stream stages may lose all of its flow at low stream stages.

Another karst feature of importance that falls into the "Others" category is a karst window. Karst windows are unroofed sections of caves that give access to karst flowpaths. These features are important as potential biological sampling sites and as potential dye introduction points. Karst windows tend to have perennial flow and similar habitat to caves. Karst windows were identified during the field check of sinkholes and springs discussed previously and were included in the CONFIDENTIAL GIS layers.

DRAFT

2.3 Dye Trace Methodology

The dye traces focused on fast-flow pathways in karst-forming rocks relevant to the Corridor and were conducted as follows:

- Results of the karst feature field checks, research, and field checks of accessible sites where karst groundwater systems return to the surface (e.g., springs or streams feed by springs) were used to develop a dye trace program.
- The program was developed to provide coverage of the relevant karst portions of Section 5, with incorporation of previous dye trace data from local sources.
- A network of sampling stations was established to provide coverage of potential dye detection and background sites.
- Background sampling and analysis were conducted to evaluate the potential for interference from fluorescent compounds if present within the study area.
- Potential dye introduction locations were identified where waters sink from the surface into the groundwater system (e.g., sinkholes or sinking streams).
- Appropriate tracer dyes selected from four different dyes were used in the Section 5 studies: fluorescein, eosine, rhodamine WT, and sulforhodamine B. All of these dyes are environmentally safe (Smart 1984; Field et. al., 1995). These dyes pose no risk to humans or to aquatic life in the concentrations used in professionally directed groundwater tracing work, and are appropriate to the work that was conducted (Aley 2002). More detailed discussion of the performance characteristics and properties of the four dyes used in this study are included in **Appendix C**.
- Dye was introduced at selected karst or drainage features.
- Samples were collected at potentially relevant sampling stations and submitted for analysis, data management, quality assurance, and evaluation at OUL (see Section 2.4).

2.3.1 Dye Trace Program

The dye trace program (2006 data and 2012 updates[4]) was designed to account for potential interference fluorescence from sources not associated with the Section 5 studies related to facilities in the study area, including:

- Significant paved surfaces (SR 37, street crossings, roads, parking areas),
- Developed/urban environment with commercial/industrial facilities.

[4] Updates to the 2006 Karst Report included additional field reconnaissance and dye tracing for and Cave recharge area(s) in the vicinity of the Section 5 corridor, based on agreement between INDOT, FHWA, and USEPA (see page 1).

- Two former landfills (Superfund sites).

Groundwater tracing in developed areas, such as Section 5, routinely encounters waters characterized by fluorescence interference peaks/dyes due to man-made compounds. These fluorescent compounds may include tracer dyes or other compounds that could be mistaken for some of the dyes. For example:

- Fluorescein dye is a common coloring agent in most automotive coolants. Vehicles that leak coolants onto paved surfaces can introduce sufficient fluorescein into runoff waters that concentrations of the dye can be detected at sampling stations.

- Rhodamine-based dyes are common coloring agents in hydraulic fluids and some coolants; leaks and spills of these fluids may result in fluorescence peaks at sampling stations. In these cases, the fluorescence peaks are commonly in or near the acceptable wavelength ranges of rhodamine WT and sulforhodamine B used in dye traces.

Due to the urbanized/industrial nature of significant portions of the Section 5 study area and the two former Superfund sites, numerous dye trace studies have been conducted or are ongoing within the study area. These have the potential to cause interference based on fluorescent compounds that were not introduced as part of the Section 5 dye-tracing program. These interference peaks are most commonly detected in carbon samplers, which accumulate (and thus concentrate) the fluorescent compounds and are continuously sampling the passing water such that they do not miss short duration pulses of fluorescent compounds.

Separating fluorescence peaks from appropriate Section 5 dyes from interference peaks/dyes was accomplished using a combination of the following four protocols:

- The fluorescence background at key individual sampling stations was routinely characterized prior to introducing dyes. Fluorescence peaks that were in or near the acceptable wavelength range for each of the tracer dyes were quantified as though they were the particular dye (**Appendix C**). Most of these fluorescence peaks were footnoted because they did not meet all of the criteria for positive dye detections (**Appendix C**). The data resulting from the background sampling permitted selection of a dye for a particular trace that was likely to experience minimal fluorescence interference at the detection sites.

- Sufficient dye was used for each trace to ensure clear results in activated carbon samplers, but not enough to expect visibly colored water. The use of excessive amounts of dye was avoided because it lengthens the period during which the dye is detectable at sampling stations, which in turn lengthens the period until another trace with the same dye can be used in that area. In many cases, the amount of dye used was sufficient to produce detectable fluorescence peaks in at least a few associated water samples.

- Activated carbon sampling was used to continuously sample water prior to introduction and post introduction of Section 5 dye to ensure that pulses of Sections 5 dyes were not

DRAFT

missed and that background fluorescence at the sampling stations were adequately characterized (**Appendix C**).

- Control stations and confirmation stations were established in a number of stream sampling stations. A control station would be located at a point where it would be likely to detect fluorescent compounds moving into the study area from outside sources. For example, Station 44 (Clear Creek at First Street) revealed dye being used by maintenance personnel at Indiana University as part of their sewer line repairs. Confirmation stations were located downstream of springs where the discharge of dye was likely. These stations served to detect any dye that might discharge from a spring that had not been discovered, and to confirm the passage of dye derived from an upstream location.

2.3.1.1 Quality Assurance/Quality Control

OUL's "Procedures and Criteria" document (**Appendix C**) contains a number of quality control and quality assurance (QA/QC) methods used during the Section 5 studies. QA/QC samples were collected throughout the dye trace program and were indicated by a letter designation following the sample number according to the following method (**Appendix B**):

- "D" indicated a duplicate sample analysis. With activated carbon samplers, duplicate samples were from the second of two activated carbon samplers placed at the sampling station for the same sampling interval.

- "R" indicated a replicate sample analysis. Replicate sample analyses were either a second analysis of the charcoal sampler elutant, or, in the case of water samples, an analysis of a second aliquot of water from the sample vial collected at the station. As a QA/QC step, the laboratory routinely analyzed a duplicate charcoal sampler or a replicate water sample for every sample where the last two digits of the sample number ended with 00, 20, 40, 60, or 80; this represented about 5% of the collected samples.

- "V" indicated a verification sample analysis. These were essentially identical to duplicate samples except that the sample number did not end with the digits 00, 20, 40, 60, or 80. Verification samples were typically analyzed if one of the tracer dyes appeared to be in the sample and the person conducting the analysis work determined that a verification sample was required.

Upon completion of fieldwork and laboratory analysis, all analytical graphs and custody records were individually examined to ensure that all data were complete and correct and that all footnotes and information associated with background fluorescence were correct and consistent. In general, a dye detection was not attributed to a particular trace unless the concentration was at least 10 times greater than the maximum concentration of fluorescent compounds in any background sample from the station. Finally, dye detections at a particular sampling station were not identified as positive traces unless the detection was reasonable in view of all other available data including the proximity of the detection station to other detection stations and the dye introduction location.

DRAFT

2.3.2 Sampling Stations

A comprehensive network of sampling stations was established to:

- Determine individual and regional background fluorescence values (interference peaks).
- Detect dye from Section 5 dye traces.
- Detect dye from traces from other investigations that might interfere with Section 5 investigations.
- Detect dye if any were introduced by outside parties to intentionally cause confusion.

Sampling stations were established by OUL and Baker staff to provide groundwater flowpath data relevant to the investigation. Relevant springs were sampled along with some additional springs that were included to demonstrate a lack of potential impact from the SR 37 and Section 5. Some sampling stations were established as control stations to identify the input of fluorescent compounds into the study area that were not derived from dye introductions made by OUL. Surface sampling stations were established in local streams to identify potential groundwater discharges from unknown springs.

Sampling stations were established by:

1. Assigning a serial number.
2. Collecting a grab sample of water.
3. Placing two, independently anchored, activated carbon packets in the spring or stream channel (often obscured to prevent disturbance by curious observers).
4. Estimating flow and describing flow conditions (for springs).
5. Hanging flagging ribbon nearby with the station name and number,
6. Writing a description of the sampling location.
7. Photographing the sampling station.
8. Collecting a Trimble® GPS location that later was downloaded into GIS.

A total of 205 sampling stations were established for this investigation. **Appendix E** includes photographs of each of the sampling stations. The sampling stations were located in the Clear Creek, Bloomington, and Modesto 7.5-minute USGS quadrangles. The locations of the sampling stations are shown on Figures 11 and 12. An index to dye sampling locations is presented in **Appendix D** Table D-1 Sampling Station Index.

DRAFT

2.3.3 Dye Introductions

The main dye tracing program was designed to provide a dye trace for approximately every 2.5 miles of Corridor that passed through karst. The supplemental dye tracing program was designed to delineate the Cave recharge area and to determine if it were likely that Cave had hydrological connections with the Cave groundwater system. Selection of dye introduction points was based on:

- Coverage of the relevant karst area.
- Projected ability to identify potential groundwater systems that could be impacted by highway construction and use.
- Proximity to areas of special concern (e.g., Superfund sites).
- Potential to determine whether specific features were karst features.
- Practicality of placement.
- Preference for larger catchment areas (the larger the area, the more area is characterized).

All of the dye introduction points were thought to be potential insurgence features: however, some features were better able to move water and dye into the groundwater system than others. Where it was impractical to wait for natural flow, potable water was used to introduce dye into the groundwater system. Potable water was obtained from nearby fire hydrants or was hauled to the dye introduction point by truck.

Insurgence features with larger catchment areas were preferred since they represent a larger portion of the landscape and have more frequent episodes of runoff entering the groundwater systems. Thus, larger insurgence features are generally more representative of groundwater flow patterns and are easier to utilize.

Dye types and quantities were selected based on relevant background analysis and in coordination with ongoing and planned dye traces to prevent ambiguous results. The dye quantities used were influenced by previous dye tracing in the area, professional experience in other karst areas, and with the intention of minimizing the quantity of dye used while still producing credible data. Smaller quantities of dye were less likely to be noticeable to the public and were more likely to quickly reduce to ambient background levels. Since primary reliance was placed on activated carbon samplers (which are cumulative samplers), the sampling methodology permitted the use of smaller quantities of dye than if the sampling primary relied on water samples.

Dye traces were coordinated with and notification given as necessary to IDEM, the Monroe County Health Department, and Viacom, Inc.(Viacom has been actively conducting dye traces in the area as part of on-going studies of the Lemon Lane Superfund site).

DRAFT

The dye traces were numbered sequentially with the first two digits indicating the year and the last pair of digits indicating the serial number of the trace. For example, Trace 04-05 was initiated in 2004 and was the fifth trace initiated in the study.

A total of 41 dye introductions that demonstrated 59 groundwater flowpaths were included in the Section 5 studies (see **Appendix F**). Twenty relevant dye traces from previous studies and other sources are included in this investigation.

2.4 Tracer Dyes Sampling and Analysis Methodologies

Sampling for tracer dyes was based primarily on activated carbon samplers with additional data from selected analysis of water grab samples. All analysis was conducted using a Shimadzu RF5301 spectrofluorophotometer operated under a synchronous scan protocol. Details of the analytical approach are presented in OUL's procedures and criteria document (**Appendix C**). The following sections discuss the details of how each type of sample was collected and handled.

2.4.1 Activated Carbon Samples

All four of the dyes used in this investigation (fluorescein, eosine, rhodamine WT, and sulforhodamine B) can be adsorbed onto laboratory grade coconut shell charcoal samplers. The samplers were placed in the water to be sampled and were left for periods which ranged from a few days to two weeks or more based upon project needs in the professional judgment of the onsite geologist.

Activated carbon samplers (samplers or packets) were used as the primary sampling matrix because they sample continuously and accumulate dyes. Two samplers were placed at each sampling station, except for one location that was sampled from a private well. The use of two samplers allowed for analysis of duplicate samples, and provided a redundant sample in case a sampler was lost or damaged.

In the event that one sampler was deemed to be less representative than the other, the preferred sampler was folded and placed in the Whirl-Pak® bag. A note was put on the Sample Collection Data Sheet to indicate that the folded packet was to be analyzed. If both samplers were absent or out of the water, then the grab sample of water was the only sample available for that sampling period at that station.

Sample stations were established in flowing water at springs and surface streams and anchored with wire or rope to sticks, rocks, roots, etc. as appropriate. Only materials free from dye were used, and the anchors were set to maintain contact between the samplers and the water being tested. Samplers were concealed to minimize disturbances from passersby.

Upon collection, activated carbon samplers were placed in a new Whirl-Pak® bag labeled with the station name, number, date and time of collection. Samples collected in the field were placed in a cooler with blue ice and maintained under refrigeration until shipment to OUL for analysis. Throughout the sampling collection, handling and shipping, the samples were accompanied with a chain-of-custody type form called "Sample Collection Data Sheet for Fluorescence Analysis." The samples were maintained in the custody of the sampler until shipment to the laboratory. The

DRAFT

sample station name, number, time of sample placement, time of collection, collector, and sampling comments were documented on the form. Sampler placement and collection was conducted by both OUL and Baker Professional Geologists following training of Baker staff by OUL personnel.

Upon receipt of sampler coolers at the OUL laboratory, samples were immediately refrigerated at 4° C, pending analysis. Prior to analysis, the sample shipment was compared to the Sample Collection Data Sheet to ensure that all samples were received and that there were no discrepancies between the information on the form and the information on the sample containers. All analysis work was conducted by OUL personnel.

2.4.2 Water Samples

Water samples were collected when a station was established and when carbon packets were collected. Water samples were collected with disposable 50 ml vials dipped into the water to be sampled. Water samples were collected downstream of the carbon packets in order to minimize potential cross contamination from other locations and to minimize turbidity in the water sample. The sample was placed in a cooler with blue ice and maintained under refrigeration until shipment to the OUL laboratory. Throughout the sampling collection, handling and shipping, the samples were accompanied with a chain-of-custody type form called "Sample Collection Data Sheet for Fluorescence Analysis." The samples were maintained in the custody of the sampler until shipment to the laboratory. The sample station name, number, time of sample placement, time of collection, collector, and sampling comments were documented on the form. Sampler placement and collection was conducted by both OUL and Baker Professional Geologists following training of Baker staff by OUL personnel.

Water samples in storage were selected for analysis according to the following criteria:

- As the first sample collected when the sampling station was established (for background fluorescence).
- If dye were detected in the associated carbon sample.
- In the event that the carbon samplers had been lost or damaged.

Following sample selection, approximately 2.5 ml of the water sample was withdrawn with a disposable pipette and placed in a disposable cuvette for analysis in a spectrofluorophotometer operated under a synchronous scan protocol by OUL personnel.

The water samples provided data for the following:

- Indication of the quantities of dyes present at the time of collection.
- Support for the carbon sampler results.
- Comparison of dye concentrations in water to concentrations derived from the associated carbon samplers to aid in characterization of flowpaths.

DRAFT

- Estimation of dye concentration reduction rates to nondetect or background levels.

2.5 Annual Pollutant Load Estimates

2.5.1 Pollutant Loads from Highway and Right-of-Way

The pollutant loads were calculated for each karst feature within the right-of-way (ROW) but outside (or with portions outside) the construction limits of the I-69 preferred alternative. All features inside the construction limits are assumed to be filled and capped. Therefore pollutant loading for those features will be zero. Any springs inside the construction limits will be provided with a "spring box" as well as drainage culvert to perpetuate the natural flow of the stream discharge.

Pollutant loads were calculated for pre and post construction conditions. The calculation procedures are based upon models developed to predict pollutant loads without field measurements presented in a Federal Highway Administration (FHWA) training course. The first part of the model calculates pollutant load estimates, developed in the late 1970's using field data from monitoring programs in various states. The second part estimates the pollutant concentrations and compares them to water quality standards. The third part estimates the pollutant loads in the "background", or what occurs before the highway is built. This methodology is included in **Appendix L** of this document.

Since the construction phasing of Section 5 is not yet determined, during-construction load estimates will not be performed. As part of the construction and construction oversight, strict adherence to the erosion control measures is essential. Runoff and sediment control are to be performed during construction in accordance with the Erosion and Sediment Control plans developed in compliance with the Indiana Handbook for Erosion Control in Developing Areas (Division of Soil Conservation, Indiana Department of Natural Resources). According to the "Results of MOU-Related Karst Studies for Indiana State Road 37, Lawrence County, Indiana (1992-1995)" (EarthTech, 1997), there were elevated levels of Total Suspended Solids (TSS) and Total Recoverable Metals (TRM) to the subsurface associated with the during-construction activities for the SR 37 project. These levels returned to pre-construction conditions about two years after construction. This pattern is anticipated for the I-69 construction.

2.6 Review of IDNR Water Well Data

In their comment letter dated August 3, 2007 on the Section 5 Draft Karst Report the USEPA suggested that IDNR Division of Water water well database should be included in this study to document local water tables and to determine the flow conditions under which the dye traces were conducted.

Because karst groundwater is moving through conduits and flowpaths may intersect within a given karst formation, there may be little correlation between the "water table" as measured in wells and a karst conduit flow system in the vicinity. Many assumptions would need to be made regarding well connectivity to and influence from a karst conduit system versus the consolidated formation system, as well as the status of the seasonal influence on these water levels across the

DRAFT

wide ranging timeframe of the IDNR well dataset. The undissolved rock (in which wells are typically placed) usually has several orders of magnitude less hydraulic conductivity than does the turbulent flow regime in the karst conduits; and therefore, response times are quite different. These factors limit the usefulness of IDNR water well data for the analyses recommended. The data were reviewed to identify references to karst voids and for assessment of major structural issues. The data may be reviewed and compared to geotechnical boring data utilized for final design of the project. Water well locations and logs in the vicinity of the Section 5 Corridor are depicted on Figure 4a and included in **Appendix M**.

2.7 Cave Biology

Accessible caves and related springs with hydraulic or physical connection with the alternatives being advanced were surveyed for biological fauna. A reconnaissance-grade biological survey was conducted by an OUL Professional Geologist with cave bioinventory experience in each cave demonstrated to have relevance to the Section 5 Corridor. During the reconnaissance, a state-listed crayfish was observed in a cave with mapped passages that cross under SR 37 and a recharge area that crosses the Section 5 Corridor.

Based on this reconnaissance and the relevance to the Section 5 Corridor, an additional task was requested for evaluation of troglobitic species by a cave biologist. The task was approved, and Dr. Julian Lewis of Lewis and Associates was contracted to conduct biological surveys via two entrances into one cave system and a nearby cave/karst window which is all the caves that have extant entrances that are related to Section 5.

The following information is summarized from the Interstate 69 Evansville to Indianapolis Tier 2 Studies: Section 5 Cave Fauna report dated September 2005 (**Appendix J**).

Sample method type, timing, and location selection were based upon the conditions encountered in the caves at the time of sample introduction/collection, methods developed during sampling in numerous similar caves, and the professional judgment of the cave biologist, Dr. Lewis.

The methods of sampling included some or all of the following:

- Manual collection.
- Placing of pitfall traps that consisted of four-ounce glass specimen jars filled with 70% isopropyl alcohol as a preservative and baited with limburger cheese spread.
- Collection of leaf litter for Berlese extraction.
- Placement of shrimp-baited jars in the deeper water of the karst window.
- Extraction of interstitial aquatic fauna via the Karaman-Chappuis method.

The baited jars holding water samples were placed in a cooler and transported to the laboratory where samples were placed in petri dishes and examined for living fauna under a dissecting microscope. Litter taken from the cave was placed in a Berlese funnel (with overhead light/heat)

DRAFT

for extraction of the invertebrates into a vial of 40% isopropyl alcohol. Pitfall residues were screened, then transferred into petri dishes for sorting of the fauna under a dissecting microscope. Specimens of each taxon were placed in 3 or 4 dram vials of 40% isopropyl alcohol and labeled per cave of origin, state, county, distance to nearest town, date and collector. The samples were maintained in the custody of the sampler (Dr. Lewis) during collection, transport to the laboratory, and during preparation and examination.

Some taxa required the use of outside taxonomists for specific identification. These taxonomists were part of the Lewis Project Team (**Appendix J**). Samples were prepared as appropriate for taxa specific identification and shipped in accordance with the requirements of the recipient facility and state, federal, and international regulations. The identification of specimens was performed by appropriate taxonomists with familiarity with the taxa to be identified:

- Dr. Thomas C. Barr, Jr. (carabid beetles), professor emeritus, University of Kentucky.
- Dr. J. P. Battigelli (collembolans), consultant, Earthworks Research Group.
- Dr. Lynn Ferguson (diplurans), professor, Longwood University.
- Dr. Robert Hershler (aquatic snails), curator, Department of Invertebrate Zoology, Smithsonian Institution.
- Dr. John R. Holsinger (amphipods),professor, Department of Biological Sciences, Old Dominion University.
- Dr. Pierre Paquin (spiders), post-doctoral fellow, Department of Biological Sciences, San Diego State University.
- Dr. Janet Reid (copepods), research associate, Virginia Museum of Natural History.

DRAFT

3.0 RESULTS

This section summarizes the results of the karst feature mapping, dye tracing, recharge area delineations, and biological surveys of caves. The 2006 Karst Report results were updated with the following:

- Additional field reconnaissance and dye tracing was conducted to determine the approximate recharge area for two overlapping cave systems (known as Cave and Cave) in the vicinity of the Section 5 corridor, based on agreement between INDOT, FHWA, and USEPA.

- Monroe County geographic information system (GIS) files such as the 2010 aerial photography and 2-foot contours into identify potential additional or adjust 2006 Section 5 karst features. The Monroe County data included topography from Light Detection And Ranging (LiDAR) that can measure beneath leaf canopy, increase reproducibility between surveys, and provide increased precision over standard aerial photography based mapping. Karst feature additions and adjustments from this data were incorporated following field check confirmations.

- Data from the I-69 Tier 2 Studies Section 4 Survey of Karst Features Report (2010) and Addendum No. 1 (2011).

These updates, additional field data, and evaluations resulted in increases in the number of identified karst features and flowpaths included in this 2012 Karst Report.

3.1 Karst Features

Karst features included sinkholes, springs, karst flowpaths, caves, and others (losing streams and sinking streams). In accordance with the 1993 MOU, the location, type, area, and significant characteristics of karst features were researched, field checked, documented and imported into a GIS for evaluation relative to SR 37 and Section 5. The Section 5 Corridor and those areas hydrologically connected through the karst were searched for the presence of these features. The results for each of these features are discussed in the following subsections.

3.1.1 Sinkholes and Other Insurgence Features

The research and field checks identified 446 sinkholes (including sinks within larger sinkholes and some sinkholes outside the Corridor), five losing/sinking stream basins, and 21 filled or appreciably modified sinkholes. Photographs of select karst features are included in **Appendix E**. Figures 5a and 6a show the distribution of insurgence features in the Bloomington, Bloomington North, and Simpson Chapel Karst areas with land use, based on consolidated terms from field reviews and updates of a GIS land use layer provided by the Monroe County Planning Department. Figures 4b, 5b, and 6b show the insurgence features on an aerial photo base.

DRAFT

Several insurgence features were observed capturing runoff from SR 37 through sinks that have formed or reopened in ditches along SR 37 or existing sinks that were used as part of the SR 37 and Bloomington drainage systems.

Three of the five losing or sinking streams had much larger topographic watersheds than sinkholes and were identified from south to north:

- An unnamed tributary of Clear Creek whose headwaters are near the intersection of Rockport Road and SR 37 (Figure 4b; GIS Feature Number 500001). The tributary flows nearly south from the northernmost reaches that recharge Spring to the southern reaches that recharge (Station 73 on Figure 11). The stream loses all of its water at low flows near Spring (Station 74 on Figure 11). At higher flows, there is appreciable water throughout its course.

- A sinking stream basin centered near the intersection of 3rd Street and SR 37 and along SR 37 (Figure 4b; GIS Feature Number 500163). This basin drains to the south through a detention pond and passes under SR 37 to its sink point on the SR 37 right-of-way. This stream resurges at Spring (Station 79 on Figure 11). Its northern topographic basin boundary is shared, in part, with the southern basin boundary of Stout Creek.

- Stout Creek, which, at low flow conditions near Hoadley Quarry between Hunter Lane and Arlington Road, loses all of its water into the karst groundwater system (Figure 4b; GIS Feature Number 500187). At normal to high flow, there is water throughout the channel. The lost water resurges into the Stout Creek channel at multiple points between Station 89 (Spring) and Acuff Road.

Sinkholes that had been deliberately filled as a part of development projects were relatively obscure karst features and difficult to identify. These sinks were identified from old topographic and roadway mapping, and stereophotography taken in 1939, prior to construction within the Section 5 Corridor. While most of the buried sinkholes drain to their current discharge points through culverts, they contribute little to no water to the karst groundwater system. Some of these filled sinkholes appear to be unstable and presumably in the process of reopening and thus reactivating the historic hydrologic role of the sinkhole.

In addition to sinkholes identified during this study, unidentified bedrock sinkholes likely exist that have been naturally filled with loess. These sinks have no surface expression, but have the potential to reopen catastrophically through internal erosion in the form of soil pipes and stoping (undercutting). This process is speeded up when excess water is directed to them by regrading or other redirection of runoff.

The research and field reconnaissance was appropriate and thorough, however, the presence of karst features beyond those identified in this study is likely, and is partly a function of the dynamic nature of the karst systems as well as historical development in the study area.

DRAFT

3.1.1.1 Drainage Area

The drainage area of each of the karst insurgence features (sinkholes/losing streams) was based on the results of the karst feature research and field checks imported into a GIS database. All land contributing to a specific karst insurgence feature was based on Section 5 2-foot contour topography and included within the drainage area boundaries. The acreage was calculated in GIS based on these boundaries and summarized (**Appendix D** - Table D-2), and the insurgence features are depicted in Figures 5 and 6.

Land uses were identified in GIS based on a field review and update of land use files provided by Monroe County. Land uses represent the developed and undeveloped land cover found within the study area in 2010, based on field reviews and updates of a GIS land use layer provided by the Monroe County Planning Department. Acres of planned development anticipated by 2035 were developed as a GIS layer based on TIF districts in coordination with local planning officials at the City of Bloomington and Monroe County. Land use within the relevant karst areas are illustrated in Figures 5a and 6a and are summarized below.

Table 3 Relevant Karst Land Use for Section 5 Study Area[5]

Land Use in 2010	Bloomington Karst (acres)	Bloomington North Karst (acres)	Simpson Chapel Karst (acres)	Acreage of Land Use in Relevant Karst	Percentage of Land Use in Relevant Karst
Agricultural	92	153	92	337	9.2%
Nonresidential/ Industrial	100	26	48	478	13.0%
Public Use and Institutional	16	59	18	103	2.8%
Mines and Quarries	36	11	0	46	1.3%
Residential	417	72	147	636	17.3%
Water	14	2	1	18	0.5%
Transportation, Communication and Utilities	472	114	150	739	20.1%
Upland and Wetland Habitat	695	257	369	1,321	35.9%
Totals	**2,160**	**694**	**825**	**3,679**	**100%**
Acres of Planned Development anticipated by 2035[6]	*492*	*245*	*0*	*727*	*20%*

[5] Updated since the 2006 Karst Report as part of the Section 5 DEIS (such as land cover, land use, population growth, planned development, setting, bedrock, Monroe County 2010 aerial photography and 2-foot contours) (see page 1).

[6] Specific sites of planned development were identified during the coordination process with planners from the City of Bloomington and Monroe County and placed in the project GIS. This development is anticipated to occur independent of the proposed project.

DRAFT

Note: the karst areas extend beyond land use data sets, therefore, the land use acreages above are for only the Section 5 study area.

To summarize, as previously discussed in Section 1.4, and illustrated by the data shown above, the relevant karst in the Section 5 study area has been affected by the residential and commercial/industrial development of the Bloomington area. Moreover, this development is projected to continue regardless of upgrading of SR 37 to I-69.

DRAFT

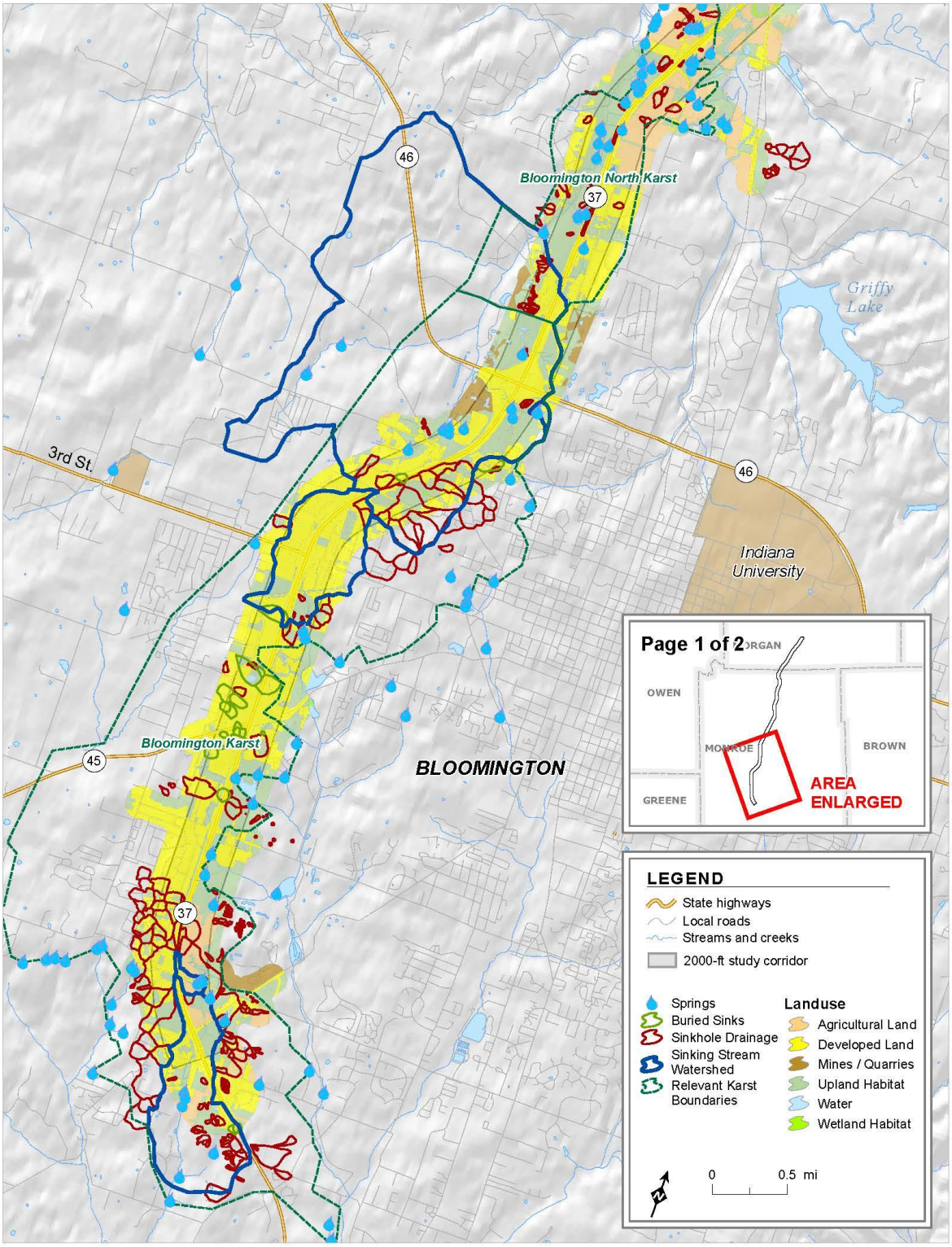


Figure 5a **Sinkholes/Insurgence Features and Land Use – Bloomington and part of Bloomington North Karst**

Figure 5b Sinkholes/Insurgence Features on Aerial Background – Bloomington and part of Bloomington North Karst

Figure 6a **Sinkholes/Insurgence Features and Land Use – part of Bloomington North and Simpson Chapel Karst**

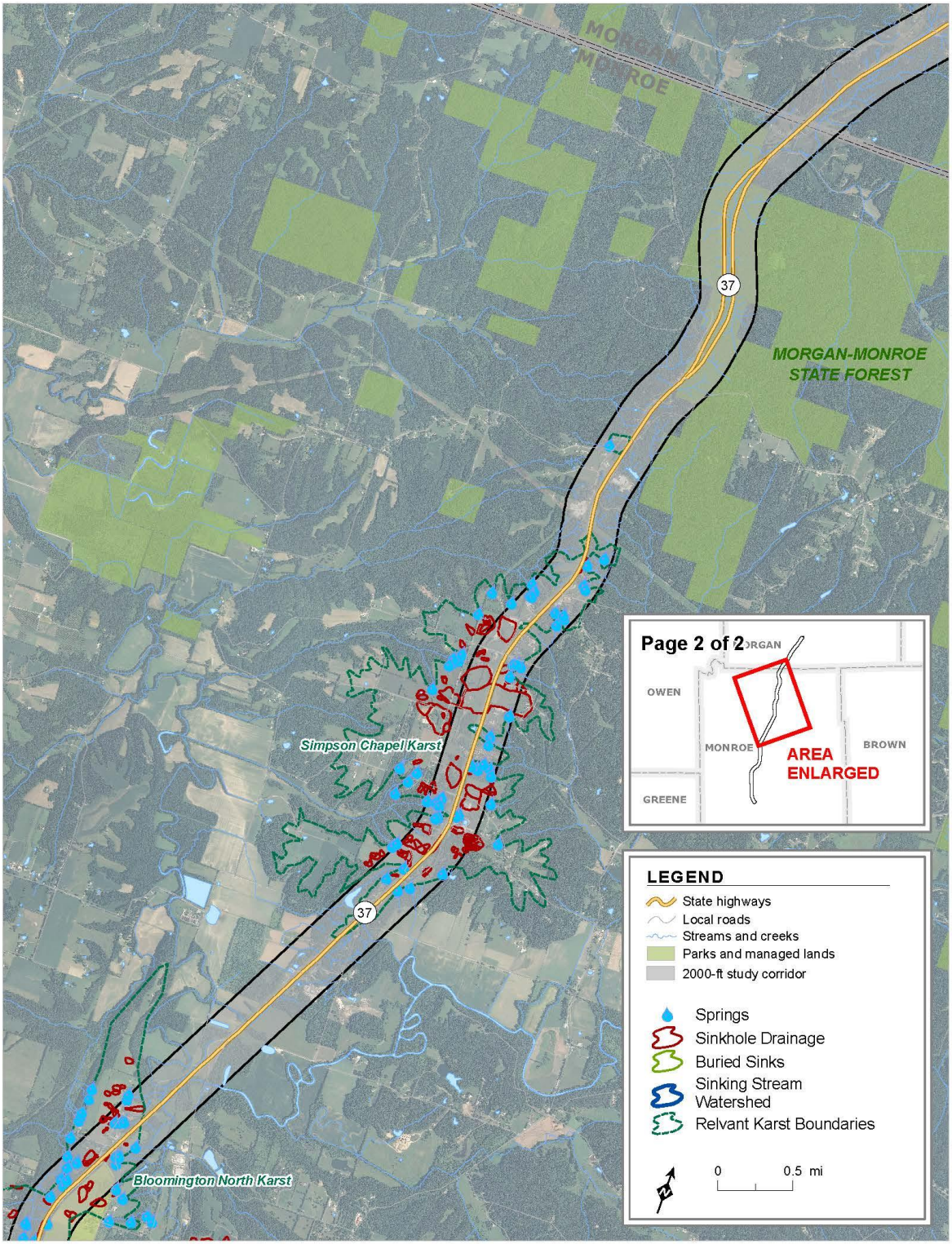


Figure 6b **Sinkholes/Insurgence Features on Aerial Background – part of Simpson Chapel Karst**

3.1.2 Springs

Springs and other resurgence features located and documented as part of this study included 26 relevant springs from I-69 Tier 1 data, and 143 additional springs (Figures 7, 8, 9 and 10). The majority of springs (approximately 80%) were located along geologic formation contacts.

Bloomington Karst springs typically discharge at the base of the St. Louis Limestone while Bloomington North and Simpson Chapel Karst springs typically discharge on top of a relatively thick bed of fossiliferous limestone at the base of the Ramp Creek formation. These springs tend to be slightly above the limestone-shale contact, but are typically found in valley heads.

Table 4 shows the relevance of the springs to the proposed road alignment. The "springs linked by dye tracing" have had hydrologic linkage to the Corridor demonstrated by dye traces initiated in the I-69 Corridor. Some of these springs are within the Corridor, but most are located outside the Corridor. "Springs located in the Corridor" are related to the Corridor by their physical location in the Corridor. These may or may not receive recharge from the Corridor. The "springs linked by logical inference" to the Corridor are springs that are generally, 1) located proximate to the Corridor, and 2) the flow direction of the spring and the surrounding geology indicate that parts of the I-69 Corridor provide some or most of their recharge. The flow patterns revealed by the dye tracing investigation and the surrounding geology indicate that the springs classified as "not related to the Corridor" almost certainly do not derive any water from the I-69 Corridor. The final column "springs where relevance was not determined" in Table 4 are the springs for which the evidence is not clear as to whether they are recharged by water from the I-69 Corridor.

Table 5 provides estimated discharge rates for most of the springs visited during the study. While there are a relatively high number of springs found in the area, these are generally springs with small baseflow discharges and therefore, have small recharge areas. None of the springs are known to provide water for human consumption. A few of them are used for watering livestock. Photos of the springs (and other sampling stations) are included in **Appendix E**. Photos 1 and 2 are shown below as examples of typical small springs that receive water from the Corridor.

Of the 131 springs related to the Corridor, all but twelve have baseflow discharges in the one to twenty gpm range. The remaining ten springs have baseflow discharges in the 20 to 600 gpm range. Two of these springs, and are currently impacted by the Lemon Lane Landfill.

DRAFT

Photo 1: **Spring (Station)**

Photo 2: **Spring (Station)**

Table 4 Spring Relevance

37 Springs Linked by Dye Tracing	65 Other Springs in the Corridor	29 Springs Linked by Logical Inference	28 Springs Not Related to the Corridor	12 Springs where Relevance was not Determined
Spring	Spring	Spring		Spring
Spring	Spring	Spring	Spring	
Spring	Spring	Spring	Spring	Spring
Spring	Spring	Spring	Spring	
Spring	Spring	Spring	Spring	Spring
Spring	Spring	Spring		Spring
Spring	Spring	Spring		Spring
	Spring	Spring	Spring	Spring
Spring		Spring		Spring
		Spring	Spring	
Illinois Central Spring		Spring		
Spring		Spring		Spring
Spring		Spring	Spring	Spring
Spring		Spring	Spring	Spring
Springs	Spring	Spring	Spring	
	Spring	Spring	Spring	Spring
Spring	Spring	Spring		
Spring	Spring	Spring		
Spring	Spring			
Spring	Spring	Spring	Spring	
Spring	Spring	Spring	Spring	
Spring	Spring	Spring	Spring	
Spring	Spring	Spring	Spring	
Spring	Spring	Spring	Spring	
Spring	Spring	Spring	Spring	
Spring	Spring	Spring	Spring	
	Spring		Spring	
	Spring	Spring		
Spring	Spring	Spring	Spring	

37 Springs Linked by Dye Tracing	65 Other Springs in the Corridor	29 Springs Linked by Logical Inference	28 Springs Not Related to the Corridor	12 Springs where Relevance was not Determined
Spring Spring Spring U/S of Spring Spring Spring Spring Spring Spring Spring	Spring Spring	Spring Spring Spring	Spring Spring	

DRAFT

Table 5 Estimated Discharge for Relevant Springs

Station Number	Station Name	Date	Estimated Discharge (Gpm)	Flow Conditions (At Time Of Estimate)
	Spring	5/20/04	200	base
	Spring	1/5/05	2,025	storm response
	Spring	5/19/04	2,500	base
	Spring	5/20/04	8	base
	Spring	1/5/05	30	storm response
	Spring	5/20/04	350	base
	Spring	5/20/04	220	base
	Spring	5/21/04	5	base
	Spring	1/5/05	160	storm response
	Spring	5/21/04	3	base
	Spring	1/5/05	100	storm response
	Spring	5/21/04	5	base
	Springs	5/21/04	10	base
	Springs	5/21/04	90	base
	Spring	6/14/05	2	base
	Illinois Central Spring	6/14/04	71	base
	Spring	1/5/05	300	storm response
	Spring	6/9/04	40	base
	Spring	1/5/05	2,200	storm response
	Spring	6/9/04	25	base
	Spring	6/9/04	1	base
	Spring	6/9/04	100	base
	Spring	1/5/05	2,000	storm response
	Spring	6/9/04	75	base
	Spring	1/5/05	2,000	storm response
	Spring	6/9/04	900	base
	Spring	1/5/05	1,200	storm response
	Spring	7/21/04	20	base
	Spring	1/5/05	70	storm response
	Spring	8/31/04	10	base
	Spring	8/31/04	3	base
	Spring	8/31/04	10	base
	Spring	8/31/04	1	base
	Spring	8/24/04	25	base
	Spring	1/5/05	300	storm response
	Spring	8/24/04	600	base
	Spring	1/5/05	4,000	storm response
	Spring	9/3/04	1	base
	Spring	9/28/04	1	low
	Spring	1/5/05	20	storm response
		9/28/04	2	low
	Spring	10/6/04	10	low
	Spring	10/6/04	90	low
	Spring	1/7/05	85	storm response
	Spring	1/7/05	20	storm response
	Spring	1/7/05	45	storm response
	Spring	1/7/05	15	storm response
	Spring	1/7/05	65	storm response

DRAFT

Station Number	Station Name	Date	Estimated Discharge (Gpm)	Flow Conditions (At Time Of Estimate)
	Spring	1/7/05	50	storm response
	Spring	1/7/05	20	storm response
	Spring	1/7/05	40	storm response
	Spring	4/20/05	3	base
	Spring	1/7/05	8	storm response
	Spring	1/7/05	12	storm response
	Spring	1/7/05	40	storm response
	Spring	1/7/05	15	storm response
		1/7/05	105	storm response
	Spring	1/9/05	10	storm response
	Spring	1/9/05	10	storm response
	Spring	1/9/05	30	storm response
	Spring	1/9/05	8	storm response
	Spring	4/12/05	0	low
	Spring	4/20/05	0	low
	Spring	1/9/05	90	storm response
	Spring	1/9/05	35	storm response
	Spring	1/9/05	15	storm response
	Spring	1/9/05	12	storm response
	Spring	1/9/05	6	storm response
	Spring	1/9/05	10	storm response
	Spring	1/14/05	18	base
	Spring	1/20/05	4	base
	Spring	1/20/05	1	base
	Springs	1/20/05	4	base
	Spring	2/1/05	3	base
	Spring	2/2/05	1	base
		2/2/05	800	base
	Spring	2/3/05	3	base
	Spring	2/3/05	3	base
	Spring	2/4/05	3	base
	Spring	2/4/05	2	base
	Spring	2/4/05	4	base
	Spring	2/4/05	<1	base
	Spring	2/11/05	1	base
	Spring	2/11/05	2	base
	Spring	2/11/05	4	base
	Spring	2/11/05	3	base
	Spring	2/11/05	3	base
	Spring	5/22/05	2	base
	Spring	2/25/05	3	base
	Spring	2/25/05	4	base
	Spring	2/25/05	7	base
	Spring	2/25/05	2	base
		3/25/05	7	base
	Spring	3/16/05	18	base
	Spring	3/25/05	2.5	base
	Spring	3/16/05	5	base
	Spring	3/16/05	30	base
	Spring	3/16/05	25	base

DRAFT

Station Number	Station Name	Date	Estimated Discharge (Gpm)	Flow Conditions (At Time Of Estimate)
	Spring	3/25/05	3	base
	Spring	3/25/05	4	base
	Spring	3/25/05	8	base
	Spring	3/16/05	20	base
	Spring	3/25/05	8	base
	Spring	3/16/05	0.25	base
	Spring	3/25/05	6	base
	Spring	3/25/05	1.5	base
	Spring	3/25/05	0.5	base
	Spring	3/25/05	6	base
		3/23/05	40	base
	Spring	3/16/05	1	base
	Spring	3/25/05	1.5	base
	Spring	3/25/05	2	base
	Spring	3/25/05	8	base
	Spring	3/25/05	1	base
	Spring	3/25/05	3	base
	Spring	3/25/05	1	base
	Spring	3/25/05	5	base
	Spring	3/25/05	3	base
	Spring	3/25/05	1	base
	Spring	3/25/05	4	base
	Spring	3/25/05	3	base
	Spring	3/25/05	2	base
	Spring	3/25/05	1.5	base
	Spring	3/25/05	10	base
	Spring	3/30/05	1	storm response
	Spring	4/2/05	8	storm response
	Spring	4/3/05	6	storm response
	Spring	4/3/05	10	storm response
	Spring	4/3/05	3	storm response
	Spring	4/3/05	1	storm response
	Spring	4/3/05	15	storm response
	Spring	4/3/05	2	storm response
	Spring	10/7/08	3	base
	Spring	12/4/08	1	base
	Springs	12/4/08	400	
	Spring	1/23/09	1	base
	Spring	3/17/09	200	
n/a	Spring	5/24/06	2	base
n/a	Spring	5/24/06	2	base
n/a	Spring	5/24/06	2	base
n/a	Spring	5/24/06	4	base

DRAFT

3.1.3 Karst Flowpaths

Fifty-nine karst flowpaths have been shown to drain to or from the Section 5 Corridor including dye introduction points that receive surface runoff from the Corridor. An additional eight karst flowpaths were demonstrated or are included for their use in recharge area delineation and there are three more karst flowpaths that have been included simply because of their proximity to the Corridor. All of these flowpaths have been demonstrated by linking a dye introduction location to one or more springs. The dye traces shown on Figures 13 and 14 are diagrammatic representations of a karst flowpath. The only mapped karst flowpaths in Section 5 are in Cave, which was mapped in the 1950s (Roy and Wells, 1959).

Fourteen karst flowpaths cross one or both lanes of SR 37, and 131 springs were either within the Corridor, linked by dye tracing, or linked by logical inference (Table 6), springs that are generally, 1) located proximate to the Corridor, and 2) the flow direction of the spring and the surrounding geology indicate that parts of the I-69 Corridor provide some or most of their recharge. Each of these springs presumably has an associated karst flowpath.

An appreciable portion of one of these streams was carried under SR37 via a culvert to a sinkhole which drains to Spring and may be the location of a covered cave conduit (Section 3.1.4).

3.1.4 Caves

A number of cave entrances that were reported are no longer accessible. These include Cave, Cave (tributary to Cave), Cave, Cave (tributary to Cave), and Cave. Three accessible caves have been linked to the Corridor hydrologically or by logical inference:

- Cave has been mapped under SR 37 (Roy and Wells, 1959) and six Tier 2 and two previous dye traces were detected at its spring. Figure 16 shows the traces in the Cave area.
- Cave is a tributary to Cave and receives runoff from the Section 5 Corridor.
- Cave has been linked by dye tracing to the Section 5 Corridor. Cave is more accurately termed a karst window with a water filled cave passage.

ICS listed a formerly accessible cave (Cave) just west of the spring; however, IGS and OUL were not able to locate a cave entrance in this area.

An INDOT employee reported that a cave had been encountered during construction in the SR 37 right-of-way. The cave was located south of , south of and east of the current The opening was large enough to enter, and an open area was found with some writing on its walls. The opening was not filled by the construction crew, but a box was constructed around it with concrete and rebar and the hole was spanned so that water could continue to flow and the structure was covered with fill material and the existing SR

37 system. The span was approximately three feet by three feet. Water near the cave was observed flowing from southwest to northeast (White 2005). Cross-referencing this report with other data sources indicated this cave was most likely Cave. The cave does not currently have an accessible opening.

The majority of the information regarding caves associated with this study is considered confidential and is presented in **Appendix I**.

3.1.5 Others

Losing/sinking stream features were discussed in Section 3.1.1 (Sinkholes and Other Insurgence Features).

Three relevant karst windows were identified and documented in Section 5. Cave was discussed in 3.1.4. The other karst window was found in a sinkhole (GIS insurgence feature No. 423) and used as a dye introduction point (Trace 05-16). Trace 05-16 is discussed in detail in Section 3.2.2.16. The base flow was approximately two gpm through the karst window, and both the upstream and downstream openings were too small for human access. The third karst window was found field checking the 2010 LiDAR data (GIS insurgence feature No.2). This karst window has no accessible passage at its upstream or downstream ends.

DRAFT

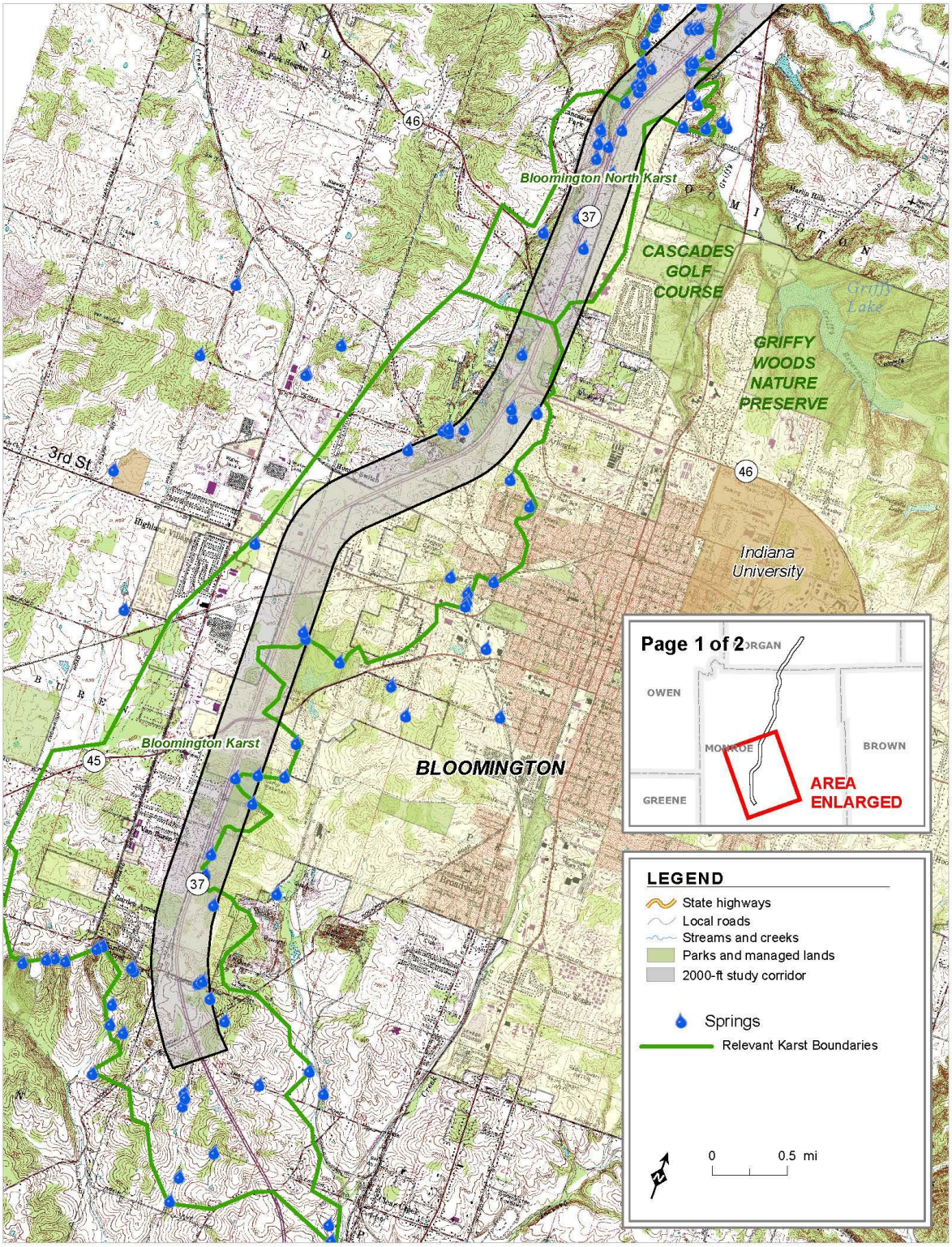


Figure 7 **Locations of Springs – Bloomington and part of Bloomington North Karst**

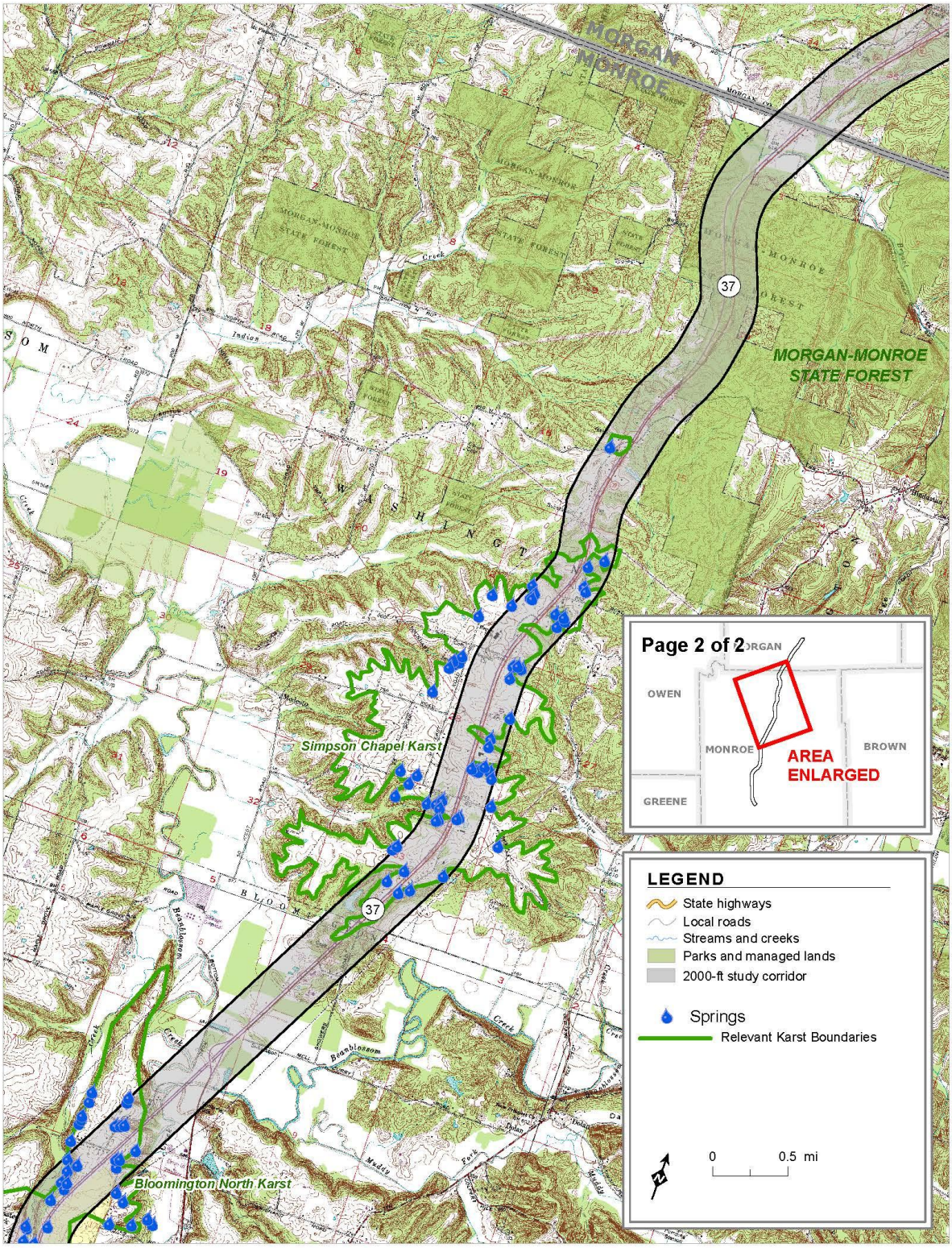


Figure 8 **Locations of Springs – part of Bloomington North and Simpson Chapel Karst**

3.2 Dye Tracing Results

A total of 41 dye introductions that traced 59 karst groundwater flowpaths were made over approximately 11.5 linear miles of relevant karst in Section 5, or approximately three traces per linear mile, not counting the traces conducted specifically for delineating the Cave recharge area. In addition, 18 traced flowpaths from the Tier 1 dataset were deemed relevant for the Tier 2 study and two traces from Section 4's Tier 2 investigation are relevant, resulting in a total of 83 groundwater flowpaths for use during alternative evaluation, planning and design.

Dye detections shown in **Appendix B** were attributed either to Section 5 dye traces or to environmental contaminants grouped together as background fluorescence. There were also dye detections attributed to specific dye tracing activities not related to the I-69 Section 5 studies:

- Dye tracing associated with the Lemon Lane Landfill Superfund site is ongoing. Illinois Central Spring, Spring, Spring, and Weddle Creek consistently had significant detections of fluorescein and rhodamine WT dyes. These detections were attributed to Viacom, Inc., the company conducting the dye-tracing program at Lemon Lane.

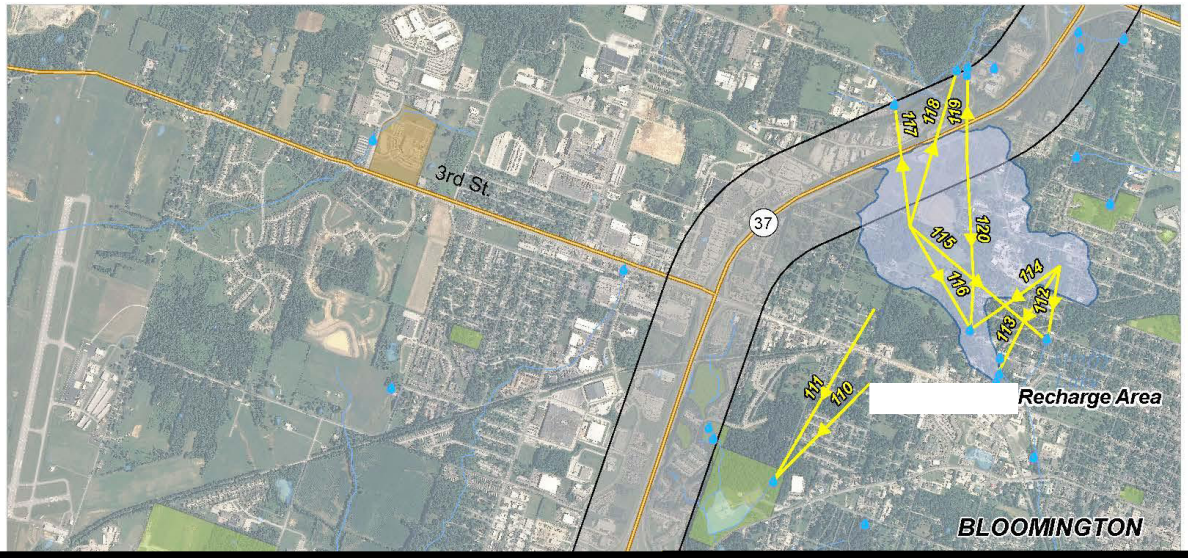
- Other detections (such as that at Station 44) were attributed to maintenance operations at Indiana University (IU). After the first detections, IU personnel were interviewed and the results of the detections made during the Section 5 study were found to be consistent with the time and place for dye releases reported by IU personnel.

3.2.1 Previous Dye Tracing Results

The 18 relevant dye traces provided in the Tier 1 dataset are shown on Figure 10. Five of the 18 traced flowpaths transfer water across the sub-watershed boundaries. While none of the previous traces were started in the Section 5 Corridor, three of the traced flowpaths cross the Corridor and indicate that there are conduits of unknown dimensions (i.e. karst flowpaths) that are capable of transmitting water across the Corridor.

Additional pre-Tier 1 traces were conducted by consultants or graduate students with different dye trace and quality control methods from those performed as part of the Section 5 study. While the low concentration detections reported in a few of these traces were considered marginal, the main flowpaths they traced were reviewed and deemed suitable for inclusion in the Section 5 study.

DRAFT



[redacted]

Figure 9 Previous Relevant Dye Traces and Spring Locations

3.2.2 Groundwater Tracing Results by Individual Traces

A total of 41 dye introductions traced 59 karst groundwater flowpaths as part of the Section 5 dye-tracing program. The flowpath data presented in this report are diagrammatic; the lines representing the flowpaths are not meant to represent the actual location or distribution of the conduits. The sampling station network is shown on Figures 11 and 12 and **Appendix D** Table D-1 Sampling Stations correlates the station number with the station name and provides location information. **Appendix B** includes complete results for both activated carbon samplers and water grab samples and contains an analytical results table with columns attributing dye detections to a particular dye trace. Graphs of all analyzed samples are presented in **Appendix G**. OUL's Procedures and Criteria document is provided in **Appendix C**. Detailed descriptions, summary tables, and figures illustrating individual dye traces are presented in **Appendix F** and include:

- Amount and type of dye used.
- Elevation and location of the dye introduction point.
- Date and time of dye introduction.
- Flow conditions at the dye introduction point at the time of dye introduction.
- Locations where dye was detected.
- Elevation difference between introduction and recovery points.
- Mean groundwater flowpath gradient.
- Time of first dye detection.
- Relevance to the project.
- Figure showing the trace and its relation to the Corridor.
- Summary table of dye trace details.
- Other relevant information.

The following factors are pertinent to the individual dye traces and summaries:

- The summaries show the first detection of dye at the primary discharge point.
- The concentrations were reported in parts per billion (ppb) from activated carbon samplers, unless otherwise noted. The water concentrations were only included if they added substantially to the discussion of the results.

DRAFT

- "ND" means no dye was detected and "NS" means that there was no sample collected for the given time interval. Generally, "NS" means that both samplers were lost to floods or animal disturbance.

- The velocity of the dye front was based on the assumption that dye arrived at the end of the sampling period in which dye was first detected (unless there were other data available such as observations of dye discharge or more accurate times associated with grab samples of water). Often dye was detected in the same sampling period at the spring at which the dye was discharged as well as downstream sampling stations. The velocity of the dye front was calculated as the distance to the most distal sampling station that had a sample collection date *no later* than that of the sample collected from the spring. The arrival time at the spring was then calculated based on the mean velocity to the distal station and the distance to the spring.

- In some cases, residual dye was present at a sampling station when a new dye pulse arrived. In such cases, the number of the trace providing the dominant dye concentration was listed as the source.

- Sampling stations (205 total stations) were established as needed or dropped from the sampling routine throughout the investigation.

In addition to the individual trace details provided in **Appendix F**, Section 3.3 discusses the summary of dye tracing results: Figure 13 and Figure 14 show all of the traced groundwater flowpaths; Table 8 summarizes the dye trace parameters; and Table 9 lists the dyes introduction and detections for each trace. General statements about individual dye trace results and highlights are presented below:

- 04-01: Trace - linked a sinkhole that currently receives runoff from SR 37 (Figure 4b) to Spring , which is also within the Section 5 Corridor. No previous traces were known to have been detected at Spring . Runoff entering the groundwater system near the Basswood sinkhole flows easterly to Spring .

- 04-02: d Acres Trace - linked a sinkhole in the Section 5 Corridor (Figure 4b) with a relatively large discharge spring (Spring) located approximately 2,600 feet from the SR 37 centerline. This trace demonstrated that springs located appreciably outside the Corridor have the potential to be impacted from activities in the Section 5 Corridor. Also, the tested insurgence feature transfers water across the sub-watershed boundary. The section of Corridor near Glenwood Acres drains west and southwest to Spring

- 04-03: Trace – linked a sinkhole receiving drainage from SR 37 to Spring . This trace provided data supporting a revision of the Illinois Central Spring recharge area. Fitch (1994) included the catchment area for this dye introduction point as being within the Illinois Central Spring recharge area (Figure 15). This trace demonstrated that it was not in the recharge area, and that road activity within the

DRAFT

catchment area of the dye introduction point would not impact the quantity or quality of water discharged from Illinois Central Spring and its associated springs. Due to polychlorinated biphenyls (PCBs) contamination, water discharged from Illinois Central Spring is treated prior to accessible surface discharge. Increase of impervious surfaces, such as roadways, can increase the quantity of runoff requiring treatment.

- 04-04: Trace – was the second trace to be detected at Spring and the third (including a pre-Tier 2 trace) to transfer water across the sub-watershed boundary to Spring This trace was from a point that currently receives runoff from SR 37 through a reopening sinkhole (Figure 4b). The reopening sinkhole apparently had been filled during construction of the adjacent lanes of SR 37. The reopening point was at the downstream end of the concrete ditch liner. This was a point that could readily transmit contaminants from SR 37 to Spring This trace expanded the area known to drain southwest from the Corridor to Spring .

- 04-05: Trace - linked a sinkhole in the Section 5 Corridor with a spring (Spring) that was also in the Section 5 Corridor. Spring had been undocumented prior to this investigation, and is a relatively small spring that discharges into in the This trace demonstrated groundwater flow to the south for the tested sinkhole.

- 04-06: Trace - demonstrated a flowpath linking a sinking stream basin that was almost entirely within the Section 5 Corridor to a spring (Spring that was also in the Corridor. The water discharged from Spring often did not thermally equilibrate with the bedrock environment. It was observed to be relatively warm during high flow events during the summer sampling events. This warming was apparently due to residence in a retention pond prior to passing through the ground to discharge at Spring the water moved along this path faster than it could equilibrate with the ambient groundwater temperature. The underground segment of this trace was approximately 800 feet long. The dye front had a velocity of more than 10,000 feet per day and some of the dye was only underground for about two hours.

- 04-07: Trace – linked a sinkhole that received Corridor runoff to three springs: Spring Spring, and Neither Spring nor had been documented prior to this investigation. The trace expanded the area known to drain to Spring demonstrating the complexity of the groundwater system (since Spring only received water from this sinkhole briefly during the trace). In addition, it showed that groundwater flow direction in this area could cover an entire USGS 7.5 minute topographic map quadrant to the south and west.

- Trace 04-08: – linked a sinkhole in the Corridor to Spring, which had been undocumented prior to this investigation. The flowpath from this part of the Corridor is to the southwest.

DRAFT

- 04-09: - demonstrated that the tested reach of sinks under very low flow conditions and would be expected to lose water under base and higher flow conditions. The sinking/losing reach received runoff from SR 37 and was located downstream of the site (Figure 20). Neither Spring nor the gaining reach downstream had been documented prior to this investigation.

- 04-10: Trace – linked a sinkhole in the Section 5 Corridor to the . This trace also addressed the recharge area refinement, as discussed in Trace 04-03 (Trace). Groundwater flow near the tested sink was to the southeast. The trace also demonstrated interbasin transfer of water from the topographic basin to the

- 04-11: Trace – the dye introduction point recharged Spring and Cave, a biologically significant cave. The trace demonstrated that Spring receives runoff from SR 37, that the stream branch was a losing/sinking stream, and that there is complexity in the distribution of recharge in the study area. The flowpath has two components, one generally westward, and the other generally southward.

- 05-12: - demonstrated that Spring's recharge area crossed the SR 37 Corridor and that at least one-half mile of the Corridor axis was within the Spring recharge area. It also demonstrated the presence of a karst flowpath crossing under SR 37. This stream also crosses the sub-watershed boundary and transfers water from the Jackson Creek topographic basin to the May Creek basin (via interbasin transfer). The flowpath is generally westward.

- 05-13: - demonstrated the presence of an karst flowpath crossing under SR 37. The flowpath is generally eastward.

- 05-14: Failure Trace – linked a sinkhole in the SR 37 median to Spring. Neither Spring nor the overflow spring upstream had been documented prior to this investigation; however, both the dye introduction point and Spring were in the Section 5 Corridor. The flowpath near the sinkhole is generally northwest.

- 05-15: Trace - linked a sinkhole in the Section 5 Corridor with Spring, which had been undocumented prior to this investigation. The trace was in the Corridor and demonstrated the presence of a karst flowpath crossing beneath SR 37. The flowpath near the sinkhole is generally southeast.

- 05-16: Trace – linked a sinkhole in the Section 5 Corridor to Spring, which had been undocumented prior to this investigation. The flowpath from the karst valley is generally northwest.

- 05-17: Trace – linked a sinkhole that received runoff from SR 37 to Spring and demonstrated that the Cave recharge area extended farther north than

DRAFT

shown by previous studies. Surface runoff from portions of SR 37 contributed to the dye introduction point and to Spring. The flowpath for this trace is generally southwest.

- 05-18: Trace – linked a sinkhole in the Section 5 Corridor to a spring called Spring, which had been undocumented prior to this investigation. The flowpath for this trace is generally southwest.

- 05-19: Trace- linked a large sinkhole in the Section 5 Corridor to Spring, a previously undocumented spring located in the Section 5 Corridor. The flowpath from the sinkhole is generally south.

- 05-20: Trace - linked a sinkhole in the median of SR37 with Spring, a previously undocumented spring located in the Section 5 Corridor. The flowpath from areas near the sinkhole is generally southwest.

- 05-21: Trace - the dye introduction point was in the road ditch of SR 37 and received runoff from the roadway. The trace was detected primarily at Spring and secondarily at Spring in the Section 5 Corridor. Neither of these springs had been previously documented. The flowpaths from the sinkhole demonstrated two different directions, the primary path is generally northeast and the secondary path is generally southeast.

- 05-22: - linked a reopening sinkhole that received runoff from SR 37 with Spring, a previously undocumented spring located in the Section 5 Corridor. Trace 05-22 demonstrated the presence of a karst flowpath crossing under SR 37. The flowpath near the sinkhole is generally northeast.

- 05-23: Trace - linked one sinkhole in a cluster of sinkholes that was located in the Section 5 Corridor to Spring, which also was located in the Section 5 Corridor. This was the second trace to Spring. The trace demonstrated the presence of an karst flowpath crossing SR 37. The flowpath of this trace is generally southwest.

- 05-24: Trace – linked a sinkhole in the Section 5 Corridor to springs in Stout Creek. This was the second trace to flow to Stout Creek's previously undocumented springs. The flowpath near the sinkhole is generally north.

- 05-25: l Trace - linked a sinkhole in the Section 5 Corridor to Spring, a previously undocumented spring in the Corridor. The trace may have discharged from a road cut along SR 37. The primary groundwater flowpath was generally east, while the possible secondary flowpath is generally north.

- 05-26: Trace - demonstrated the presence of an karst flowpath crossing SR 37. The trace also linked a reopening sinkhole that abuts SR 37 with Spring in the Section 5 Corridor. This was the second trace detected at Spring. The flowpath of this trace is generally east.

DRAFT

- 05-27: - demonstrated that an karst flowpath flows under SR 37. The trace also linked a reopened sinkhole that abuts SR 37 with Spring, an undocumented spring in the Section 5 Corridor. The flowpath of this trace is generally southeast.

- 05-28: r Trace – linked a sinkhole outside the Corridor (but relevant to a potential interchange) to Spring and Spring in the Section 5 Corridor. Neither of the springs that received water from Trace 05-28 had been documented prior to this investigation. Both flowpaths are generally southeast.

- 08-01: Trace – linked a sinkhole that receives runoff from the Corridor to Spring and ; demonstrating two groundwater flowpaths. It also demonstrated that the dye introduction point lies outside the Cave recharge area. The flowpaths are generally southwest.

- 08-02: – linked a sinkhole outside the Corridor to Spring. This is the first known dye trace detected at Spring and it demonstrates that the sinkhole does not recharge Cave. The flowpath is generally to the southeast.

- 08-03: Trace - linked a sinkhole inside the Corridor to Spring. This is the second known dye trace detected at Spring and it demonstrates that the sinkhole does not recharge Cave. The flowpath is generally to the southeast.

- 09-04: Tributary Trace – helped define the losing reach of this losing stream. Trace 04-11 demonstrated that this stream loses some of its water to Cave and this dye introduction point proved to be downstream of that losing reach. However, the stream did have dye which was detected at Spring and ; demonstrating at least two karst flowpaths.

- 09-05: Trace – linked a sinkhole in the Corridor with three springs; Spring Springs, and Spring, thus demonstrating three karst flowpaths and that the sinkhole does not recharge Cave. The flowpaths are generally to the southeast.

- 09-06: Trace – linked a sinkhole in the Corridor with an unknown spring upstream of Station and demonstrated that this sinkhole does not recharge Cave. The flowpath is generally to the southwest.

- 09-07: Trace – linked a roadside ditch with no apparent karst features, including buried sinkholes, with several springs: Spring, Spring, Springs, and Spring. This is the first known trace detected at Spring. This dye introduction demonstrated flowpaths both southeast and southwest and contributes to two topographic basins.

- 09-08: Trace – linked a inkhole on the east side of the Corridor with Cave on the west side of the Corridor. The flowpath is generally to the southwest and demonstrated interbasin transfer from the Jackson Creek basin to the May Creek basin.

DRAFT

- 09- Trace - linked a sinkhole in the Corridor with three springs; Spring Springs, and Spring, thus demonstrating three karst flowpaths and that the sinkhole does not recharge Cave. It also shows that these springs' shared recharge area extends at least from this dye introduction point to that of Trace 09-05. The flowpaths are generally to the southeast.

- 09-10: e Trace - helped define the losing reach of this losing stream. Traces 04-11 and 09-04 had demonstrated some boundaries for the losing reach of interest and this trace defined it further. This trace linked its losing reach with Spring demonstrating that it recharges Cave, as well as Spring The flowpath is generally to the southwest.

- 09-11: Trace – defined the hydrologic relationship between this karst feature and the nearby springs. The farthest upstream point at which this trace was detected was Spring. All the other detections were almost certainly derived from losses in the stream downstream from Spring. The flowpath is generally to the southwest.

- 09-12: Trace – linked a sinkhole in the Corridor to Cave. The flowpath is generally to the southwest and demonstrated interbasin transfer from the basin to the basin.

- 09-13: Trace – linked a sinkhole outside the Corridor to an unknown spring upstream of Station ( ) demonstrating that this sinkhole lies outside the Cave recharge area. The flowpath is generally to the southwest.

DRAFT

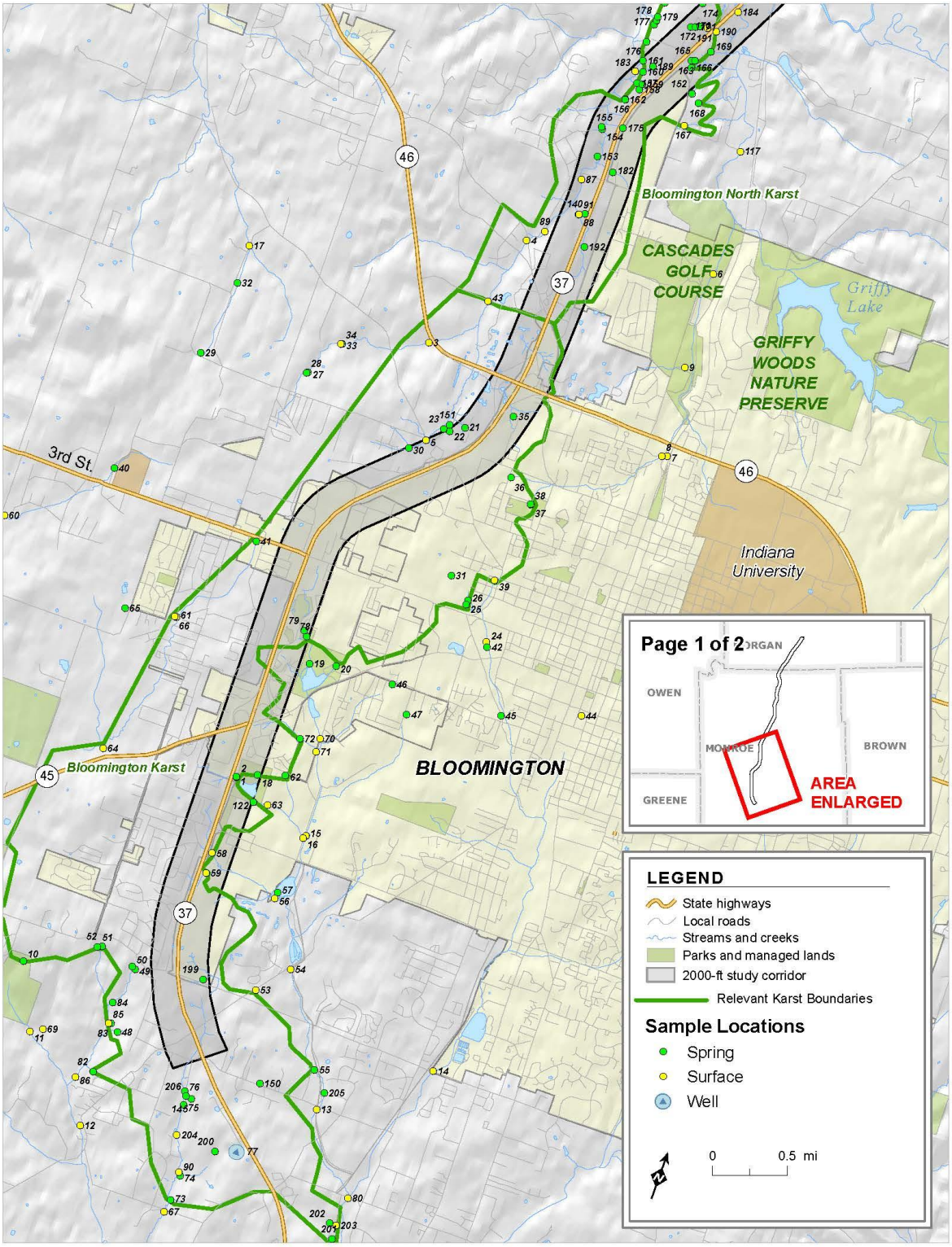


Figure 10 **Location of Sampling Stations - Bloomington and part of Bloomington North Karst**

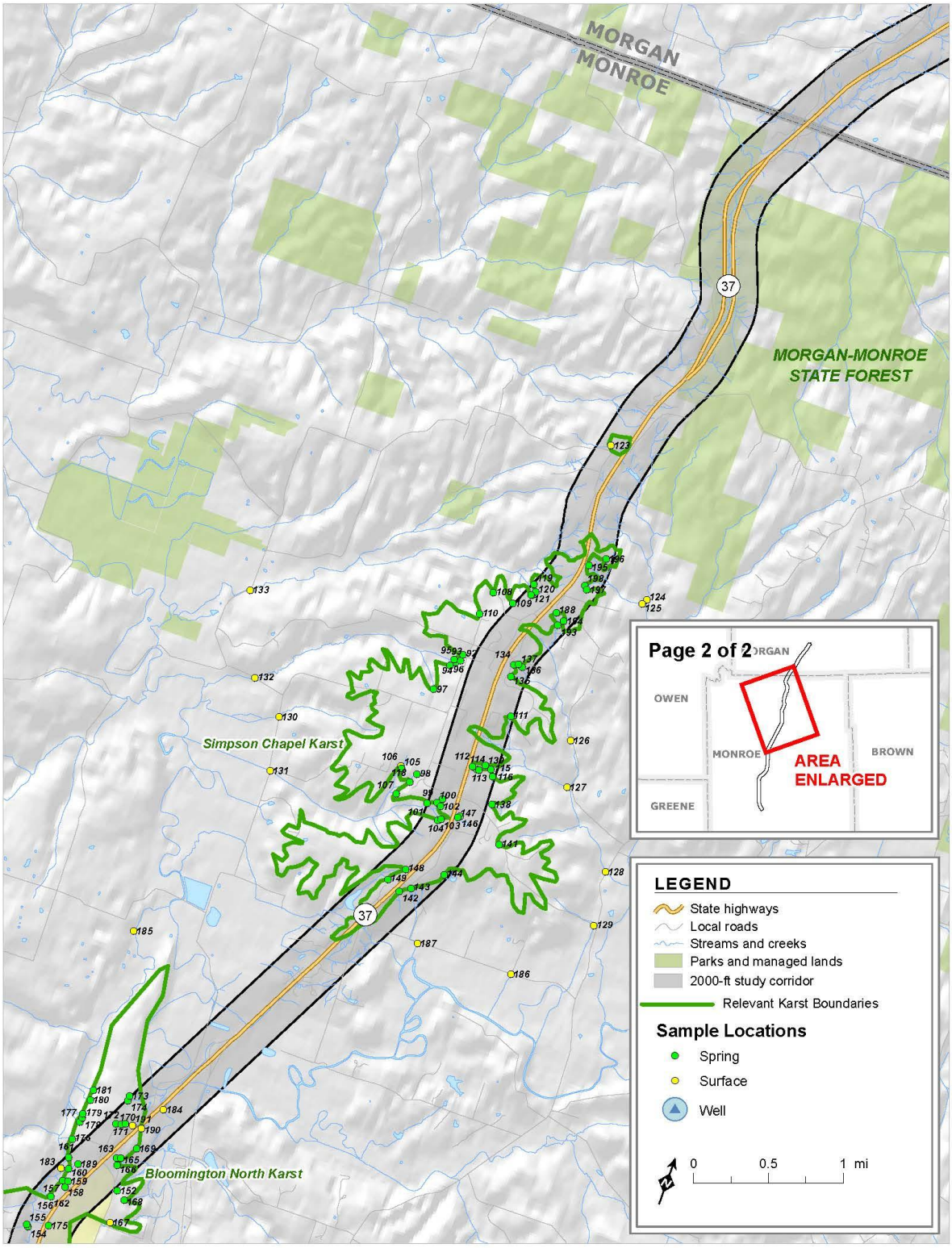


Figure 11 **Location of Sampling Stations – part of Bloomington North and Simpson Chapel Karst**

3.3 Summary of Dye Tracing Results

A total of 83 groundwater flowpaths have been traced during pre-Tier 2 and Tier 2 studies in the Section 5 area. Relevant traced groundwater flowpaths for Bloomington and Bloomington North Karst are shown on Figure 13, and for Simpson Chapel Karst on Figure 14. The Tier 2 Section 5 flowpaths parameters are presented in Table 6 and Table 7 summarizes the dyes used, the dates dye was introduced, and the sampling stations at which dye was detected for each trace. The flowpath data presented in this report are diagrammatic; the lines representing the flowpaths are not meant to represent the actual location or distribution of the conduits.

The Tier 2 data indicated relatively rapid to very rapid mean groundwater velocities in all three karst areas:

- Bloomington Karst: 1,561 feet per day with a mean gradient of 194 feet per mile.
- Bloomington North Karst: 7,025 feet per day with a mean gradient of 330 feet per mile.
- Simpson Chapel Karst: 2,017 feet per day with a mean gradient of 251 feet per mile.

Each of the karst areas appeared to retain dye (and by inference, potential contaminants) associated with the upper portion of the karst formations (epikarst). The lower mean gradients in the Bloomington Karst probably resulted from thicker karst aquifers than in the Simpson Chapel and Bloomington North Karst. The thinner karst formations have less potential to develop extensive epikarst because of the lack of room for vertical weathering in the subsurface.

The background sampling indicated impacts from current land use in Section 5, and from stormwater runoff, leaks and spills on and along SR 37. Dye traces routinely showed that the karst groundwater system served to transport water and associated contaminants from their point or points of origin to springs and streams that were fed by the springs. An example of this in Section 5 was the relatively high level of background fluorescence values found for Spring (Station 103, **Appendix B**). The appreciable fluorescence in the range of fluorescein dye was likely associated with runoff from a gas station and convenience store parking lot located across SR 37 from the spring ( ). Other background fluorescence values (or potential runoff leaks/spills) can be found in **Appendix B**. General engineering concerns and Best Management Practices for addressing these impacts are discussed in Section 5.0 of this report.

DRAFT

Table 6 Summary of Dye Trace Parameters

Trace Number	Trace Name	Sampling Station Linked	Length (ft)	Elevation loss (ft)	Gradient (ft/mile)	Minimum Velocity of Dye Front (ft/day)*	Duration of Dye Detection (days) since dye introduction
Bloomingt							
04-01		Spring	535	20	197	5,718	>216
04-02		Spring	2,616	88	178	8,710	<33
04-03		Spring	1,617	58	189	2,097	>255
04-04		Spring	2,940	90	162	10,462	>176
04-05		Spring	802	40	263	1,813	>176
04-06		Spring	1,631	59	191	9,910	<98
04-07			1,604	105	346	147	>210
04-07		Spring	2,155	116	284	120	>210
04-07		Spring	1,911	74	204	783	<68
04-08		Spring	2,128	83	206	78	>210
04-10		Illinois Central Spring	2,968	37	66	1,475	<90
04-10		Springs	4,012	63	83	200	<85
04-11		Spring	2,760	91	174	214	>122
04-11		Spring	5,971	111	98	425	>122
05-12		Spring	4,075	92	119	833	<51
05-13			3,210	99	163	660	>43
05-17		Spring	927	92	524	893	>39
05-18		Spring	770	52	357	157	>39
08-01		Spring	1,605	108	355	969	>166
08-01			1,306	97	392	352	>166
08-02		Spring	2,561	103	212	50	<51
08-03		Spring	5,041	85	89	1,688	>336
09-04		Spring	4,137	69	88	262	>170
09-04			5,014	82	86	1,002	dye overridden
09-05		Spring	1,210	49	214	1,076	<106
09-05		Springs	7,098	99	74	883	<78
09-05		Spring	6,574	101	81	817	<15
09-06		Spring	1,280	50	206	594	<77
09-07		Spring	1,196	65	287	178	dye overridden
09-07		Spring	869	49	298	10	>177
09-07		Springs	6,653	123	98	996	>97

DRAFT

Trace Number	Trace Name	Sampling Station Linked	Length (ft)	Elevation loss (ft)	Gradient (ft/mile)	Minimum Velocity of Dye Front (ft/day)*	Duration of Dye Detection (days) since dye introduction
09-07		Spring	6,376	132	109	954	<85
09-08		Spring	3,904	90	122	1,186	dye overridden
09-09		Spring	1,093	69	333	181	<6
09-09		Springs	6,504	119	97	1,082	<84
09-09		Spring	6,195	128	109	1,030	<21
09-10		Spring	2,806	76	143	475	<106
09-11		Spring	341	16	248	301	>106
09-12		Spring	3,764	102	143	551	>106
09-13			2,771	98	187	200	>14
Bloomington North Karst							
04-09		Spring	3,083	35	60	949	<189
05-14		Spring	693	40	305	2,371	>92
05-21		Spring	243	24	521	13,997	>18
05-21		Spring	365	27	391	20	>18
05-24		Spring	2,895	110	201	598	>18
05-24		springs	5,052	140	146	3,770	>18
05-25		Spring	314	31	521	107	>18
05-26		Spring	687	39	300	71	>16
05-28		Spring	268	30	591	48,240	>16
05-28		Spring	1,195	55	243	125	>10
Simpson Chapel Karst							
05-15		Spring	1,094	24	116	5,276	<68
05-16		Spring	792	41	273	1,483	>74
05-19		Spring	809	56	365	980	>29
05-20		Spring	804	28	184	132	>28
05-22		Spring	689	27	207	2,866	>17
05-23		Spring	758	56	390	3,087	>18
05-27		Spring	478	20	221	293	>15

* For traces started as dry sets, the date used for velocity calculations is that for the first credible storm event following placement. Minimum velocity may be derived from data from stations other than the spring at which the trace was discharged.

DRAFT

Table 7 Dye Traces and Detection Stations

Trace Number	Trace Name	Dye Type & Dye Quantity	Date Introduced	Detection Stations
04-01		1 lb eosine	6/15/04	13,15,19,54,78
04-02		2 lb rhodamine WT	6/15/04	12,52,68
04-03		2 lb eosine	6/30/04	4,5,30,43
04-04		2 lb eosine	7/26/04	12,52,68,85,86
04-05		1 lb rhodamine WT	7/26/04	16,18,53,54,63
04-06		1 lb rhodamine WT	8/30/04	13,15,19,54,70,79,80
04-07		1/3 lb fluorescein	9/10/04	12,52,83,84,85,86
04-08		1 lb rhodamine WT	9/10/04	67,74
04-09		2 lb rhodamine WT	9/30/04	4,87,89
04-10		4 lb eosine	12/1/04	24,25,26,31
04-11		3 lb eosine	12/7/04	48,67,73,75,76,90
05-12		3 lb SRB	1/5/05	48
05-13		1/2 lb fluorescein	1/13/05	16
05-14		2/3 lb fluorescein	1/13/05	87,88,91
05-15		1 lb fluorescein	2/3/05	126,128,137
05-16		1 lb rhodamine WT	2/4/05	94,132
05-17		1/2 lb rhodamine WT	2/28/05	48
05-18		1/2 lb eosine	2/28/05	75,76,90
05-19		1/2 lb eosine	2/28/05	102,131
05-20		1/2 lb rhodamine WT	3/23/05	148
05-21		1/4 lb eosine	4/2/05	163,166
05-22		1/4 lb eosine	4/2/05	126,128,135
05-23		1/2 lb rhodamine WT	4/2/05	102,131
05-24		1 lb eosine	4/2/05	87,89,183,185
05-25		1 oz fluorescein	4/4/05	169
05-26		1/4 lb SRB	4/4/05	166
05-27		1/2 lb rhodamine WT	4/4/05	198
05-28		1/4 lb rhodamine WT	4/4/05	172,173
08-01		1/4 lb fluorescein	11/19/08	12,83,84,85
08-02		3/4 lb rhodamine WT	11/19/08	55
08-03		1 lb eosine	11/19/08	13,53,55,80
09-04		1 lb eosine	2/1/09	67,68,73,74,75,76,90,204
09-05		1/4 lb fluorescein	2/2/09	150,201,202, 203
09-06		3/4 lb SRB	2/3/09	67,68.90,204
09-07		3 lb eosine	4/27/09	75,145.201,203,204
09-08		1/2 lb fluorescein	4/27/09	12,48,86
09-09		1 lb rhodamine WT	4/28/09	150,201,203
09-10		2 1/2 lb eosine	7/7/09	12,48,67,73,75,76,86,90,204
09-11		1/4 lb SRB	7/7/09	67,73,75,90,145,204
09-12		1 lb fluorescein	7/7/09	12,48,86
09-13		1/2 lb rhodamine WT	7/7/09	12

DRAFT

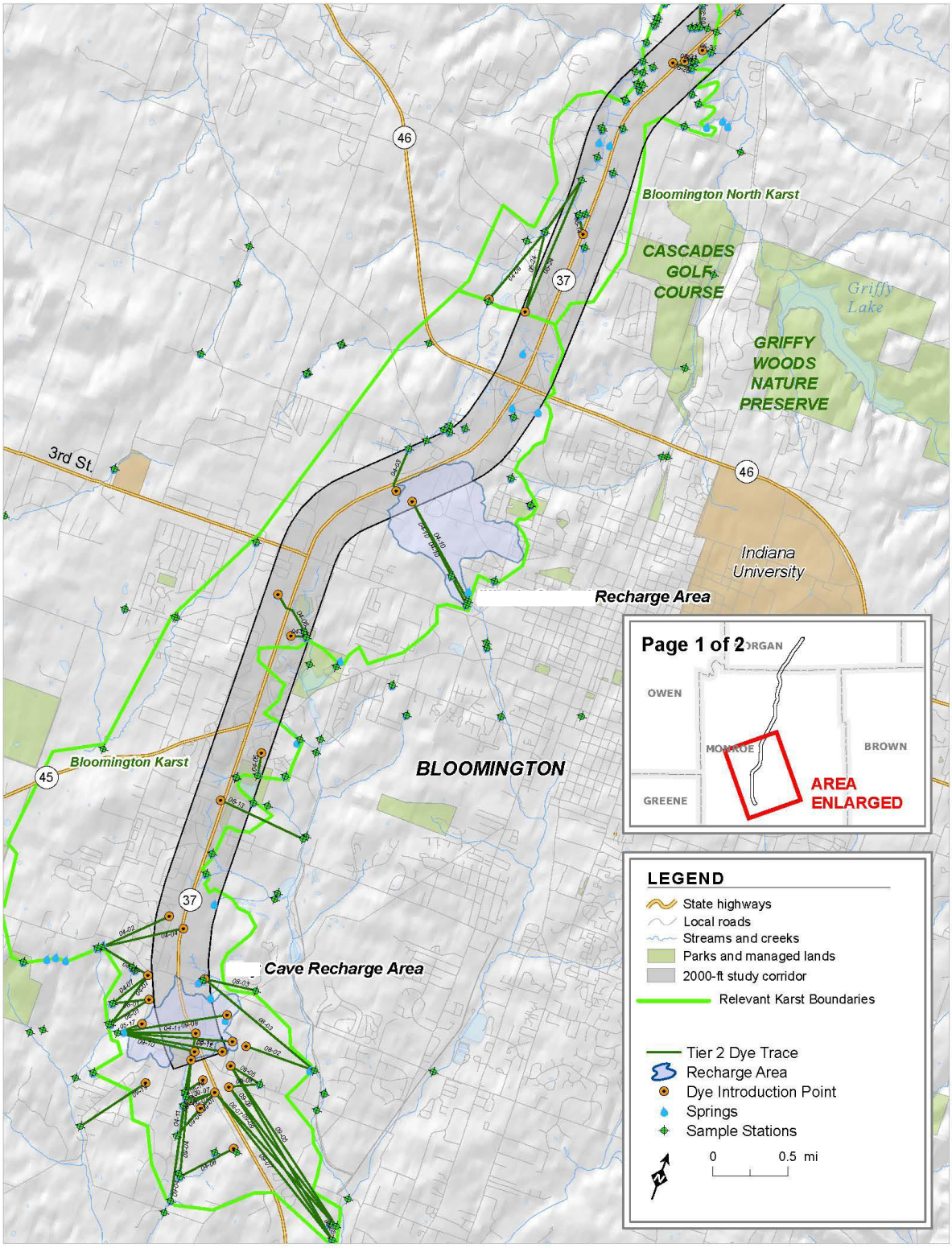


Figure 12 Summary of Dye Tracing for the Bloomington and Bloomington North Karst

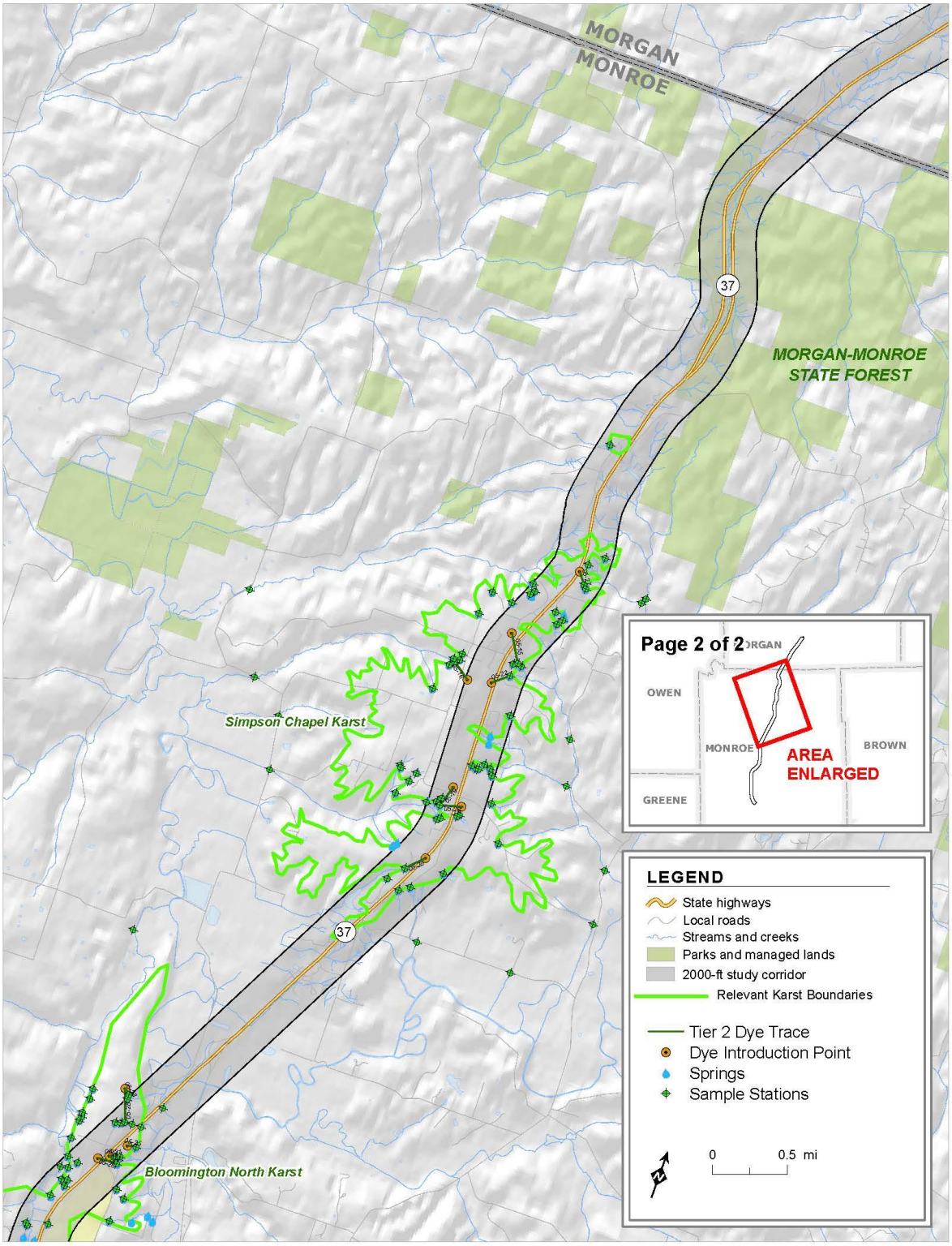


Figure 13 Summary of Dye Tracing for the Simpson Chapel Karst

3.4 Recharge Area Delineations

A recharge area of a spring consists of those lands which contribute at least some water to the spring under some flow conditions. This includes those lands that contribute to dye introduction points that were traced to the spring. Dye introduction points traced to other locations, and the lands that contributed to these points, were deemed to be outside of the recharge area.

While recharge area delineations were not part of the 1993 MOU Items 1-4, the data collected during the Section 5 study permitted revision of the recharge area for:

- Illinois Central Spring, which drains the Lemon Lane Landfill Superfund site.
- Spring, which drains the Cave system - a biologically significant cave that receives water from SR 37 and the Section 5 Corridor.

3.4.1 Illinois Central Spring Recharge Area

Water from the Illinois Central Spring (ILCS) is being treated as part of the Lemon Lane Landfill Superfund site remedial action. Changes to the base and peak flow conditions of this spring are potentially significant to the operations of the treatment facility and have financial, engineering, human and ecological risk implications. The research and refinement of the ILCS recharge area was used, where possible, as part of this evaluation for potential avoidance and/or alternative drainage options for planning and design of the proposed I-69 roadway. The goal will be to avoid an increase in water entering the ILCS recharge area from the proposed I-69, both during and following construction.

A previous recharge delineation of the ILCS groundwater system, which includes and Springs, reported in 1994 by J. R. Fitch was reviewed. The original recharge area delineation was based on five dye introductions made primarily by a graduate student to determine where the water from approximately 24 sinkholes flowed. It also relied on USGS 10-foot contour interval topographic mapping to determine the location of sinkhole boundaries. The current investigation looked not just at the reported results, but looked at the reported analytical data.

The Section 5 studies augmented this delineation by conducting additional dye traces and incorporating higher quality two-foot topographic contour data derived from 2010 LiDAR data. The resulting recharge area was found to be appreciably smaller than had been previously reported. This revision is not represented to have tested the Fitch version of the recharge area; only that area crossing the Corridor. At least one of Fitch's trace results was not reproduced; the nondetection at Spring from GIS insurgence feature No.192, which is the adjacent sinkhole to the west of the sinkhole used by Fitch (GIS insurgence feature No. 203) failed to replicate the detection reported by Fitch from Karst Feature 203. It is possible that professional dye tracing along GIS insurgence feature Nos.198 and 199 might result in additional revisions as no tracing by any party has been done there and the closest trace is about 1,000 feet away from the boundary as drawn.

DRAFT

The majority of the revision came from results of one trace, Trace 04-03, which demonstrated that its sinkhole, which had not been previously traced despite it being the farthest from Illinois Central Spring, does not contribute water to Illinois Central Spring. These empirical data conflict with the interpretation based on assumptions. The remaining revisions are simply the result of better topographic data.

While it is not uncommon in karst areas for recharge areas boundaries to fluctuate under differing flow conditions, it is at least as common for them to not vary with changing flow conditions. While the study did not trace under every possible flow condition, there were no data suggesting that the boundaries of the Illinois Central Spring recharge area vary with flow conditions. The Fitch and augmented delineations, and the traces used for both, are shown on Figure 14.

3.4.2 Cave Recharge Area

Cave (Cave A) is part of a biologically significant cave system that discharges to the surface at Spring. The Cave system includes Cave, Cave Annex, and caves. The recharge areas of the spring and the cave system are nearly equivalent in their geographical boundaries; however, the cave system is underground and consists of relatively small interconnected conduits within this area, and the recharge area is the entire land surface within the defined geographical boundary.

Eighteen dye introductions are relevant to the Cave recharge area. These traces and inclusion of lands that contribute to the dye introduction points were used to delineate the Cave recharge area. Some traces demonstrated lands that recharge Cave, while others demonstrated areas that do not recharge the cave system.

Figure 15 shows the recharge area and relevant dye traces for Spring.

DRAFT

Figure 14 Revised Illinois Central Spring Recharge Area

Figure 15 Recharge Area of Cave

3.5 Cave Biology Results

A biological survey was conducted in Cave, Cave, and Cave, based on a demonstrated connection with SR 37, literature and Section 5 reconnaissance observations, and cave passages and recharge area that cross SR 37. The specific locations of the cave entrances are part of the confidential data and will not be released (**Appendix I**). The biological survey (**Appendix J**) results are shown on Table 10 and are as follows:

- There were no federally listed species identified as part of the biological surveys.
- and caves have not been demonstrated to be related hydrologically, however, they are located fairly near one another.
- Cave has aquatic habitat, but almost no air-filled, enterable passages, and Spring has no troglobitic species.

Table 8 Obligate Subterranean Species Summary

Common Name	Scientific Name	Global Rarity Rank	Listing Status	Ecological Status	Cave	Cave	Cave
Hidden spring snail	*Fontigens cryptica*	G1	State Endangered	Stygobite	X		
Northern cave isopod	*Caecidotea stygia*	G5		Stygobite	X		X
Indiana cave amphipod	*Crangonyx indianensis*	G3		Stygobite	X		X
Packard's groundwater amphipod	*Crangonyx packardi*	G3	State Rare	Stygobite	X		
Barr's cave amphipod	*Crangonyx barri*	G3	State Rare	Stygobite			X
Cave crayfish	*Orconectes inermis testii*	G3	State Threatened	Stygobite	X		X
Barr's cave crayfish ostracod	*Sagittocythere barri*	G3		Stygobite/ Commensal	X		
Subterranean sheet-web spider	*Phanetta subterranea*	G5		Troglobite	X		
Bollman's cave milliped	*Conotyla bollmani*	G3	State Rare	Troglobite	X		
Indiana cave springtail	*Sinella alata*	G3	State Endangered	Troglobite	X		
Mayfield cave beetle	*Pseudanophthalmus shilohensis mayfieldensis*	G1	State Endangered	Troglobite	X		
Cave dung fly	*Spelobia tenebrarum*	G5		Troglobite	X	X	X

DRAFT

Dr. Lewis reported that Cave ranked 9th highest for biological significance out of 484 Indiana caves. The ranking is based on the number of obligate subterranean species (troglobites and stygobites) and species of high global rarity identified from cave bio-inventories in Indiana (Lewis, 2005). Dr. Lewis included caves in Indiana with appreciable data on their biological communities.

The presence of one State-listed Threatened Species in Cave, and two State-listed Endangered Species and one State-listed Threatened in Cave makes these caves and their recharge areas of special concern in Section 5.

Note in reference to **Appendix J**: the State Listing Status has been updated since the generation of Dr. Lewis' report (Lewis, 2005) for the following:

State Listed Species	2005 Status	2012 Status
• Indian cave springtail	State Endangered	State Watch List
• Packard's groundwater amphipod	State Rare	State Watch List
• Cave crayfish	State Threatened	State Rare
• Barr's cave crayfish	not listed	State Watch List
• Bollman's cave millipede	State Rare	State Watch List

The survey report concluded the following:

- There were no federally listed species identified as part of the biological surveys.
- Five troglobitic species were identified in Cave, two of which are State-listed Rare Species (cave crayfish *Orconectes inermis testii* and Barr's cave amphipod *Crangonyx barri*).
- A spring located down gradient of Cave had no troglobitic species.
- had one troglobitic species (cave dung fly *Spelobia tenebrarum*) that are not designated rare or protected.
- Cave had 11 troglobitic species, eight are globally rare, two are State-listed Rare Species (Barr's cave amphipod *Crangonyx barri* and cave crayfish *Orconectes inermis testii*), four species are on the State Watch List (Barr's cave crayfish ostracod *Sagittocythere barri*, Packard's groundwater amphipod *Crangonyx packardi*, Bollman's cave millipede *Conotyla bollmani*, and Indiana cave springtail *Sinella alata*), and two are State-listed Endangered Species (hidden spring snail *Fontigens cryptica* and Mayfield cave beetle *Pseudanophthalmus shilohensis mayfieldensis*).

DRAFT

3.6 Annual Pollutant Load Estimates

The Karst Memorandum of Understanding (MOU) dated 1993 between INDOT, IDNR, IDEM, and the USFWS delineates guidelines for construction of transportation projects in karst regions of the state. As part of the I-69 project, the USEPA has also been invited to participate in the MOU activities review process. The MOU signatory agencies and the USEPA have been informed that Steps 1-4 of the Karst MOU will be followed as part of the National Environmental Policy Act (NEPA) study for Sections 4 and 5 of the I-69 project. Step 2 of the Karst MOU states the following "….Calculations of estimates of annual pollutant loads from the highway and drainage within the right-of-way will be made, including prior to, during and post construction estimates. The design of the treatment of the karst features will take into consideration treatments necessary to meet the standards of the monitoring and maintenance plan…."

This section summarizes key points from the research gathered as part of the karst pollutant loading estimations for the Tier 2 EIS of I-69 Section 5 in Monroe County. It also discusses the attempts made and limitations to compute the pollutant loadings as a desk top exercise, or without actual field sampling, using a Federal Highway Administration (FHWA) published process.

3.6.1 INDOT's Previous Karst Study on SR 37

In April 1996, Earth Tech prepared "Results of MOU-Related Karst Studies for Indiana State Road 37, Lawrence County, Indiana (1992-1995)" for INDOT. This document described the Karst MOU and documented the results of the BMP's used both during and after construction. The project was to reconstruct SR 37 from a two-lane highway to four-lane divided between SR 60 (Mitchell) to US 50 (Bedford). In general, INDOT used the following steps to fulfill the Karst MOU:

1. Survey all karst features directly or indirectly affected by the project
2. Delineate sub-surface drainage routes using dye-tracing.
3. Install drainage structures (Best Management Practices (BMPs)) such as settlement basins, peat filters and rock filters to all karst features within the right-of-way. The size and type of each BMP was estimated based on the drainage area and type of karst feature. By all indication, the choice of the BMP was an estimation with the understanding that monitoring of the BMP is essential to assure its effectiveness.
4. Collect samples of runoff at the BMP's both during and after construction and test for pollutants (e.g. lead, zinc, copper, etc.). These samples were collected during six storm events between February 1993 and August 1995. The concentrations of pollutants were compared to Indiana's Water Quality Standards for aquatic life and drinking water.
5. Observe the BMP effectiveness at conveying stormwater during rain events. Most BMPs proved effective, although some need to be enlarged or their drainage basins enlarged to assure water was not going to pond onto the roadway.

DRAFT

The study concluded that less than 2 years after construction, the pollutant concentrations in the runoff were reduced to what one would expect prior to construction. As long as the filter systems operate as designed, no long term effects to karst features is expected.

In the short term (within two years after construction), high levels of Total Suspended Solids (TSS) and Total Recoverable Metals (TRM) (copper, lead, zinc, etc.) were found. This was likely due to the fact the BMPs were installed prior to earthwork and grading activities. Therefore, even though the BMP filters and normal erosion control measures were monitored, the filters were typically found to be clogged. The study does not give a recommendation on how to remediate this.

3.6.2 Kentucky's Previous Karst Study on I-65 at Mammoth Cave

As part of the literature research conducted, a report completed by the Kentucky Transportation Center, "Evaluation of Methods to Protect Water Quality in Karst Areas: Phase I" was reviewed. This study, done for the Kentucky Transportation Cabinet in October 2003, analyzed pollutant loads to karst features near an interchange of I-65 and an entrance to Mammoth Cave. The procedures detailed in the study match those of Indiana's Earth Tech report. Field samples were collected to find the pollutant concentrations and those values compared to national standards. Their findings were highway runoff pollutant loadings were minimal. Additional phases of the research report were to study other karst features throughout the state, and report a methodology that could be used for loading calculations and BMP design. One of the authors was contacted to check the status of additional phases to the study; however none have been completed at this time.

3.6.3 Karst Features to Analyze

The karst survey identified over 672 karst features in the karst study area. About 319 features are located within the 2,000' wide Corridor of Section 5, 77 within existing SR 37 right-of-way, and 110 inside the total proposed right-of-way for Preferred Alternative 8. The drainage areas for all these features were estimated using GIS software and are listed in **Appendix L** of this report. It was assumed that any karst feature inside the construction limits would be capped, so its pollutant load estimate is zero. A karst feature had to be outside the construction limits (or with a portion outside the construction limits) yet inside the proposed right-of-way to be eligible for analysis. The number of features that fit this criterion is 53 Pre-Construction (Existing) and 72 Post-Construction (Proposed).

The calculation of the pollutant loadings into the karst features required some assumptions; primarily when delineating how much of the proposed right-of-way would drain into the karst feature. Three main assumptions were made, all likely erring on the side of a higher pollutant loading than what will realistically occur after construction:

1. It was assumed that the entire right-of-way width would drain into the karst feature. In many cases, this is highly unlikely. For instance, if a karst feature is located on the backslope of a ditch along the southbound lane, there is no guarantee that highway run off from the median or ditch along the northbound lane would drain to the karst feature

DRAFT

on the other side of the road. More often than not, the road acts as a barrier, preventing runoff from being conveyed from one ditch to the other. The only exception would be if a cross culvert or median drain would convey drainage to a karst basin.

2. Also, where multiple karst features are located within the same right-of-way drainage area, the pollutant loading calculation for each feature assumed no run off would drain into the other features. In all likelihood, the karst features would share the runoff volumes.

3. Finally, the roadside and median ditches are designed for conveyance and outlet into streams and creeks, not into karst features such as sinkholes or swallets. Therefore, it is reasonable to assume runoff may not find its way to a feature, instead traveling along the ditch grades and culverts as designed and constructed. The pollutant loading calculation assumed the entire right-of-way would drain into the karst feature, and not be conveyed elsewhere.

3.6.4 FHWA Highway Runoff Water Quality Training Course

FHWA conducted a class on water quality and storm water runoff from highways. Section 8 of this workshop dealt with models and studies that have been developed to predict pollutant loads without field measurements. The first part of the model calculates pollutant load estimates, developed in the late 1970's using field data from monitoring programs in various states. The second part estimates the pollutant concentrations and compares them to water quality standards. The third part estimates the pollutant loads in the "background", or what occurs before the highway is built. This methodology is included in **Appendix L** of this document.

3.6.4.1 Part 1: Pollutant Loadings from Highway Runoff

In order to estimate the pollutant loading from the highway runoff, the length of the road that would drain into the karst feature must be estimated. This included the area of the karst feature within the existing SR 37 right-of-way (≥0.3 acres) for existing conditions and the area of the karst feature within the Preferred Alternative 8 right-of-way for post construction conditions. The pollutant loading calculation assumes the *entire* highway right-of-way along this length would drain into the karst feature. This is unlikely, given the three drainage ditches (two roadside and the median) are not designed to convey drainage to karst features. For instance, if a karst feature is located inside the roadside ditch along the southbound lanes, there is no guarantee (and in fact is very unlikely) that cross culverts would be installed to convey drainage from the other roadside ditch and the median under the road to the karst feature.

The model estimates the pollutant loading by first determining the load of total solids. Once that load is found, regression equations are used to determine the load for other various pollutants (lead, copper, zinc, etc.). The theory behind this is solids act as "carriers" for other pollutants, so the higher the solids the higher the metals and other pollutants. The estimated pollutant load prior to the rain event is calculated using the daily traffic estimate. It is assumed that the road has not been washed of pollutants in 20 days, which the study's analysis determined to be an adequate length of time for an accurate initial load estimate. The initial pollutant load is then

DRAFT

modified to account for the runoff rate. This rate was calculated using National Oceanic and Atmospheric Administration (NOAA) data four design storms:

1. 1-year/1-hour design storm (1.21 inches)
2. 2-year/24-hour design storm (3.16 inches)
3. 5-year/24-hour design storm (3.92 inches)
4. 50-year/10-minute design storm (1.20 inches)

The rate also takes into account the drainage control on the highway, in this case, open median and ditches, and the length of highway within the drainage basin of the particular karst feature. The I-69 Section 5 project was considered a Type II roadway, which is indicative of an urban setting with some curb or barrier, structured drainage, and grassy right-of-way.

Once the runoff and rain data is taken into account, the pollutant loading of total solids at each karst feature was calculated. Regression models are then used to determine the pollutant load (pounds) for other pollutants. For karst features with very small drainage areas, some of the regression equations produce values in the negative. It should be assumed, for these cases, the load is zero. **Tables 1-1, 1-2, 1-3, and 1-4** included in **Appendix L** summarize the pre-construction (Existing) pollutant mass loadings for each of the four design rainfall events (1-year/1-hour, 2-year/24-hour, 5-year/24-hour, and 50-year/10-min) for Preferred Alternative 8. **Tables 1-5, 1-6, 1-7, and 1-8** show the post-construction (Proposed) pollutant mass loadings for each of the four design rainfall events.

3.6.4.2 Part 2: Pollutant Concentrations from Highway Runoff

The pollutant loadings calculated in Part 1 can then be modified into concentrations. The loadings are divided by the volume of rain water (for a particular rain event) inside the right-of-way that would drain into the karst feature. **Tables 2-1, 2-2, 2-3, and 2-4** in **Appendix L** summarize the pre-construction (Existing) results of the pollutant concentration estimates for each design rainfall event for the Preferred Alternative 8. **Tables 2-5, 2-6, 2-7, and 2-8** show the post-construction (Proposed) pollutant concentration estimates for each of the four design rainfall events.

Concentrations of pollutants are then compared to Indiana's Water Quality Standards for aquatic life and drinking water. These standards are from Indiana Administrative Code (327 IAC 2-1-6) and assume a hardness of 250 mg/L. The five pollutants that are exceeded the most often are lead, copper, total nitrogen, cadmium and mercury. **Table 9** below summarizes the results for those five pollutants for pre-construction (Existing) and post-construction (Proposed) for the four types of rain events analyzed. The more intense the rain event, the more wash-off of the highway will result and the less settling of solids in the ditches, hence the 1-year/1-hour event shows more pollutants exceeding the water quality standards. The FHWA course materials state that caution must be used when interpreting the pollutant loadings of lead predicted by the model. The reduction in lead in gasoline has resulted in an estimated 50% reduction in lead loadings since the predictive equation was developed.

DRAFT

Table 9 Summary of Karst Features Exceeding Water Quality Standards for Preferred Alternative 8[1]

Design Rainfall	No. of Features Exceeding Water Quality Standards[2]					Highest Concentration (mg/L) / Feature ID				
	Lead	Copper	Total Nitrogen	Cadmium	Mercury	Lead	Copper	Total Nitrogen	Cadmium	Mercury
Pre-Construction (Existing)										
1-year/ 1-hour	53	53	53	53	53	2.847 (i020)	1.205 (i020)	9.040 (i082)	0.269 (i082)	0.006 (i020)
2-year/ 24-hour	53	49	53	53	38	0.668 (i020)	0.331 (i020)	3.302 (i182)	0.098 (i182)	0.001 (i020)
5-year/ 24-hour	53	45	53	53	37	0.602 (i020)	0.286 (i020)	2.686 (i182)	0.080 (i182)	0.001 (i020)
50-year/ 10-min	53	53	53	53	53	2.872 (i020)	1.216 (i020)	9.116 (i182)	0.271 (i182)	0.006 (i020)
Post-Construction (Proposed)										
1-year/ 1-hour	72	72	72	72	70	5.065 (i017)	1.876 (i017)	10.386 (i017)	0.322 (i017)	0.012 (i017)
2-year/ 24-hour	72	62	72	72	59	1.154 (i017)	0.475 (i017)	3.509 (i182)	0.104 (i182)	0.003 (i017)
5-year/ 24-hour	72	60	72	71	54	1.048 (i017)	0.419 (i017)	2.872 (i182)	0.086 (i182)	0.002 (i017)
50-year/ 10-min	72	72	72	72	70	5.109 (i017)	1.892 (i017)	10.474 (i017)	0.324 (i017)	0.012 (i017)

[1] The lowest of the three Water Quality Standards listed in the IAC is 0.01 mg/L for lead, 0.01 mg/L for total nitrogen, 0.0023 mg/L for cadmium and 0.00014 mg/L for mercury.
[2] Total number = 53 Pre-Construction (Existing) features and 72 Post-Construction (Proposed) features.

According to the FHWA estimating calculations included in **Appendix L** and summarized above in Table 9, both the existing SR 37 right-of-way and proposed Preferred Alternative 8 exceed the applicable water quality standards. The increase in the total number of features exceeding water quality standards from Pre-Construction (Existing) conditions to Post-Construction (Proposed) conditions is associated with the increased number of features within existing SR 37 right-of-way to the proposed Preferred Alternative 8 right-of-way. In addition, many of the specific features are within existing or planned local development areas that are not related to the Section 5 project such as:

- The northern ½ of feature i17 is located within an area planned for commercial development as part of the South Monroe Medical Park while the southern ½ includes residential development along West Watson Drive and South Rockport Road.

- Most of the i020 feature is covered with local roads, commercial development along West Fullerton Pike South Monroe Medical Park Boulevard (such as the multi-building Monroe Hospital and Golf Car complexes), and residential development along Judd Avenue and West Jordan Court.

DRAFT

4.0 POTENTIAL MEASURES TO OFFSET IMPACTS TO KARST

The intent of the 1993 MOU is to minimize impacts to karst from road construction and operation via four preferred strategies, listed in order of preference: avoidance, alternative drainage, mitigation/treatment, and operations and maintenance. Each is discussed briefly below.

4.1 Avoidance

The 1993 MOU indicates that avoidance is the best alternative for preventing impacts to karst features. Due to the constraints of the Section 5 Corridor, appreciable development on and along SR 37, and connections to the existing infrastructure, the opportunities to avoid karst features are limited.

4.2 Alternative Drainage

The 1993 MOU indicates that providing alternative drainage is the second measure in order of preference to offset impacts to karst. Alternative drainage entails controlling roadway runoff and redirection of runoff to alternative drains, features or surface water bodies instead of insurgence features (sinkholes and losing streams). Alternative drainage has two potential drawbacks:

- Reduction of existing water quantity where there are aquatic species of concern.
- Potential to increase flooding downstream of the redirected drainage.

These concerns should be considered when evaluating the alternative drainage options. Additional data may need to be collected in order to adequately assess such measures. Hazardous waste, ecologically sensitive populations, and limited potential for flooding at several of the areas of special concern may outweigh other considerations during evaluation of preventive measures. Drainage and treatment alternatives will be considered concurrently so as to not impede drainage in recharge areas and having potentially harmful impacts to cave biota.

4.3 Mitigation/Treatment

The third measure indicated in the 1993 MOU is mitigation or treatment, such as peat-sand filters, gravel filters, vegetative buffers, and lined spill or runoff containment structures. Use of filters, buffers, containment structures, reinforced soil, void grouting, compaction grouting, concrete caps, reinforced bridging slabs (land bridges), deep foundations, etc. are potentially effective mitigation measures, but will not be determined until subsequent detailed design stages. Each of these would be designed to reduce or prevent contaminants from entering the karst groundwater system.

DRAFT

4.4 Operations and Maintenance

The fourth measure, operations and maintenance, is actually a supplement to alternative drainage and mitigation/treatment and includes the following actions:

- Mowing protocols to minimize the formation of soil pipes and liner failures (such as were frequently observed along SR 37 during this investigation).
- "No mowing" and/or "no spray" zones.
- Inspection of drainage systems for leaks or other failure modes.
- Maintenance and routine inspection of containment structures for capacity to contain a spill (i.e., removal of sediment or standing water) and structural integrity.
- Monitoring and testing of treatment systems to meeting system specifications. Use of filters, buffers, containment structures, reinforced soil, void grouting, compaction grouting, concrete caps, reinforced bridging slabs (land bridges), deep foundations, etc. are potentially effective mitigation measures, but will not be determined until subsequent detailed design stages.

DRAFT

5.0 SUMMARY AND CONCLUSIONS

The report study results are specific to conditions identified within the Section 5 study area. Although some particular karst features may be avoided, since Section 5 is essentially the upgrade of the existing four-lane divided highway SR 37 to a new four to six-lane divided interstate I-69, karst geology cannot be avoided within the Section 5 Corridor. Therefore, the focus of alignment and design should be on minimizing impacts via alternative drainage, mitigation/treatment, and operations and maintenance.

5.1 Karst Settings Description and Distribution

5.1.1 Bloomington Karst

The Bloomington Karst extends from approximately Clear Creek ,south of the Section 5 Corridor northward through Section 5 from That Road to approximately Arlington Road (old SR 46) and is developed in the St. Louis Limestone. The contact with the underlying Salem Limestone generally forms the lower limit of fast-flow groundwater circulation. Springs tend to be located at the contact between the St. Louis Limestone and the Salem Limestone. Springs draining the Bloomington Karst are typically contact springs, but are not limited to valley heads. The St. Louis Limestone has relief developed in excess of 150 feet (see elevation loss in Table 8). Recharge areas for springs generally include the grade of SR 37. These springs are being impacted by current road use and maintenance, development along SR 37, and other non-road related activities within their recharge areas.

The Bloomington Karst is the most extensive of the three karst areas investigated, and was crossed by about 36,000 linear feet of Section 5 Corridor. A total of 232 sinkholes and 64 springs were identified and associated with this karst during the study. The largest discharge springs in Section 5 are in the Bloomington Karst.

Illinois Central Spring is the most studied spring associated with Section 5. During the main investigation, mean daily discharge from Illinois Central Spring was 257 gpm and ranged from a daily discharge of 18 gpm to 3,916 gpm. The variation in discharge appeared to be representative of springs in the Section 5 study area.

A total of 27 dye introductions were conducted in the Bloomington Karst. Straight-line distances from the dye introduction points to the resurgent springs had a mean length of 3,023 feet and ranged from 341 to 7,098 feet. The Bloomington Karst mean trace length was longer than that of the Bloomington North Karst and Simpson Chapel Karst to the north.

Three losing streams that recharged karst groundwater systems were determined via dye traces in the Bloomington Karst.

Discrete recharge was not limited to sinkholes and losing streams, as some traces demonstrated discrete recharge from insurgence features without surface expression. Some rapid movement of water into karst groundwater systems can occur from locations where there is no surface

DRAFT

expression to indicate the drainage conditions. This would be especially true in areas where the landscape has been modified and resulted in filled or altered sinkholes.

5.1.2 Bloomington North Karst

The Bloomington North Karst extends from about Arlington Road north to Kinser Pike at the southern slope of the Beanblossom Creek Valley and is developed in the Ramp Creek and Harrodsburg Limestones. The karst development is limited by underlying Edwardsville Shale that serves to perch the groundwater in the Ramp Creek Limestone. Karst development extends only 25 to 40 feet below sinkhole bottoms. Springs were typically small, just above the contact, and were generally found in valley heads. About half of the insurgence features and some of the springs in the Corridor were at higher elevations than the SR 37 grade.

Approximately 11,775 feet of the Section 5 Corridor crossed the Bloomington North Karst, the smallest of the three karst areas. A total of 99 sinkholes and 38 springs associated with this karst were identified during this investigation. The sinkholes were smaller on average than those found in the other two karst areas.

Seven dye introductions were conducted in the Bloomington North Karst. Straight-line distances from the dye introduction points to the resurgence springs had a mean length of 1,567 feet and ranged from 243 to 5,052 feet. This reflected the thin nature of the karst and the termination at the edges of the ridge tops.

5.1.3 Simpson Chapel Karst

The Simpson Chapel karst extends from Wayport Road at the northern slope of the Beanblossom Creek Valley and continues north to just south of Chambers Pike. This karst area was known to some local karst experts and appeared on a map produced by the IGS (Harke and Gray, 1998). The geology is similar to the Bloomington North Karst with development from 25 to 60 feet below sinkhole bottoms. Most of the insurgence features are above the SR 37 grade; therefore, many springs are not receiving road runoff. SR 37 was cut into the limestone through most of this area and was essentially redirecting runoff to other lower elevation karst features, or off the karst entirely.

Approximately 17,000 feet of the Section 5 Corridor crossed the Simpson Chapel Karst and was restricted to ridge tops. A total of 112 sinkholes and 57 springs associated with this karst were identified during this investigation. Road cuts on existing SR 37 often cut through karst in this area. In addition, many of the karst features in this area are not visible from roadways.

Seven dye introductions were conducted in the Simpson Chapel Karst. Straight-line distances from the dye introduction points to the resurgence springs had a mean length of 775 feet and ranged from 478 to 1,094 feet. This reflected the thin nature of the karst and the termination at the edges of the ridge tops. All of the dye introductions in this area were in sinkholes because no streams crossed the Simpson Chapel Karst (the stream channels have cut into the underlying shale).

DRAFT

5.2 Drainage Patterns and Land Use

Drainage patterns seem to have evolved quickly in some areas due to changes in land use. Numerous springs that had been used in previous investigations during the past 15 years were observed to have ceased discharging water. Some of these appear to have had sufficient flow since previous investigators had installed weirs to measure discharge.

In general terms, SR 37 was near both the topographic drainage divides as well as near the groundwater divides. Figures 16 and 17 show the difference between the topographic basin divides and the groundwater drainage divides. These divides do not correspond in all of the tested locations and it should be assumed that not all of the locations that transfer water between topographic basins were identified.

The 2010 land use (based on field reviews and updates of a GIS land use layer provided by the Monroe County Planning Department (2006 data and 2012 updates[7]) in the relevant karst portions of Section 5 included the following:

- Agricultural — 337 acres or 9.2%
- Nonresidential/ Industrial — 478 acres or 13.0%
- Public Use and Institutional — 103 acres or 1.2%
- Mines and Quarries — 133 acres or 1.3%
- Residential — 636 acres or 17.3%
- Water — 18 acres or 0.5%
- Transportation, Communication and Utilities — 739 acres or 20.1%
- Upland and Wetland Habitat — 1,321 acres or 35.9%
- Planned Development[8] (by 2035) — 735 acres or 20.0%

As shown above, substantial portions of the Bloomington area have been developed. With an additional 735 acres or 20.0% of the relevant karst within the land use area planned for development by 2035 (based on only those specific areas of development identified by the local planning staffs [City of Bloomington and Monroe County]), the trend is for continued development, with corresponding increases in impervious surfaces, utility lines, drainage alterations, and potential sources of contaminants.

The relevant karst in the Section 5 study area has been impacted by residential and commercial/industrial development of the greater Bloomington area. This development is projected to continue regardless of potential interstate highway development.

[7] Include post 2006 Section 5 DEIS updates (such as land cover, land use, population growth, planned development, setting, bedrock, Monroe County 2010 aerial photography and 2-foot contours (see page 1).

[8] Specific sites of planned development were identified during the coordination process with planners from the City of Bloomington and Monroe County and placed in the project GIS. This development is anticipated to occur independent of the proposed project.

DRAFT

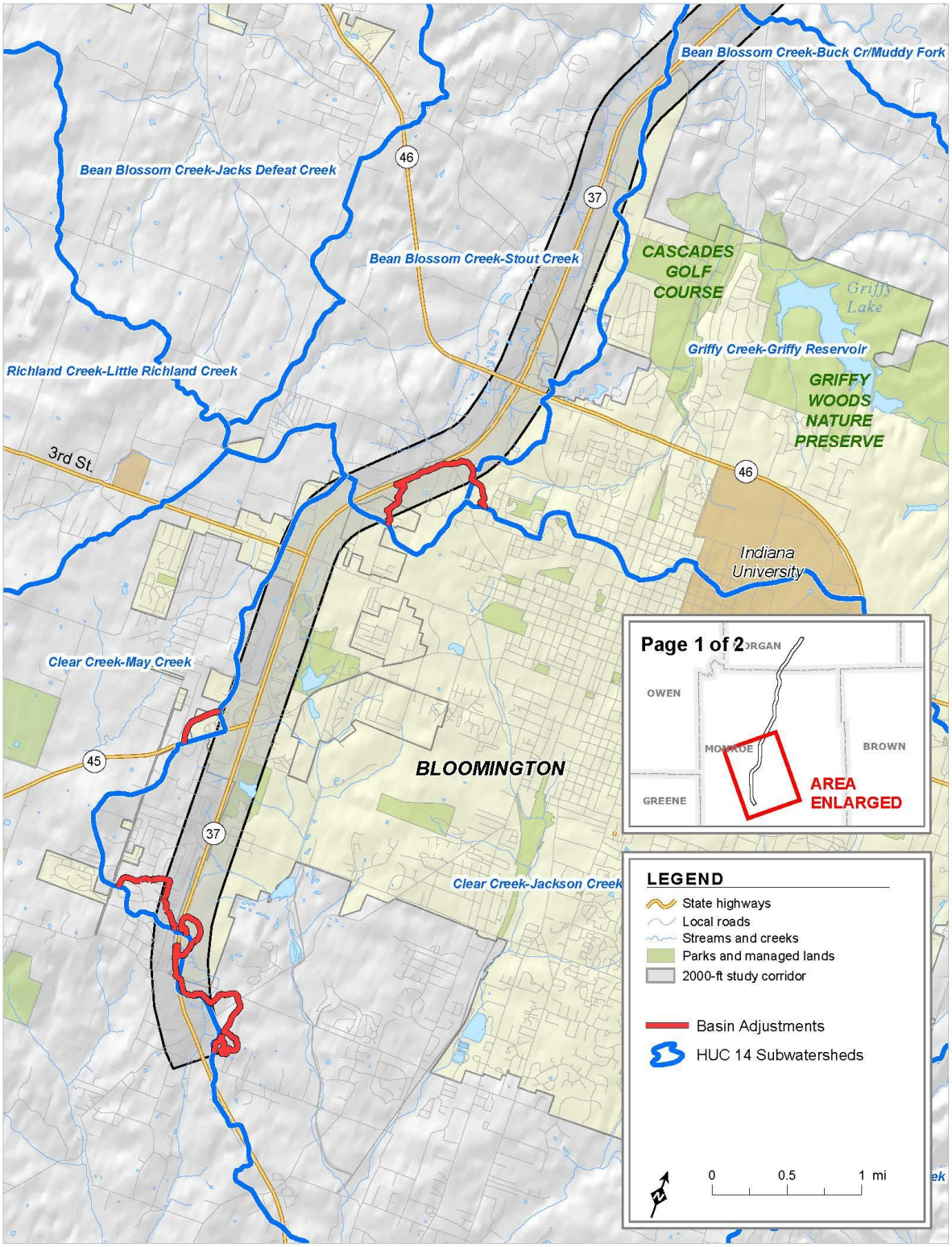


Figure 16 Adjustment of Sub-Watershed Boundaries Resulting from Dye Tracing - Bloomington and Bloomington North Karst

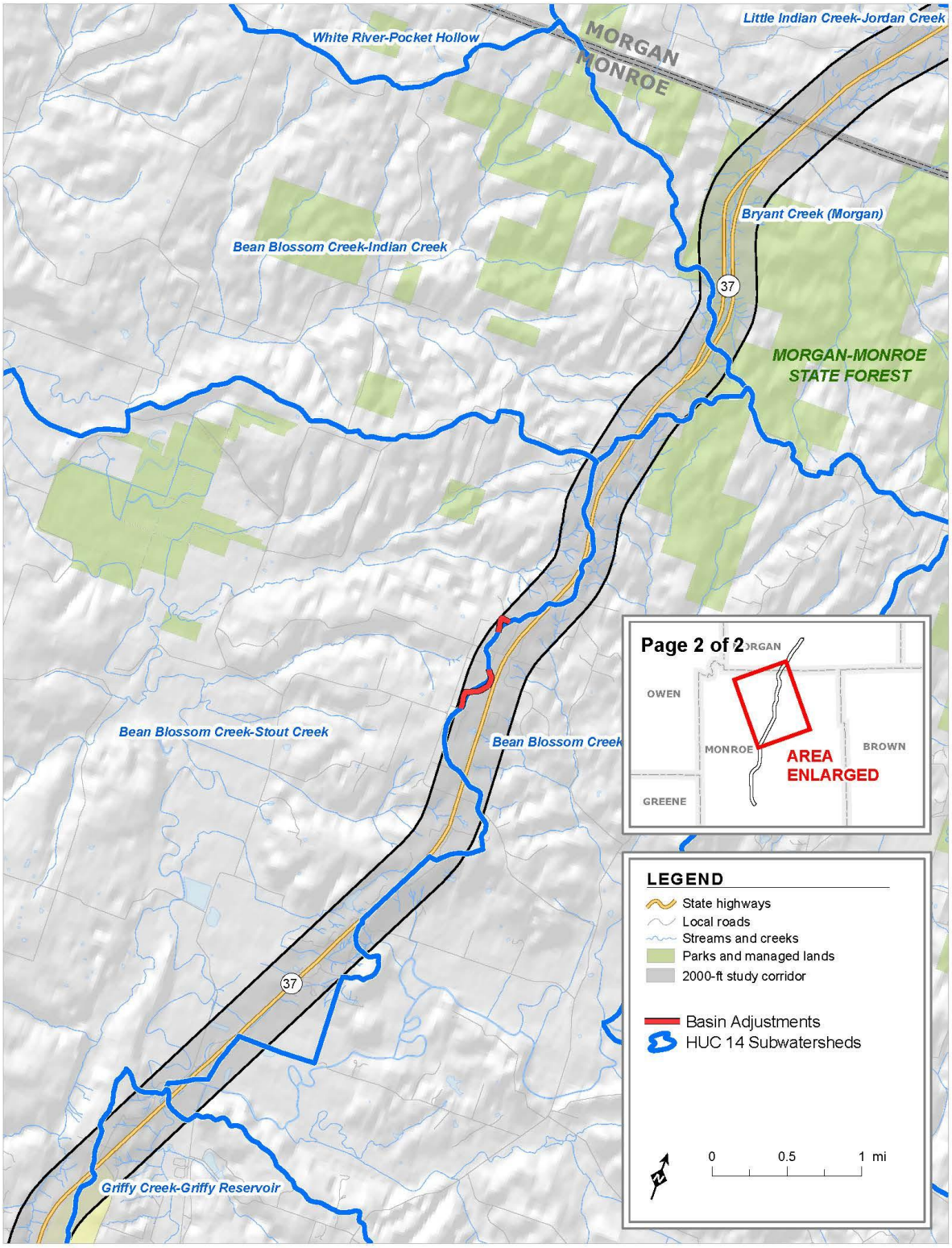


Figure 17 Adjustments of Sub-Watershed Boundaries Resulting from Dye Tracing (Simpson Chapel Karst)

5.3 Dye Tracing

Forty-one dye introductions were made during this investigation. These dye introductions demonstrated 59 groundwater flowpaths, many to previously undocumented springs. Eighteen relevant previous dye traces and two Section 4 traces were used in this investigation for a total of 80 traced groundwater flowpaths. A total of 143 previously unreported springs were found in this investigation, over 3,800 samples were analyzed for the presence of fluorescent tracer dyes, and the dye-tracing program demonstrated the existence of three losing/sinking streams and their resurgences.

5.4 Characterization of Karst Groundwater Flowpaths

While the Bloomington Karst has longer and slower groundwater flowpaths than the other karst areas, these relatively slow flowpaths were still faster than those generally found in non-karst areas. Velocity tended to be in the hundreds to thousands of feet per day, and water from the fast-flow regime tended to travel from the surface to a spring in one to two days. The slower velocity is likely due to the lower average groundwater gradients.

The flowpaths in the Bloomington North Karst and Simpson Chapel Karst tended to be relatively shorter and faster than those in the Bloomington Karst, with velocities up to 48,000 feet per day. Travel times in the fast-flow regime typically ranged from minutes to one day for water to leave the surface and discharge at the springs.

The pathways traced are in turbulent flow regimes based on documented travel times and are competent to carry sediment, material adsorbed to sediments, bacteria, and dissolved loads into and through the groundwater system. These streams have most of the characteristics of surface streams, like surface streams, their flow velocity and ability to carry sediment varies dramatically with changes in discharge. The discharge of the springs investigated varied by at least two orders of magnitude. During the investigation, mean daily discharge from the ILCS was 257 gpm (**Appendix H)** however, the range for mean daily discharge was 18 gpm to 3,916 gpm. The hydrologic characteristics of the ILCS were representative of springs in the study area.

Most of the dye introductions in this area were in sinkholes. Sinkholes were the most common insurgence feature found in Section 5 and the dominant insurgence feature in which traces were initiated. Most of the sinkholes did not have bedrock exposed in them and did not have visible openings draining them. While only three traced insurgence features out of 28 had visibly open drain points, ponded water was observed in two features at the time of dye introduction. These observations indicated that dissolved contaminants would not be detained in the sinkholes, even if the sinkholes did not have obvious openings.

SR 37 tended to follow the sub-watershed boundaries with the groundwater divides fairly close to the topographic divides; thus, water generally flowed away from SR 37 through relatively short pathways (hundreds of feet to about one-half mile) to springs on either side of SR 37. Clearly there were karst flowpaths that crossed under the Corridor (and under SR 37); however, it was generally the headwaters of these systems that passed visibly, or via culverts, under SR 37.

DRAFT

For a karst groundwater system, the study area systems were relatively small and simple. Despite the relatively large number of springs found, the investigation revealed that there were relatively few interconnections among the groundwater systems, although that is less true south of That Road. Most traces were detected at only one spring, and most of the remaining traces showed some minor leakage to a nearby spring. The traces did not reproduce the complex flowpaths in the Bloomington area that appear in the resource literature and were reported as having trace detections of dye (Fitch 1994).

South of That Road, there is a relatively large shared recharge area that contributes water to Spring, Spring Spring, Springs, and Spring as demonstrated by Traces 09-05, 09-07, and 09-09. These hydrologically linked groundwater systems have karst groundwater flowpaths that range from generally east to southeast, to southwest, to nearly west.

There is also the hydrologically complex tributary containing Spring (GIS insurgence feature No.ss1) that had three dye introductions made at different locations in it; 04-11, 09-04, and 09-10. This stream has losing reaches, springs, and possibly gaining reaches. Water discharged at the in-channel springs Upstream of Spring and Spring sinks through the stream channel, at least in part, to later resurge at Spring and Spring . Spring receives water, in part, from Spring. The stream reach between Rockport and That Roads loses water to Cave.

The Section 5 karst groundwater systems tend to be small and relatively isolated; therefore, a single spill along the roadway, even if uncontained, would generally impact a single, relatively small groundwater system. The only significant cave system linked hydrologically to the Section 5 Corridor is the Cave System that receives water from a relatively small part of the Corridor. South of the Cave recharge area to the Section 5 southern terminus with Section 4, the flowpaths are longer and shared recharge areas become more common.

5.5 Cave Biology

Cave and Cave and their associated conduits, groundwater systems and recharge areas were identified for a supplemental biological survey based on their connection to SR 37, and literature and reconnaissance observations conducted as part of the Section 5 investigation. OUL and its subcontractor, Lewis & Associates, conducted the survey (**Appendix J**).

The survey report concluded the following:

- There were no federally listed species identified as part of the biological surveys.
- Five troglobitic species were identified in Cave, one of which was a State-listed Threatened Species (cave crayfish [*Orconectes inermis testii*]).
- Spring had no troglobitic species.
- cave had one troglobitic species that was not designated rare or protected.

- Cave had 11 troglobitic species, eight were globally rare, two were State-listed Rare Species, one was a State-listed Threatened Species (cave crayfish [*Orconectes inermis testii*]), and two were State-listed Endangered Species (hidden spring snail [*Fontigens cryptica*] and Mayfield cave beetle [*Pseudanophthalmus shilohensis mayfieldensis*]).

Cave was ranked 9th most significant biological community out of 484 caves according to the number of obligate subterranean species (troglobites and stygobites) and species of high global rarity from cave bioinventories in Indiana (Lewis, 2005).

Cave and Cave were considered biologically significant due to the state-listed species demonstrated to occupy them. Special measures may be required to protect these fauna from potential impacts from road construction, operation, and maintenance.

Note that the State Listing Status has been updated since the generation of Dr. Lewis' report (Lewis, 2005) included for the following:

State Listed Species	2005 Status	2012 Status
Indian cave springtail	State Endangered	State Watch List
Packard's groundwater amphipod	State Rare	State Watch List
Cave crayfish	State Threatened	State Rare
Barr's cave crayfish	not listed	State Watch List
Bollman's cave millipede	State Rare	State Watch List

5.6 Areas of Special Concern

This investigation revealed four areas of special concern: Lemon Lane Landfill, Bennett's Dump, the area around the 2nd Street interchange with SR37, and Cave. Each is discussed in the following sections.

5.6.1 Lemon Lane Landfill

Lemon Lane Landfill is a Superfund site and is described below in its USEPA Record of Decision Summary:

- *The original remedy for the Lemon Lane Landfill (as described in the Consent Decree and the Enforcement Decision Document) called for the excavation of approximately 196,000 cubic yards of material disposed of after 1958. The 1958 level within the landfill was based upon records which indicated that polychlorinated biphenyls (PCBs) disposal occurred after 1958. The PCB contaminated material was to be treated through the construction of a permitted, Toxic Substances Control Act (TSCA) approved municipal solid waste-fired incinerator. The modified remedy for the source control operable unit at the Lemon Lane Landfill consists of the following:*
    - *Excavation and removal of selected areas of contamination (referred to as hot spots) contaminated with greater than 50 parts per million (ppm) PCBs on average, and disposal of the excavated soils and materials in a commercial,*

DRAFT

permitted chemical waste landfill. The estimated volume of material is 38,000 cubic yards.

- *All PCB oil filled capacitors discovered during the hot spot excavation will be incinerated off-site in a permitted, commercial incinerator capable of meeting a destruction and removal efficiency of 99.9999%.*

- *Construction of a Resource Conservation Recovery Act (RCRA) Subtitle C compliant cap meeting the permeability requirements of 1 x 10-7 centimeters per second (cm/sec) placed over the landfill surface to address the low level threat wastes remaining. To limit surface water from migrating into the landfill, lined drainage ditches will be put in place to control water run on and runoff from the site.*

- *Areas outside the landfill cap to the north, east and west side of the site and outside the site fence line will be remediated to high occupancy/residential standard of 2 ppm PCBs on average. Areas within the fence line not covered by the landfill cap will be remediated to a low occupancy standard/industrial standard of 10 ppm PCBs on average with 10 inches of clean soil cover. Areas on the south side of the site that are outside the final cap, including the railroad berm will be remediated to 20 ppm PCBs on average.*

- *Development of a long-term inspection and maintenance plan for the landfill cap along with groundwater, springs, and surface water monitoring program for governmental parties approval.*

- *Treatment by off-site incineration of PCB oil filled capacitors is included as part of the remedy thereby partially meeting the requirement of reduction in toxicity, mobility, or volume through treatment. Off-site landfilling of PCB contaminated landfill material does not reduce the toxicity or volume through treatment, but does reduce mobility and is justified based upon the large quantities of municipal landfill waste mixed with industrial waste that was disposed of at the site. The court ordered deadline of December 31, 2000, along with community opposition to on-site thermal treatment, was factored into the decision making process. The low level threat waste remaining on-site will be contained under a RCRA Subtitle C compliant cap.*

- *The source control operable unit remedial action selected in the ROD Amendment results in hazardous substances remaining on-site above health-based levels, but these will be contained under a landfill cap. Future remedial decisions will be made regarding additional final water treatment and sediment removal. A long-term inspection and maintenance plan along with a groundwater and surface water monitoring plan will be implemented. A Five-Year Review will be conducted after commencement of the remedial action to ensure that residual PCBs do not pose a threat to public health and the environment.*

DRAFT

The Lemon Lane Landfill Superfund site is approximately 800 feet east of the existing SR 37 pavement and adjacent to the I-69 Corridor. The Second Five-Year Review Report for the Lemon Lane Landfill (USEPA May 2010) describes the background and actions taken for the Lemon Lane site, located in the City of Bloomington, Indiana. The site is a former 10-acre municipal landfill that accepted both municipal and industrial waste material. The Lemon Lane Landfill was operated as a sanitary landfill from the late 1930s to 1964 and included polychlorinated biphenyl (PCB) contaminated capacitors, materials, and other industrial wastes. Remedial measures at the site included: Phase II Assessment and delineation; and excavation and offsite disposal of 80,087 tons of PCB contaminated material and 4,402 capacitors; consolidation of 40,000 cubic yards of landfill material to an approximately 9 acres area; installation of a landfill cap over this material, perimeter drainage, security fencing, and a stormwater retention pond. The cleanup of areas outside the landfill boundary to high occupancy/residential standard of 2 ppm PCBs (on average) to the north (toward Vernal Pike), east, and west (toward SR 37) side of the site. Coordination with IDEM site managers has occurred throughout the Section 5 study and is ongoing.

At the Superfund site, PCB impacted groundwater drains to Illinois Central Spring (ILCS) via conduits developed in the karst (limestone bedrock). The EPA treatment plant (with the capability to treat up to 1000 gpm via carbon adsorption) captures the water emanating from the ILCS emergence, treat it for PCBs and then discharge the treated water to the stream. While attempts were made to treat all of the PCB impacted water discharged from the ILCS, peak flows have exceeded treatment and storage capacities, and the highest concentrations of contaminants are associated with the peak flows. Thus, any change in land use that would increase the volume or frequency of the excess flow could have significant adverse impact on the effectiveness of the site's discharge treatment. PCB impacted water discharging from ILCS that originates from the Lemon Lane Landfill is captured and treated prior to release to surface water. Recent additions at the plant have increased the treatment to a goal of 5,000 gpm. The combined treatment systems are expected to treat nearly 100% of the ILCS spring water and treat 99.9% of the PCB mass from ILCS.

USEPA and IDEM and site participants (primarily CBS – former Westinghouse) involved in the ongoing treatment operations have requested that the Section 5 design and planning processes take into account the overall goal of reducing the volume of water entering the ILCS recharge area. Since the ILCS treatment system operations directly affect the local surface water and sediment quality, and consequently potential human and ecological receptors, roadway pavement runoff control and redistribution away from the ICLS recharge area has been determined to be of specific concern for mitigation planning.

The current alignment of SR 37 crosses the recharge area of ILCS as delineated by Fitch (1994). The Section 5 Tier 2 investigation revised the recharge area based on new data, see Figure 18. The revised recharge area shows that minimal amounts of SR 37 are currently in the ILCS recharge area.

The preferred alignment and design for Section 5 of I-69 should avoid contributing additional water to the ILCS recharge area and drainage control during construction should avoid increasing runoff to the site. Ideally, less water would be directed from the pavement, frontage

DRAFT

roads, and right-of-ways, and thus reduce the duration and frequency of discharges in excess of treatment and storage capacity at the ILCS treatment facility.

All of the alternatives maintain use of the existing SR 37 right-of-way with potential widening, away from Lemon Lane Landfill. The existing SR 37 and subsequent I-69 drainage along the western edge of the ILCS recharge area will be re-routed to drain to the west towards the upper portion of Stout Creek to prevent increased flow into the Lemon Lane Landfill/ILCS system.

The following three measures are recommended for reduction of roadway contribution to the ILCS recharge area:

- Maintain the eastern boundary of the SR 37 right-of-way with any required mainline expansion or new access roads to the west, away from the landfill, in Alternatives 4, 5.

- Shift the proposed Vernal Pike grade crossing north to connect with 17th street in all Alternatives and use of an overpass rather than rock cut for use of underpass in Alternative 7 and the Preferred Alternative 8.

- Curbing control of pavement runoff and alternative drainage (hydraulic diversion) west to the Stout Creek drainage system during subsequent design phases.

  The area where this hydraulic diversion to the west and away from the ILCS recharge area is proposed to be implemented is shown on Figure 18.

DRAFT

Figure 18 Area of Special Concern: Lemon Lane Landfill

5.6.2 Bennett's Dump

The Bennett's Dump Superfund site is described below in its USEPA Record of Decision Summary:

- *The cleanup remedies for the Bennett site was developed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986 (CERCLA), and, to the extent practicable, the National Oil Hazardous Substances Pollution Contingency Plan (NCP) and Agency Policy.*

- *Original remedy called for excavation of 55,000 cubic yards. The excavated soils and materials contaminated with PCBs were to be treated by incineration through the construction of a permitted, municipal solid waste fired incinerator.*

- *The modified remedy for Bennett's Dump consists of the following:*

    - *Excavation of approximately 55,000 cubic yards of PCB contaminated soils and materials and off-site disposal in a permitted, commercial chemical waste/TSCA landfill. Cleanup of PCBs will be to industrial/low occupancy standards of 25 ppm PCBs on average.*

    - *Off-site incineration of large PCB oil filled capacitors. Small capacitors, defined as containing less than three pounds of PCBs, will be disposed of in a TSCA landfill.*

    - *Long-term groundwater monitoring and implementation of deed restrictions.*

- *The selected remedies are protective of human health and the environment, comply with, at a minimum, federal and state requirements that are legally applicable or relevant and appropriate to the remedial action, and are cost effective. Treatment by off-site incineration of large, PCB oil filled capacitors is included as part of the remedy thereby meeting the requirement of reduction of toxicity, mobility, or volume through treatment.*

- *Off-site landfilling of PCB contaminated soil and materials does not reduce the toxicity, mobility, or volume through treatment but is justified based upon the court mandated deadline and community opposition to thermal treatment.*

- *The remedial actions selected in the ROD Amendment do not result in hazardous substances remaining on-site above health-based levels. Groundwater monitoring and a Five-Year Review will be conducted after commencement of the remedial action to ensure that residual PCBs do not pose a threat to public health and the environment. After the completion of the first five-year review for each site, the U.S. EPA will evaluate whether further five-year reviews are necessary and whether groundwater monitoring will continue.*

DRAFT

Bennett's Dump is located in the northwest corner of the interchange of SR 37 and SR 46, approximately 1,400 feet from existing SR 37 pavement and adjacent to the Section 5 Corridor. I-69 Section 5 will be designed to avoid directing water through the site or to abandoned quarries that drain through the site.

The Second Five-Year Review Report for Bennett's Dump (USEPA August 2007) describes the background and actions taken for the site. During the previous SR 46 interchange construction, a series of former quarries were filled and portions of the Stout Creek drainage system were altered. The site has exhibited elevated groundwater levels since construction of SR 46. After soil and material excavation and off-site treatment/disposal activities were completed in 1999, two springs on the Bennett's Dump site that discharge to Stout Creek showed PCB contamination. To address these springs, a passive drainage system to allow upgradient abandoned quarry pits and waste stone areas to drain directly to Stout Creek thereby bypassing residual contaminates at the dump site was installed in 2010. On-site groundwater treatment and potential hydraulic isolation (via installation of a slurry wall/groundwater barrier) treatments are under consideration by the overseeing agencies and site participants (primarily CBS – former Westinghouse).

USEPA and IDEM and site participants involved in ongoing remedial design and mitigation measures at the site have requested that the I-69 Section 5 design and planning processes take into account the overall goal of redirecting runoff around the site. Since mobilization of residual contaminants at the site has the potential to directly affect the local surface water and sediment quality, and consequently potential human and ecological receptors, roadway pavement runoff control and redistribution outside of the recharge area and drainage control during construction should avoid increasing runoff to the site. This has been has been determined to be of specific concern for mitigation planning. Coordination with IDEM site managers has occurred throughout the Section 5 study and is ongoing. IDEM has indicated that it potential additions to groundwater in the SR 46 area would be of concern, rather than surface water flow from diversion of runoff water upstream to Stout Creek.

While none of the five alternatives will impact the Bennett's Dump, the current alignment of SR 37 and all of the five alignments are upgradient of Bennett's Dump. The ramp drainage in the northwest quadrant of the SR 37/future I-69 and SR 46 will be rerouted to drain to the west towards the Stout Creek either upstream or downstream of the Bennett Dump area. The area where this hydraulic diversion is proposed upstream and/or downstream portion of Stout Creek, away from Bennett's Dump, is shown on Figure 19.

The following measures are recommended for reduction of roadway contribution to the Bennett's Dump recharge area during subsequent design phases:

- Limit paving and construction to the existing SR 37 and SR 46 mainline and intersection.
- Curb control of pavement runoff and provide alternative drainage (hydraulic diversion) west to Stout Creek upstream (south) and downstream (north) of Bennett's Dump.

DRAFT

Figure 19 Area of Special Concern: Bennett's Dump

5.6.3 SR 45/2nd Street – SR 37 Interchange

The intersection of SR 45/2nd Street and SR 37 is considered an area of special concern due to the presence of numerous sinkholes and a reported former cave that were filled as part of SR 37 construction, and by various local developments. Many of these sinkholes have had roadway and development runoff culverts installed in or near them. There has been a history of some of these sinkholes reopening. Figure 20 shows the area of special concern, the associated modified and filled sinkholes, and their historic catchment areas.

The literature search provided numerous examples from across the country of roadbed failures at reopened sinkholes resulting in economic loss, and sometimes loss of life (Waltham *et al*. 2005). Care should be taken to ensure that the design of I-69 Section 5 consider sinkholes which no longer have the appearance and function of sinkholes, but have the potential to destabilize the roadbed and adjacent lands.

DRAFT

Figure 20 Area of Special Concern: Second Street – SR 37 Interchange

5.6.4 Cave Recharge Area

Cave is considered an area of special concern due to its biological significance from diverse troglobitic (obligate cave dwelling) fauna, and state-listed threatened and endangered species (Lewis, 2005). A mapped cave passage extends under SR 37 (Roy and Wells, 1959), and the groundwater recharge area of the cave extends across SR 37 and the Section 5 Corridor.

The Lewis, 2005 investigation indicated that the cave's biological community appears to be in relatively good health despite historical and current runoff from SR 37 and other land uses in its recharge area. No federally listed species were identified.

The I-69 Section 5 planning and design process will attempt to minimize potential additional impacts from water derived from Section 5. While there is little direct data on cave passage depth, based on a comparison of spring and Corridor elevations, some Cave conduits may be not much more than 20 feet and are no more than 100 feet in depth. While the Cave passage that extends under SR 37 was reported as a narrow, linear feature, if bedrock removal is included in construction designs in this area, geophysical surveying to evaluate the potential for intercepting this conduit will be required.

The Monroe Hospital complex, Medical Park Boulevard, parking lots, electrical sub-station, and two retention basins were constructed on the southwest corner of the Fullerton Pike/SR 37 intersection. Additional medical or commercial development buildings and related parking lots, new access roads, onsite stormwater management, and a helipad are also planned. Most of this complex and new development is within the Cave recharge area and are expected to alter the recharge patterns for the Cave system (see Figure 21).

All of the alternatives are within the Cave recharge area and have similar impact areas. The proposed six-lane I-69 will have similar type of direct impacts to the Cave and Cave Systems as the existing four-lane SR 37, see Figure 21.

Several treatment options are available for consideration as potential mitigation measures in implementation of the Karst MOU to reduce roadway impacts to the Cave recharge area and maintain the existing base flow levels in the system:

- Engineered wetland sediment and contaminant reduction systems.
- Linear peat sand filters and/or vegetated swales along the roadway or at the terminus of lined storm water control structures.
- Runoff and storm water detention/retention systems, treatment, and infiltration galleries.
- Control of "first flush" (or initial stormwater runoff which typically will have higher contaminant concentrations) volumes with designed overflow into natural drainage systems.

See **Appendix F** - Figure F-42 for a summary of the individual dye traces used for the determination of the Cave Recharge Area. This summary includes historical traces, those

DRAFT

conducted for the Section 5 Karst evaluations, and thirteen additional traces conducted specifically for determination of the Cave recharge area:

F-29 Trace 08-01
F-30 Trace 08-02:
F-31 Trace 08-03:
F-32 Trace 09-04:

F-33 Trace 09-05:
F-34 Trace 09-06:

F-35 Trace 09-07:
F-36 Trace 09-08:
F-37 Trace 09-09:
F-38 Trace 09-10:
F-39 Trace 09-11:
F-40 Trace 09-12:
F-41 Trace 09-13:

DRAFT

Figure 21 Area of Special Concern: Cave Recharge Area

5.7 General Environmental Concerns

In addition to the previously discussed areas of special concern, there are general environmental concerns when planning road construction in karst. Karst cannot be entirely avoided within the Section 5 Corridor, although some particular karst features may be avoided. Thus, the focus of alignment development and design should be on minimizing impacts to the karst via alternative drainage, mitigation/treatment, and operations and maintenance.

It is characteristic of karst systems to exhibit high groundwater velocities through natural conduits large enough to permit turbulent flow. Turbulent flow is capable of transporting sediment and contaminants quickly into caves and to springs that may be relatively far from their source. In addition, karst systems often transfer water across sub-watershed boundaries (i.e., interbasin transfer). Fourteen traces demonstrated this transfer in Section 5. Consequently, if a hazardous material spill containment failure should occur in the vicinity of the roadway, the location for an effective response might not be obvious. The dye tracing data provided in this report demonstrated certain specific linkages as well as patterns in groundwater flowpaths. These data should be used to plan spill responses in the event that spill containment and/or passive treatment systems fail. Additional dye tracing may be necessary to provide more data for identifying appropriate locations for spill response.

Flooding in the southern portion of the Section 5 study area was a common complaint of residents in the Bloomington area. Sub-watershed boundaries are not the only data required to determine where runoff will flow. While the local flooding was probably not related to karst groundwater flowpaths, redirection of runoff may be perceived as aggravating existing problems. Thus, care should be taken to quantify the amount of redirected water and to minimize overall increases to peak flows.

One characteristic that was favorable to highway construction in this karst area was that groundwater systems tend to be small and relatively isolated. A single spill along the roadway, even if uncontained, should generally impact a single, relatively small groundwater system. In many other karst areas, spills have the potential to impact very large, interconnected groundwater systems. Only a relatively small portion of the Section 5 Corridor is hydrologically linked to significant cave systems, Cave.

Existing road use, maintenance, and adjacent development currently impact Section 5 karst.

5.8 Engineering Concerns

Karst is a distinct landscape in which standard engineering practices are sometimes inappropriate. Consideration should be given to how this landscape functions under given conditions:

- There are sinkholes throughout Section 5 that have been filled or otherwise modified by people or natural processes. In areas where loess-derived soils overlie karst, sinkhole collapse can result with no apparent surface expression prior to collapse. Loess is

DRAFT

internally erodible and is susceptible to soil piping and stoping upward from bedrock cavities to the surface.

- Impervious surfaces, such as roads, can inherently change patterns of runoff and infiltration. Concentrated or redirected water can destabilize sinkholes (with or without current surface expression) as they equilibrate with the new water input conditions. Unlined water detention or retention structures can increase the hydraulic head (i.e., saturate) in the supporting earthen materials and possibly lead to failure of such structures.

- Impervious surfaces, such as roads, can sever recharge features. This can result in decrease spring discharges and alteration of habitat for any biological communities within the karst system

- The flowpaths determined in this investigation are naturally occurring conduits in limestone bedrock (karst flowpaths). Fourteen of these flowpaths have been determined to cross under SR 37, and additional conduits are likely to be discovered. The flowpath data presented in this report are diagrammatic; the lines representing the flowpaths are not meant to represent the actual location or distribution of the conduits. While these conduits are large enough to have turbulent flow, they are unlikely to have spans greater than a few feet, based on the relatively small groundwater systems of which they are components.

- There are hydrologically active insurgence and resurgence features under SR 37. The dye introduction point for Trace 04-03 is a sinkhole under the highway that has a culvert leading into it. Spring (Station) is under SR 37 and has a steel culvert installed to allow water to flow out from under the highway. Springs in karst terrain can have a wide range of discharges. If the seal between a culvert and a spring orifice is or becomes imperfect, or if the culvert is undersized (for peak flows that tend to increase over time in urbanizing areas), excess head can build up under the road, leading to failure of the highway facility. Road bases can be eroded by an underlying spring that is not properly engineered.

- During the investigation, numerous reopening sinkholes and soil piping was observed that had formed under concrete-lined and natural grass roadside ditches and within the study area, most notably along road ditches on SR 37. Wheel ruts found at the upstream end of concrete paved ditches, or adjacent to the paved linings seemed to have a high correlation with the locations of soil piping. Presumably, these ruts are causing water to pond at the edge of the paved ditches and become a point source for relief of hydraulic head. The excess hydraulic head is relieved by erosion underneath the concrete lining. In other words the water passes under the concrete linings and causes internal erosion (soil piping). Some of the wheel ruts appeared to result from vehicles accidentally leaving the roadway in wet weather, while others clearly resulted from tractors mowing the right-of-way grass when the ground was soft.

DRAFT

6.0 RECOMMENDATIONS

The recommendations are divided into: 1) additional studies; 2) Best Management Practices (BMPs) related to highway construction and design; and 3) Measures in areas of Special Concern.

6.1 Best Management Practices

The following recommendations for Best Management Practices (BMPs) relevant to the design, construction, and maintenance of Section 5 in the relevant karst areas were developed to conform to the 1993 MOU:

- Construction within the karst areas should be planned with effective erosion and sediment control measures. Procedures to reduce the impacts to karst will be implemented in accordance with INDOT's Standard Specifications and the 1993 Karst MOU between the INDOT, IDNR, IDEM and the USFWS. Stormwater runoff protection measures will be installed at all karst features in the right-of-way at the initiation of construction and maintained until all stormwater drainage has been diverted away from the feature, or final permanent stormwater treatment measures are in place. Erosion control measures will be put in place as a first step in construction and maintained throughout construction. Temporary erosion control devices such as silt fencing, check dams, sediment basins, inlet protection, sodding and other appropriate BMPs will be used to minimize sediment and debris in tributaries within the project area. Timely revegetation after soil disturbance will be implemented and monitored. Any riprap used will be of a large diameter in order to allow space for habitat for aquatic species after placement. Prior to construction, heavy equipment parking and turning areas will be located outside the construction limits but within the right-of-way to minimize soil erosion. Soil bioengineering techniques for bank stabilization will be considered where appropriate. The staging of equipment and materials should occur outside of karst areas, or at a minimum on impervious material with controlled drainage. Same-season re-vegetation of disturbed land during construction, repairs and maintenance should be used when feasible.

- Road maintenance should include posted low salt/no spray areas to prevent contaminants from entering karst systems. Mowing should be restricted to appropriate times, and repairing damaged vegetation and drainages should be required.

- Some of the channels that cross the Corridor may be under-drained in karst areas and may appear to transmit water infrequently. Culverts and bridge openings must be sized to accommodate the required rainfall events as defined by the INDOT Drainage Design Manual and be appropriate to the specific karst feature, where applicable. Unique backwater conditions created by sinking streams and other insurgence features will require further evaluation during subsequent design stages to assure that adequate detention storage volume is available.

- The roadway project needs to convey surface water runoff with as much natural treatment for water quality as is feasible. This treatment is best accomplished by dispersing the

DRAFT

runoff through at least 100 feet of vegetation filter swale or passing it through an engineered treatment system (sediment basin) before it reaches the invert elevation for a sinkhole.

- Where possible, the road prism (structures, base and pavement) should not restrict flow into a sinkhole or other insurgence feature. Use of filters, buffers, containment structures, reinforced soil, void grouting, compaction grouting, concrete caps, reinforced bridging slabs (land bridges), deep foundations, etc. are potentially effective mitigation measures, but will not be determined until subsequent detailed design stages.

- Utilization of lined ditches to the outfall discharge points are recommended within the karst areas designed to prevent erosion. Water flow within the roadway ditches will need an analysis for lining requirements. Culvert outlets should be designed to discharge water to at grade terrain. This design will reduce erosion scour and sediment transport into the karst and other environments. Design of ditches and culverts should be based on INDOT's Drainage Design Manual and be appropriate to the specific karst feature.

- The drainage design for I-69 should provide for proper energy dissipation devices at the culvert and storm sewer system outlet locations to prevent erosion to existing channels. Energy dissipater devices include such items as scour holes, riprap linings and stilling basins. Design of energy dissipater devices and ditch linings should be based on INDOT's Drainage Design Manual and be appropriate to the specific karst feature.

- The roadway drainage system should be incorporated into the Operations and Maintenance Plan for inspection and repair to prevent disturbance of karst drainage patterns and undercutting observed along SR 37. The karst areas will require monitoring to evaluate roadway slopes and ditches and repair of off-road disturbances. Mowing should be restricted to periods of dry weather/firm soil conditions to avoid rutting from vehicles. Reseeding/drainage repair should be required following accidents that disrupt vegetative cover. Installation of guardrails could be utilized to prevent vehicles from leaving paved roadway surfaces. Roadway maintenance should include posted no-salt/spray areas to prevent chemicals from entering the karst system.

- Excavation into bedrock below the current SR 37 roadway grade that could potentially expose cave passages and other karst conduits and should be avoided where feasible. Roadway grading constructed with embankment fill is preferable to cuts in bedrock.

- Implementation of hazardous waste traps will conducted by INDOT (or their designated contractors) to protect karst features against hazardous materials spills per Step 7 of the Karst MOU. Spill response equipment should be readily available during construction and subsequent use of the road. Due to the high flow rate within karst systems, response times are critical for prevention/reduction of impacts to karst ecologic communities, groundwater resources, and surface water. The first priority must be to prevent contaminants from entering the karst groundwater system at the location of the release. Once contaminants have entered the karst system, use of preventive or mitigation measures at appropriate resurgence points for both surface water and sediment are time

DRAFT

critical due the high water velocities (depending on the particular conduit system, precipitation, and flow conditions).

- In the event that a sinkhole cannot be avoided, the sinkhole should be capped. A special design of the roadway subgrade and pavement structure should be considered in these areas to avoid the hazards of sinkhole instability and reallocated water runoff. The special design may include increased structural design of roadway pavement and anchoring of pavement slabs crossing the sinkhole area(s) to underlining bedrock.

- In the event that disturbance of a spring cannot be avoided, a spring box and culvert should be constructed to discharge the flow to an appropriately designed outfall. A special design of the roadway subgrade and pavement structure should address potential undermining of the roadbed due to excess pressure head discharging from the spring or potential water leakage from the spring boxes and culverts over time. The special design may include increased structural design of roadway pavement and an anchoring of pavement slabs crossing the spring areas to underlining bedrock.

- In the event that disturbance of a karst flowpath (underground steam) cannot be avoided, the top of the karst flowpath should be capped, but still allow for natural flow within the flowpath. A special design of the roadway pavement structure should be considered in these areas to ensure that the natural conduit does not collapse and threaten the integrity of the roadbed. The special design could include increased structural design of roadway pavement and an anchoring of pavement slabs crossing the karst conduits to underlining bedrock.

- If caves are exposed during construction, karst experts should be consulted to determine their project significance. Drainage and treatment alternatives will be considered concurrently so as to not impede drainage in recharge areas and having potentially harmful impacts to cave biota.

- In the event that federal and/or state listed species are encountered during construction that were not previously reported/evaluated (e.g., at and caves) construction should be halted until an evaluation can be performed.

6.2 Areas of Special Concern

Control of construction water runoff, post construction roadway water, and alternative drainage to either surface water systems or drains, is recommended for portions of the proposed roadways and support structures. Feature specific impact reduction recommendations were made for four karst Areas of Importance in Section 5:

1) <u>Lemon Lane Landfill / Illinois Central Spring Superfund Site</u>

   The following three measures are recommended for reduction of roadway contribution to the ILCS recharge area:

DRAFT

- Maintain the eastern boundary of the SR 37 right-of-way with any required mainline expansion or new access roads to the west, away from landfill.

- Shifted the proposed Vernal Pike grade crossing north to connect with 17th street in all Alternatives and use of an overpass rather than rock cut for use of underpass in Alternative7 and the Preferred Alternative 8.

- Curbing control of pavement runoff and alternative drainage (hydraulic diversion) west to the Stout Creek drainage system during subsequent design phases.

2) Bennett's Dump Superfund Site

The following measures are recommended for reduction of roadway contribution to the Bennett's Dump recharge area during subsequent design phases:

- Limit paving and construction to the existing SR 37 and SR 46 mainline and intersection.

- Curb control of pavement runoff and provide alternative drainage (hydraulic diversion) west to Stout Creek upstream (south) and downstream (north) of Bennett's Dump.

3) 2nd Street/SR45 – SR 37 Interchange Buried Sinks

The following two measures are recommended during design for reduction of roadway contribution to the 2nd Street/SR45 – SR 37 Interchange Buried Sinks area:

- Limit paving and construction to the existing SR 37 and 2nd Street/SR 45 mainline and intersection.

- Care should be taken to ensure that the final design of SR 37 and 2nd Street/SR 45 consider sinkholes which no longer have the appearance and function of sinkholes, but have the potential to destabilize the roadbed and adjacent lands.

4) Cave Recharge

Several treatment options are available for consideration of potential mitigation measures in implementation of the Karst MOU to reduce roadway impacts to the Cave recharge area and maintain the existing base flow levels in the system:

- Engineered wetland sediment and contaminant reduction systems.
- Linear peat sand filters and/or vegetated swales along the roadway or at the terminus of lined storm water control structures.
- Sinkhole sediment and contaminant traps.
- Runoff and storm water detention/retention systems, treatment, and infiltration galleries.

DRAFT

- Control of "first flush" (or initial stormwater runoff which typically will have higher contaminant concentrations) volumes with designed overflow into natural drainage systems.

DRAFT

7.0 REFERENCES

Aley, Thomas. 2002. The Ozark Underground Laboratory's groundwater tracing handbook. 35 p.

Arroyo, K.J. 2001. A shallow temperature profile, fracture trace and very low frequency investigation to determine locations of lateral inflow beneath a Superfund site in Bloomington, Indiana. Unpublished Master's thesis, Indiana University. 144 p.

Droste, J.B., and S.J. Keller. 1995. Subsurface Stratigraphy and Distribution of Oil Fields of the Buffalo Wallow Group (Mississippian) in Indiana. Indiana Geological Survey Bulletin, B63, 24 p., 18 fig., 1 pl.

Earth Tech. Inventory of Karst Features and a Discussion of Potential Karst-Related Environmental Consequence of State Road 46 Roadway and Interchange Construction, Bloomington, Indiana. prepared for Indiana Department of Transportation. 1996.

Earth Tech. Memo: Karst Inventory of Tapp Road Property. prepared for Smith Neubecker and Associates. 2002.

Eklund, B.A. 1999. An investigation of a PCB contamination point source within a karst terrain using the stable isotopes of sulfur and deuterium to perform a three-part hydrograph separation on a karst spring in Monroe County, Indiana. Unpublished Master's thesis, Indiana University. 89 p.

Field, Malcolm S., Wilhelm, R.G., Quinlan, J.F.. and Aley, T.J. 1995. An assessment of the potential adverse properties of fluorescent tracer dyes used for groundwater tracing. *Environmental Monitoring and Assessment*, Vol.38, pp. 75-96. Kluwar Academic Publishers.

Fitch, J.R. 1994. A karst groundwater study to delineate the Spring basin groundwaters near west-central Bloomington, Indiana. Unpublished Master's thesis, Indiana University. 154 p.

Freeze, R.A. and J.A. Cherry. 1979. *Groundwater*. Prentice-Hall, Inc. 604 p.

Gates, G. R. 1962. Geologic considerations in urban planning for Bloomington, Indiana: Indiana Geological Survey Report of Progress 25.

Gray H. 2000. Physiographic Divisions of Indiana, Indiana Geological Survey Special Report 61.

Gray H., 2001. Map of Physiographic Divisions of Indiana, Indiana Geological Survey.

Harke and Gray. 1998. Geology for Environmental Planning in Monroe County; Published by the Indiana Geologic Survey, 1989, reprinted in 1998.

Hasenmueller, Walter A. "Bedrock Geologic Map of Monroe County, Indiana". Indiana Geological Survey, 2008.

DRAFT

Indiana Department of Natural Resources, Division of Soil Conservation. 1992. Indiana Handbook for Erosion Control in Developing Areas: Guidelines for Protecting Water Quality through the Control of Sedimentation on Construction Sites.

Keith, J.H., J.L. Bassett, J.A. Duwelius, and B.L. Luther. 1997. Results of 1993 MOU-related karst studies for Indiana State Road 37, Lawrence County, Indiana (1992-1995). Unpublished contract report prepared by Earth Tech for the Indiana Department of Transportation. 72 p. + appendices

Lewis, J.J. 2005. Cave Fauna of the Section 5 Corridor of I-69. Unpublished contract report to the Ozark Underground Laboratory. 22 p.

Melhorn, W.N. and N.M., Smith. 1959. The Mt. Carmel Fault and related structural features in south-central Indiana: Indiana Geological Survey Report of Progress 16.

Moss, Philip L. and Thomas Aley. 2003. Mapping presumptive habitat for subterranean, aquatic species of concern in 16th National Cave and Karst Management Symposium Proceedings. p.70-73

Robinson, W.H. 1986. The study of surface and ground-water interactions in two watersheds. Unpublished Master's thesis, Indiana University. 107 p.

Roy, S. and S. Wells. 1959. Cave Area. Map archived in the Indiana Cave Survey files. 2 sheets.

Rupp, J.A. 1991. Structure and Isopach Maps of the Paleozoic Rocks of Indiana, Department of Natural Resources Geological Survey Special Report 48, 106 p.

Shaver, R.H., and G. S. Austin. 1986. Compendium of Paleozoic Rock Unit Stratigraphy in Indiana – A Revision of the State of Indiana Department of Natural Resources Geological Survey 59.

Shaver, R.H. and C.H. Ault, et al. 1972. A field guide to the Mt. Carmel Fault of southern Indiana: Indiana Geological Survey Guidebook.

Smart, P.L. 1984. A review of the toxicity of twelve fluorescent dyes used for water tracing. National Speleological Society Bulletin, vol. 46, pp. 21-33.

Talarovich, S.G. 1998. Stable isotopic three-component storm hydrograph separation of Illinois Central Emergence located in Monroe County, Indiana. Unpublished Master's thesis, Indiana University. 85 p.

Thomas, J.A., R.C. Wingard, and P.A. Kempf. 1981. Soil survey of Monroe County, Indiana. U.S. Department of Agriculture Soil Conservation Service.

DRAFT

Thompson, Todd A., Geologic Map of Bloomington 7.5-Minute Quadrangle. Indiana Geological Survey. 2007. U.S. Geological Survey. 1980a. Bloomington Quadrangle, Indiana-Monroe County: 7.5-minute series (topographic).

U.S. Geological Survey. 1980b. Clear Creek Quadrangle, Indiana-Monroe County: 7.5-minute series (topographic).

Veni, G., H. DuChene, N.C. Crawford, C.G. Groves, G.N. Huppert, E.H. Kastening, R. Olson, and B.J. Wheeler. 2001. Living with karst, a fragile foundation. American Geological Institute Environmental Awareness Series No. 4 64 p.

Waltham, T., F. Bell, and M. Culshaw. 2005. Sinkholes and subsidence: karstand cavernous rocks in engineering and construction. Published by Springer-Verlag, New York. 382 p.

White, B. 2005. Interview. Ben White is an INDOT Construction Project Supervisor for the Seymour District.

DRAFT

Appendix A
Karst Memorandum of Understanding

MEMORANDUM OF UNDERSTANDING

THIS MEMORANDUM OF UNDERSTANDING IS MADE AND ENTERED INTO THIS THIRTEENTH DAY OF OCTOBER: 1993 BETWEEN THE INDIANA DEPARTMENT OF TRANSPORTATION (INDOT). THE INDIANA DEPARTMENT OF NATURAL RESOURCES (IDNR). THE INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT (IDEM) AND THE U. S. FISH AND WILDLIFE SERVICE (USFWS) FOR THE PURPOSE OF DELINEATING GUIDELINES FOR CONSTRUCTION OF TRANSPORTATION PROJECTS IN KARST REGIONS OF THE STATE.

WHEREAS. INDOT. IDNR. IDEM AND THE USFWS WISH TO COOPERATE IN THE IDENTIFICATION. STUDY AND TREATMENT OF DRAINAGE IN KARST REGIONS RELATED TO THE CONSTRUCTION OF TRANSPORTATION PROJECTS AND.

WHEREAS. INDOT. IDNR. IDEM AND THE USFWS ACCEPT RESPONSIBILITY TO ENSURE THE TRANSPORTATION NEEDS OF INDIANA ARE MET IN AN ENVIRONMENTALLY SENSITIVE MANNER THAT PROTECTS THE HABITAT OF ALL SPECIES AND.

WHEREAS. DESIGN AND CONSTRUCTION PRACTICES MUST PROTECT GROUND WATER QUALITY, PUBLIC HEALTH AND SAFETY. AND THE ENVIRONMENT.

WHEREAS. IDNR WILL CONFORM TO THE TERMS AND CONDITIONS OF THIS MOU ON THEIR TRANSPORTATION PROJECTS. LIKEWISE. IT WILL BE IDNR'S RESPONSIBILITY TO PROVIDE STANDARD BIOLOGICAL REVIEW FOR PROJECTS IN THE KARST REGION.

THEREFORE. IN CONSIDERATION OF THE TERMS AND CONDITIONS SET FORTH HEREIN THE INDOT, IDNR. IDEM. AND USFWS AGREE AS FOLLOWS:

1. INDOT IN COOPERATION WITH THE IDNR. IDEM AND USFWS SHALL DETERMINE THE LOCATION OF SINKHOLES. CAVES. UNDERGROUND STREAMS, AND OTHER RELATED KARST FEATURES AND THEIR RELATIONSHIP PRIOR TO PROPOSED ALTERATIONS OR CONSTRUCTION IN KARST REGIONS OF THE STATE. A CONSULTANT WITH EXPERTISE IN KARST GEOLOGY/HYDROLOGY MAY ASSIST IN THE IDENTIFICATION AND CHARACTERIZATION OF THE KARST FEATURES. THE CHOICE OF THE CONSULTANT RETAINED BY INDOT WILL BE SUBJECT TO THE REVIEW OF IDNR. USFWS AND IDEM.

2. TASKS TO ACCOMPLISH THIS WORK WILL INCLUDE:

RESEARCH AVAILABLE FROM PUBLIC AND PRIVATE SOURCES FOR INFORMATION RELATIVE TO KARST FEATURES.

FIELD CHECK KARST AND CAVE FEATURES THAT APPEAR FROM THE FIRST TASK AND IDENTIFY ANY ADDITIONAL KARST FEATURES.

PREPARE A DRAFT REPORT. WITH PHOTOGRAPHS AND MAPS. DRAINAGE AREAS. AND LAND USE OF THAT DRAINAGE AREA FOR EACH SINKHOLE OR KARST

FEATURE. DYE-TRACING AND/OR OTHER GEOTECHNICAL INFORMATION TO DETERMINE SUBSURFACE FLOW OF WATER IN THE PROJECT AREA AND SURFACE WATER DRAINAGE PATTERNS OF THE AREA. CALCULATIONS OF ESTIMATES OF ANNUAL POLLUTANT LOADS FROM THE HIGHWAY AND DRAINAGE WITHIN THE RIGHT-OF-WAY WILL BE MADE, INCLUDING PRIOR TO, DURING AND POST CONSTRUCTION ESTIMATES. THE DESIGN OF THE TREATMENT OF THE KARST FEATURES WILL TAKE INTO CONSIDERATION TREATMENTS NECESSARY TO MEET THE STANDARDS OF THE MONITORING AND MAINTENANCE PLAN.

THAT REPORT WILL BE USED AS A TOOL TO ASSIST IN DETERMINING THE PROPOSED HIGHWAY ALIGNMENT. THE INTENT OF INDOT IS TO AVOID KARST AREAS AND USE ALTERNATE DRAINAGE WHERE POSSIBLE.

3. IDNR, IDEM AND USFWS WILL BE REQUESTED TO REVIEW AND COMMENT ON THE FINDINGS AT THE EARLY COORDINATION PHASE OF PROJECT DEVELOPMENT.

4. INDOT, USING THE INPUT FROM IDNR, IDEM, AND USFWS WILL BEGIN TO FORMULATE APPROPRIATE MEASURES TO OFFSET UNAVOIDABLE IMPACTS TO THE KARST FEATURES. IT IS UNDERSTOOD BY ALL PARTIES THAT SOME OF THE METHODS PROPOSED AT THIS TIME WILL BE GENERIC AND COULD BE APPLIED THROUGHOUT THE LENGTH OF THE CORRIDOR. OTHER METHODS MAY BE SPECIFIC TO A PARTICULAR CAVE OR KARST FEATURE. SOME OF THE APPROACHES MAY REQUIRE ADDITIONAL INVESTIGATIONS TO DETERMINE THEIR NECESSITY AND/OR THEIR FEASIBILITY. A REVISED DRAFT REPORT WILL BE PREPARED BY INDOT'S CONSULTANT AND PROVIDED TO THE IDNR, IDEM, AND THE USFWS AS PART OF THE DESIGN REVIEW PROCESS.

5. DRAINAGE ENTERING FROM BEYOND THE RIGHT-OF-WAY WILL BE TREATED ACCORDING TO THE SAME PROCESS AS DRAINAGE GENERATED BY THE PROJECT.

6. AS THE PROJECT PROGRESSES FURTHER INTO THE DESIGN PHASE, THE IDNR, IDEM AND USFWS WILL BE INVITED AND WILL ATTEND FIELD CHECKS AND MEETINGS DEALING WITH EFFORTS TO NEGATE OR MINIMIZE ADVERSE IMPACTS.

7. HAZARDOUS MATERIALS TRAPS (HMT'S) WILL BE CONSTRUCTED AT STORMWATER OUTFALLS AND OTHER LOCATIONS THAT WILL PROTECT KARST FEATURES FROM SPILL CONTAMINATION.

8. INDOT AGREES TO DEVELOP A MONITORING AND MAINTENANCE PLAN FOR THE AFFECTED KARST FEATURES. IDNR, IDEM AND USFWS WILL BE PROVIDED AN OPPORTUNITY TO REVIEW THIS PLAN. THE ESTABLISHMENT OF WATER QUALITY AND A POINT AT WHICH A STANDARD IS ESTABLISHED FOR REMEDIATION WILL BE A PART OF EACH MONITORING PLAN. THE RESULTS OF THE MONITORING WILL BE SUBMITTED TO IDNR, USFWS, AND IDEM ON A REGULAR BASIS.

9. A LOW SALT, AND NO SPRAY STRATEGY WILL BE DEVELOPED FOR EACH FUTURE PROJECT. A SIGNING STRATEGY FOR THESE ITEMS WILL ALSO BE DEVELOPED FOR EACH PROJECT.

10. PRIOR TO ACCEPTANCE OF THE FINAL DESIGN PLANS AN AGREEMENT WILL BE DEVELOPED WHICH WILL SET OUT THE APPROPRIATE AND PRACTICABLE MEASURES TO OFFSET UNAVOIDABLE IMPACTS TO KARST FEATURES. THIS AGREEMENT WILL BE SIGNED BY THE DEPARTMENT DIRECTOR OF IDNR, THE COMMISSIONER OF THE IDEM, THE COMMISSIONER OF INDOT AND THE SUPERVISOR OF THE USFWS BLOOMINGTON INDIANA FIELD OFFICE. THE AGREEMENT WILL BECOME A PART OF THE CONTRACT DOCUMENTS FOR THE PROJECT, WILL BE

DISCUSSED AT THE PRE-CONSTRUCTION CONFERENCE AND WILL BE ON FILE AT THE OFFICE OF THE PROJECT ADMINISTRATOR.

11. INDOT WILL ASSURE THAT THE TERMS OF THE AGREEMENT WILL BE COMPLETED WITH ALL SAFEGUARDS GIVEN TO THE KARST AREA. SPECIAL PROVISIONS, WHICH ARE BINDING PROVISIONS THAT ARE A PART OF THE CONTRACT, WILL BE INCLUDED OUTLINING THE PRECAUTIONS TO BE TAKEN. CONSTRUCTION AND DESIGN STRATEGIES FOR HANDLING KARST FEATURES WILL BE DISCUSSED WITH THE CONTRACTOR(S) AND PROJECT ADMINISTRATOR DURING THE PRECONSTRUCTION CONFERENCE. PROJECT ADMINISTRATOR SHALL ENSURE THAT THE CONTRACTOR IS FOLLOWING THE NEW EROSION CONTROL STANDARDS THAT MEET RULE 5 OF 327 IAC 15 AND ANY SPECIAL PRECAUTIONS OUTLINED IN THE DESIGN PLANS THAT THE SINKHOLE TREATMENT IS BEING HANDLED CORRECTLY. THE EROSION CONTROL PLAN MUST BE AVAILABLE AT THE PROJECT ADMINISTRATOR'S OFFICE. AN EMERGENCY RESPONSE PLAN WILL BE MADE A PART OF THE CONTRACT DOCUMENTS. IN ADDITION, THE CONTRACT DOCUMENTS WILL CONTAIN A STRATEGY FOR SIGNING TO ALERT THE PUBLIC TO THE FACT THAT ALL TYPES OF SPILLS ARE POTENTIALLY HAZARDOUS TO THE KARST ENVIRONMENT. FOR INDOT. THIS PLAN WOULD BE PROCEDURE 20 OF THE FIELD OPERATIONS MANUAL DATED 6/24/92 (ATTACHED).

12. THE LOCATION AND NATURE OF THE SINKHOLES AND DRAINAGE SCHEMATIC WILL BE PROVIDED TO THE IDEM. THEY WILL PROVIDE THE INFORMATION TO THE APPROPRIATE LOCAL AUTHORITIES AND THE HAZMAT TEAMS. AN EMERGENCY RESPONSE PLAN WILL BE FOLLOWED. THIS CONSTITUTES PROCEDURE 20. INCLUDED IN THIS INFORMATION IS AN UNDERSTANDING THAT ALL TYPES OF SPILLS ARE POTENTIALLY HAZARDOUS TO KARST REGIONS.

13. IDNR, IDEM AND USFWS PERSONNEL WILL MONITOR CONSTRUCTION AND MAINTENANCE TO THE AGREED UPON TERMS. AS DEEMED NECESSARY.

14. IF DURING CONSTRUCTION IT IS FOUND THAT THE MITIGATION AGREEMENT MUST BE ALTERED, ALL OF THE AGENCIES WILL BE CONTACTED AND AGREEMENT REACHED PRIOR TO WORK CONTINUING IN THAT SPECIFIC AREA OF THE PROJECT. IN ORDER TO NOT UNDULY DELAY PROJECTS, A TWO WORKING DAYS RESPONSE TIME IS NEEDED FROM THE RESOURCE AGENCIES.

15. TREATMENTS WILL BE MAINTAINED DURING CONSTRUCTION BY MEANS OF A VISUAL INSPECTION ON A WEEKLY BASIS OR AFTER EVERY RAIN. CORRECTIVE ACTION WILL BE TAKEN AS NEEDED.

16. IF AFTER THE ABOVE PROCEDURE IS FOLLOWED AND A STATE/FEDERAL ENDANGERED/THREATENED SPECIES IS FOUND DURING CONSTRUCTION, WORK IN THAT AREA OF THE PROJECT WILL STOP. THE IDNR, AND USFWS WILL BE IMMEDIATELY NOTIFIED. THE IDNR AND USFWS WILL PROMPTLY INVESTIGATE THE SITUATION, ADVISE THE PROJECT ADMINISTRATOR AND ASSUME RESPONSIBILITY FOR PROTECTING THE ENDANGERED SPECIES AND TAKING THE APPROPRIATE ACTION.

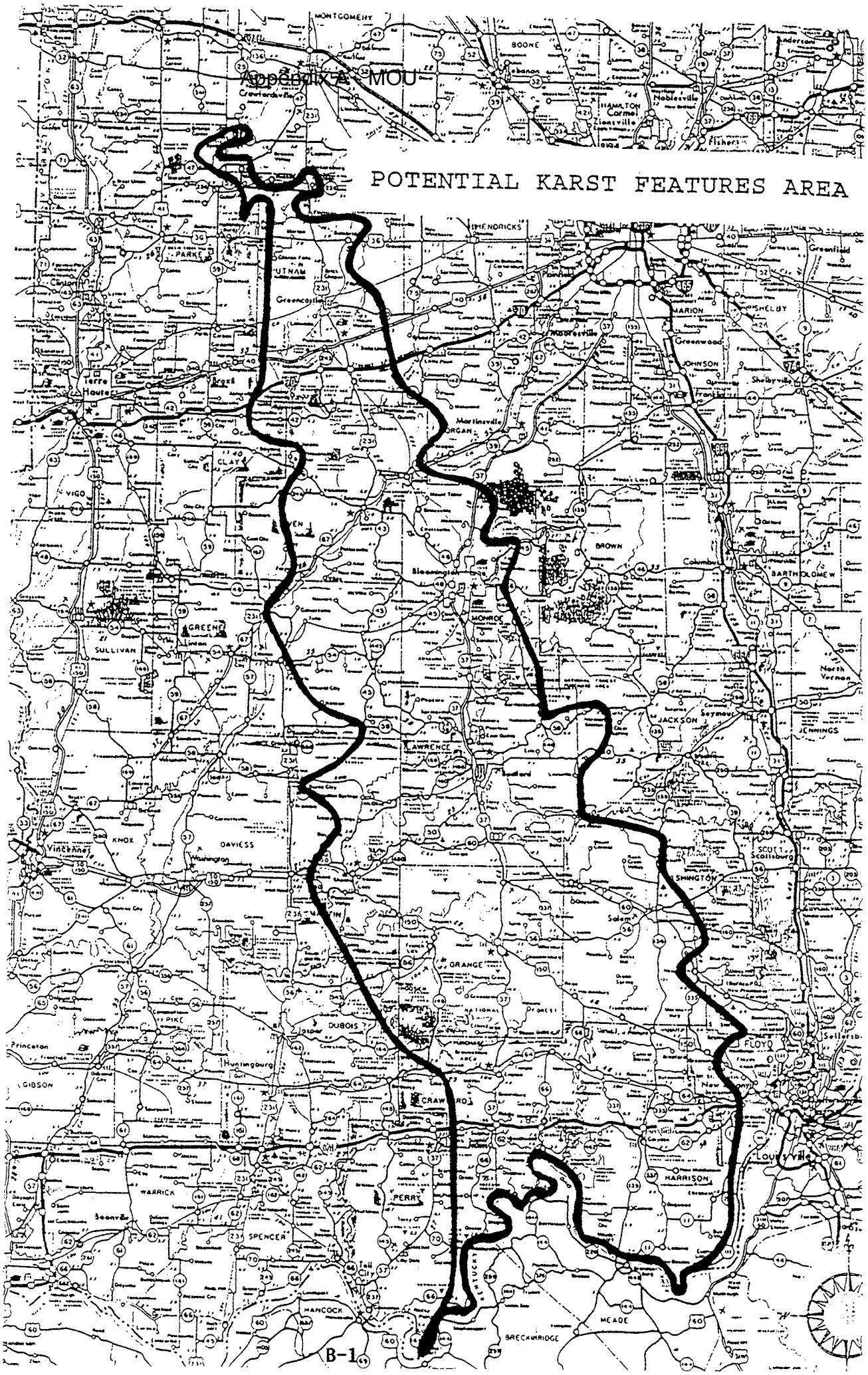
17. THIS DOCUMENT WILL BE REVIEWED ANNUALLY OR MORE FREQUENTLY AT THE REQUEST OF ANY OF THE FOREGOING AGENCIES.

MR. FREDERICK C. P POOL, COMMISSIONER
INDIANA DEPARTMENT OF TRANSPORTATION

MR. PATRICK R. RALSTON, DIRECTOR
INDIANA DEPARTMENT OF NATURAL RESOURCES

MS. KATHY PROSSER, COMMISSIONER
INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

MR. DAVID C HUDAK, FIELD SUPERVISOR, BLOOMINGTON FIELD OFFICE
U. S. FISH AND WILDLIFE SERVICE


POTENTIAL KARST FEATURES AREA
MONTGOMERY
BOONE
HENDRICKS
PARKE
PUTNAM
MARION
SHELBY
JOHNSON
Greenwood
Terre Haute
VIGO
CLAY
BROWN
BARTHOLOMEW
GREENE
SULLIVAN
MONROE
JACKSON
JENNINGS
LAWRENCE
KNOX
DAVIESS
Vincennes
SCOTT
ORANGE
PIKE
DUBOIS
Princeton
GIBSON
FLOYD
HARRISON
WARRICK
PERRY
SPENCER
HANCOCK
MEADE
BRECKINRIDGE
Louisville

Appendix B

Carbon and Water Result Tables

Table 1. Results for charcoal samplers analayzed for the presence of fluorescein, eosine, rhodamine WT (RWT) and sulforhodamine B (SRB) dyes
Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N3045	**1**		**4/22/04 1010**	**5/20/04 1432**	**512.4 (1)**	**2.57**	**bkg**	**ND**			**570.8**	**9.89**	**bkg**	**ND**		
N3216	1		5/20/04 1432	5/26/04 1415	511.8 (1)	0.792	bkg	ND			570.6 (1)	1.78	bkg	ND		
N3383	1		5/26/04 1415	6/3/04 1140	512.0 (1)	0.741	bkg	ND			569.8 (1)	2.23	bkg	ND		
N3712	1		6/3/04 1140	6/16/04 1820	ND			ND			570.2 (1)	2.20	bkg	ND		
N3859	1		6/16/04 1820	6/23/04 1310	ND			ND			ND			ND		
N4024	1		6/23/04 1310	6/29/04 1250	ND			ND			ND			ND		
N4222	1		6/29/04 1250	7/8/04 1205	511.8 (1)	0.967	bkg	ND			ND			ND		
N4463	1		7/8/04 1205	7/18/04 1200	510.8 (1)	0.936	bkg	ND			572.2 (1)	2.07	bkg	ND		
N4645	1		7/18/04 1200	7/28/04 0915	511.4 (1)	0.874	bkg	ND			ND			ND		
N4853	1		7/28/04 0915	8/4/04 1340	513.2 (1)	1.27	bkg	ND			ND			ND		
N5016	1		8/4/04 1340	8/13/04 1035	ND			ND			ND			ND		
N5286	1		8/13/04 1035	8/31/04 1530	513.2 (1)	3.60	bkg	ND			567.8 (1)	3.48	bkg	ND		
N5882	1		8/31/04 1530	9/29/04 1022	514.1	3.59	bkg	ND			ND			ND		
N6634	1		9/29/04 1022	10/26/04 0855	514.1	6.18	bkg	ND			568.4	2.22	bkg	ND		
N8003	1		10/26/04 0855	1/10/05 1327	515.2	5.26	bkg	ND			ND			ND		
N8173	1		1/10/05 1327	1/13/05 1456	515.0	1.99	bkg	ND			ND			ND		
N8245	1		1/13/05 1456	1/14/05 1030	ND			ND			ND			ND		
N8448	1		1/14/05 1030	1/21/05 0756	515.2	1.50	bkg	ND			ND			ND		
N8439	1		1/21/05 0756	2/1/05 1752	514.8	1.70	bkg	ND			ND			ND		
N8537	1		2/1/05 1752	2/9/05 1745	515.1	2.64	bkg	ND			ND			ND		
N8956	1		2/9/05 1745	2/25/05 1155	515.6	3.22	bkg	ND			ND			ND		
N3046	**2**		**4/22/04 1015**	**5/20/04 1433**	**512.2 (1)**	**1.43**	**bkg**	**ND**			**572.1**	**2.98**	**bkg**	**ND**		
N3217	2		5/20/04 1433	5/26/04 1430	511.4 (1)	0.768	bkg	ND			573.0 (1)	2.14	bkg	ND		
N3384	2		5/26/04 1430	6/3/04 1150	512.6 (1)	0.870	bkg	ND			572.4 (1)	2.33	bkg	ND		
N3713	2		6/3/04 1150	6/16/04 1830	ND			ND			570.2 (1)	2.71	bkg	ND		
N3861	2		6/16/04 1830	6/23/04 1320	512.4 (1)	1.11	bkg	ND			572.0 (1)	2.40	bkg	ND		
N4025	2		6/23/04 1320	6/29/04 1255	ND			ND			ND			ND		
N4223	2		6/29/04 1255	7/8/04 1210	510.2 (1)	1.10	bkg	ND			ND			ND		
N4464	2		7/8/04 1210	7/18/04 1205	512.6 (1)	0.857	bkg	ND			571.4 (1)	2.02	bkg	ND		
N4646	2		7/18/04 1205	7/28/04 0920	511.8 (1)	1.21	bkg	ND			572.8 (1)	1.85	bkg	ND		
N4854	2		7/28/04 0920	8/4/04 1340	513.4 (1)	1.22	bkg	ND			ND			ND		
N5017	2		8/4/04 1340	8/13/04 1040	512.0 (1)	0.660	bkg	ND			ND			ND		
N5287	2		8/13/04 1040	8/31/04 1533	513.8	7.97	bkg	ND			569.0 (1)	10.4	bkg	ND		
N5883	2		8/31/04 1533	9/29/04 1026	514.2	12.1	bkg	ND			567.4 (1)	1.98	bkg	ND		
N6635	2		9/29/04 1026	10/26/04 0900	514.4	13.2	bkg	ND			569.8 (1)	4.09	bkg	ND		
	2		10/26/04 0900	1/10/05 1312	(8)											
N8174	2		1/10/05 1312	1/13/05 1452	515.3	3.08	bkg	ND			ND			ND		
N8246	2		1/13/05 1452	1/14/05 1035	516.4	1.26	bkg	ND			ND			ND		
N8449	2		1/14/05 1035	1/21/05 0752	515.6	2.83	bkg	ND			ND			ND		
N8441	2		1/21/05 0752	2/1/05 1755	514.7	3.40	bkg	ND			ND			ND		
N8441D	2		1/21/05 0752	2/1/05 1755	514.8	2.27	bkg	ND			ND			ND		
N8538	2		2/1/05 1755	2/9/05 1742	515.1	4.21	bkg	ND			ND			ND		
N8957	2		2/9/05 1742	2/25/05 1200	515.2	7.52	bkg	ND			ND			574.0 (1)	2.72	bkg
N3218	**3**		**5/19/04 0955**	**5/26/04 0845**	**ND**			**ND**			**ND**			**ND**		
N3385	3		5/26/04 0845	6/3/04 0800	ND			ND			ND			ND		
N3714	3		6/3/04 0800	6/17/04 1430	515.8 (1)	1.03	bkg	540.2 (1)	0.944	bkg	ND			ND		
N3862	3		6/17/04 1430	6/24/04 1150	515.6 (1)	0.742	bkg	ND			ND			ND		
N4026	3		6/24/04 1150	6/30/04 0650	514.6 (1)	0.582	bkg	ND			ND			ND		
N4224	3		6/30/04 0650	7/9/04 0905	515.6 (1)	0.323	bkg	ND			ND			ND		
N4465	3		7/9/04 0905	7/18/04 1755	515.2 (1)	0.384	bkg	ND			ND			ND		
N4647	3		7/18/04 1755	7/29/04 0815	515.2 (1)	0.351	bkg	ND			569.6 (1)	1.42	bkg	ND		
N4855	3		7/29/04 0815	8/5/04 1130	514.8 (1)	0.372	bkg	ND			ND			ND		
N5018	3		8/5/04 1130	8/14/04 0830	513.0 (1)	0.954	bkg	ND			563.8 (1)	1.68	bkg	ND		
N5288	3		8/14/04 0830	9/1/04 1330	ND			ND			ND			ND		
N5504	3		9/1/04 1330	9/9/04 1406	ND			ND			ND			ND		

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N5658	3		9/9/04 1406	9/21/04 1525	ND			ND			ND			ND		
N5884	3		9/21/04 1525	9/29/04 1531	ND			ND			ND			ND		
N6011	3		9/29/04 1531	10/5/04 1725	ND			ND			ND			ND		
N6264	3		10/5/04 1725	10/14/04 0930	512.8 (1,4)	0.771	bkg	ND			ND			ND		
N6636	3		10/14/04 0930	10/27/04 1540	514.4	1.28	bkg	ND			ND			ND		
N9656	3		10/27/04 1540	3/29/05 1655	ND			ND			ND			ND		
N3219	**4**		**5/19/04 1050**	**5/26/04 0830**	**514.8 (1)**	**0.441**	**bkg**	**ND**			**ND**			**ND**		
N3386	4		5/26/04 0830	6/3/04 0745	516.0 (1)	0.417	bkg	ND			ND			ND		
N3386D	4		5/26/04 0830	6/3/04 0745	ND			ND			ND			ND		
N3715	4		6/3/04 0745	6/17/04 1420	515.4 (1)	0.861	bkg	ND			ND			ND		
N3863	4		6/17/04 1420	6/24/04 1200	515.8	0.798	bkg	ND			ND			ND		
N4027	4		6/24/04 1200	6/30/04 0640	ND			ND			ND			ND		
N4225	4		6/30/04 0640	7/9/04 0855	ND			539.9	65.9	04-03	ND			ND		
N4466	4		7/9/04 0855	7/18/04 1745	515.8 (1)	0.415	bkg	539.3	10.7	04-03	ND			ND		
N4648	4		7/18/04 1745	7/29/04 0800	ND			539.4	5.43	04-03	ND			ND		
N4856	4		7/29/04 0800	8/5/04 1110	ND			539.7	2.26	04-03	ND			ND		
N5019	4		8/5/04 1110	8/14/04 0815	ND			ND			ND			ND		
N5289	4		8/14/04 0815	9/1/04 1315	514.3 (1)	1.34	bkg	535.8 (1)	1.65	04-03	ND			ND		
N5505	4		9/1/04 1315	9/9/04 1356	514.0 (1)	1.53	bkg	ND			ND			ND		
N5659	4		9/9/04 1356	9/21/04 1512	ND (4)			ND			ND			ND		
N5885	4		9/21/04 1512	9/29/04 1505	ND			ND			ND			ND		
N6012	4		9/29/04 1505	10/6/04 0910	ND			ND			ND			ND		
N6265	4		10/6/04 0910	10/14/04 0920	ND			ND			ND			ND		
N6637	4		10/14/04 0920	10/27/04 1500	515.8 (1)	1.11	bkg	ND			567.7	6.99	04-09	ND		
N6955	4		10/27/04 1500	11/8/04 1610	ND			ND			570.0	4.80	04-09	ND		
N7223	4		11/8/04 1632	11/17/04 1450	ND			ND			572.6	6.80	04-09	ND		
N7511	4		11/17/04 1540	12/3/04 1610	ND			ND			571.8 (1)	3.67	04-09	ND		
N9927	4		12/3/04 1610	4/7/05 1032	517.5 (1)	1.60	bkg	540.2 (1)	3.25	04-03	567.8 (1)	6.24	04-09	ND		
P0439	4		4/7/05 1032	4/15/05 0902	515.2 (1)	0.799	bkg	ND			ND			ND		
N3221	**5**		**5/19/04 1125**	**5/26/04 0900**	**513.2 (1)**	**0.576**	**bkg**	**ND**			**ND**			**ND**		
N3387	5		5/26/04 0900	6/3/04 0815	513.6 (1)	0.770	bkg	ND			ND			ND		
N3716	5		6/3/04 0815	6/17/04 1500	514.7 (1)	0.840	bkg	ND			ND			ND		
N3864	5		6/17/04 1500	6/24/04 0855	515.6	0.527	bkg	ND			ND			ND		
N4028	5		6/24/04 0855	6/30/04 0710	516.0 (1)	0.299	bkg	ND			ND			ND		
N4226	5		6/30/04 0710	7/9/04 1105	ND			540.2	7210	04-03	ND			ND		
N4467	5		7/9/04 1105	7/18/04 1815	ND			539.3	272	04-03	ND			ND		
N4649	5		7/18/04 1815	7/28/04 1625	ND (2)			539.3	787	04-03	ND			ND		
N4857	5		7/28/04 1625	8/5/04 0805	ND (2)			538.8	255	04-03	ND			ND		
N5021	5		8/5/04 0805	8/13/04 1530	515.6 (2)	51.6	bkg	538.3	334	04-03	ND			ND		
N5021D	5		8/5/04 0805	8/13/04 1530	515.6 (2)	47.4	bkg	537.9	253	04-03	ND			ND		
N5290	5		8/13/04 1530	9/1/04 1355	515.8 (2)	30.6	bkg	538.4	179	04-03	ND			ND		
N5506	5		9/1/04 1355	9/9/04 1415	515.6 (2)	22.1	bkg	538.2	104	04-03	ND			ND		
N5661	5		9/9/04 1415	9/21/04 1532	517.0 (2)	36.7	bkg	538.2	130	04-03	ND			ND		
N5886	5		9/21/04 1532	9/29/04 1605	ND			536.4	28.2	04-03	ND			ND		
N6013	5		9/29/04 1605	10/5/04 1635	ND			535.2	27.8	04-03	ND			ND		
N6266	5		10/5/04 1635	10/14/04 0955	518.4 (2)	15.2	bkg	536.2	19.5	04-03	ND			ND		
N6638	5		10/14/04 0955	10/27/04 1120				537.5	18.6	04-03	ND			ND		
N6956	5		10/27/04 1120	11/8/04 1632	517.2 (2)	3.88	bkg	540.4	14.2	04-03	ND			ND		
N7222	5		11/8/04 1610	11/17/04 1540	515.8 (2)	4.71	bkg	539.8	15.9	04-03	ND			ND		
N7512	5		11/17/04 1450	12/3/04 1415	521.0 (2)	4.58	bkg	539.1	10.9	04-03	ND			ND		
N9928	5		12/3/04 1415	4/7/05 1055	515.4 (2)	3.27	bkg	541.1	26.5	04-03	ND			ND		
P0441	5		4/7/05 1055	4/15/05 1031	517.0	2.39	bkg	540.2	4.41	04-03	ND			ND		
P0441D	5		4/7/05 1055	4/15/05 1031	517.8	2.91	bkg	540.6	7.19	04-03	ND			ND		
N3222	**6**		**5/19/04 1225**	**5/26/04 0800**	**ND**			**ND**			**572.2 (1)**	**2.31**	**bkg**	**ND**		
N3388	6		5/26/04 0800	6/3/04 0730	ND			ND			569.6 (1)	2.58	bkg	ND		
N3717	6		6/3/04 0730	6/17/04 1340	ND			ND			ND			576.8	11.3	bkg
N3865	6		6/17/04 1340	6/23/04 1850	ND			ND			573.4 (1)	4.49	bkg	ND		

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N4029	6		6/23/04 1850	6/29/04 1715	ND			ND			572.8 (1)	3.91	bkg	ND		
N4227	6		6/29/04 1715	7/9/04 0830	ND			ND			572.8 (1)	4.20	bkg	ND		
N4468	6		7/9/04 0830	7/18/04 1720	ND			ND			ND			574.0 (1)	1.72	bkg
N4650	6		7/18/04 1720	7/28/04 1745	512.4 (1)	0.688	bkg	ND			573.0 (1)	1.72	bkg	ND		
N4858	6		7/28/04 1745	8/5/04 1040	ND			ND			ND			ND		
N5022	6		8/5/04 1040	8/14/04 0745	ND			ND			566.6 (1)	4.68	bkg	ND		
N5291	6		8/14/04 0745	9/1/04 1252	513.4 (1)	2.43	bkg	ND			569.2 (1)	6.28	bkg	ND		
N5887	6		9/1/04 1252	9/29/04 1436	515.2	2.65	bkg	ND			ND			ND		
N6639	6		9/29/04 1436	10/27/04 1400	514.8	2.74	bkg	ND			ND			ND		
N6639D	6		9/29/04 1436	10/27/04 1400	514.3	2.45	bkg	ND			ND			ND		
N8175	6		10/27/04 1400	1/13/05 1358	516.2	7.23	bkg	ND			ND			ND		
N9657	6		1/13/05 1358	3/29/05 1623	515.2 (1,9)	0.760	bkg	ND			ND			ND		
P0442	6		3/29/05 1623	4/14/05 1739	515.1	1.70	bkg	ND			ND			ND		
N3223	**7**		**5/19/04 1445**	**5/26/04 0715**	**ND**			**ND**			**572.4 (1)**	**2.04**	**bkg**	**ND**		
N3389	7		5/26/04 0715	6/3/04 0645	ND			ND			571.6 (1)	3.37	bkg	ND		
N3718	7		6/3/04 0645	6/17/04 1400	ND			ND			570.6 (1)	2.91	bkg	ND		
N3866	7		6/17/04 1400	6/23/04 1830	ND			ND			ND			576.6 (1)	2.30	bkg
N4030	7		6/23/04 1830	6/29/04 1735	ND			ND			ND			ND		
N4228	7		6/29/04 1735	7/9/04 0805	ND			ND			ND			ND		
N4469	7		7/9/04 0805	7/18/04 1700	ND			ND			ND			ND		
N4651	7		7/18/04 1700	7/28/04 1725	ND			ND			572.0 (1)	2.79	bkg	ND		
N4859	7		7/28/04 1725	8/5/04 1025	ND			ND			ND			ND		
N5023	7		8/5/04 1025	8/13/04 1630	ND			ND			ND			ND		
N5292	7		8/13/04 1630	9/1/04 1200	ND			ND			570.8 (1)	7.06	bkg	ND		
N5888	7		9/1/04 1200	9/29/04 1412	ND			ND			ND			574.2 (1)	0.943	bkg
N6641	7		9/29/04 1412	10/27/04 1335	513.8 (1)	1.40	bkg	ND			571.2 (1)	1.47	bkg	ND		
N8176	7		10/27/04 1335	1/18/05 1403	515.7	3.42	bkg	ND			571.4 (1)	5.69	bkg	ND		
N3224	**8**		**5/19/04 1500**	**5/26/04 0730**	**ND**			**ND**			**ND**			**ND**		
N3390	8		5/26/04 0730	6/3/04 0700	ND			ND			ND			ND		
N3719	8		6/3/04 0700	6/17/04 1405	ND			ND			571.2 (1)	3.46	bkg	ND		
N3867	8		6/17/04 1405	6/23/04 1835	ND			ND			ND			576.0 (1)	1.70	bkg
N4031	8		6/23/04 1835	6/29/04 1740	ND			ND			ND			ND		
N4229	8		6/29/04 1740	7/9/04 0810	ND			ND			572.8 (1)	2.59	bkg	ND		
N4470	8		7/9/04 0810	7/18/04 1705	ND			ND			572.6 (1)	2.11	bkg	ND		
N4652	8		7/18/04 1705	7/28/04 1730	ND			ND			ND			ND		
N4861	8		7/28/04 1730	8/5/04 1020	ND			ND			572.6 (1)	1.58	bkg	ND		
N4861D	8		7/28/04 1730	8/5/04 1020	ND			ND			ND			ND		
N5024	8		8/5/04 1020	8/13/04 1635	ND			ND			ND			ND		
N5293	8		8/13/04 1635	9/1/04 1155	ND			ND			569.2 (1)	5.92	bkg	ND		
N5889	8		9/1/04 1155	9/29/04 1416	ND			ND			ND			ND		
N6642	8		9/29/04 1416	10/27/04 1330	513.6 (1)	1.49	bkg	ND			ND			ND		
N8177	8		10/27/04 1330	1/18/05 1408	515.1	1.61	bkg	ND			ND			ND		
N3225	**9**		**5/19/04 1525**	**5/26/04 0745**	**ND**			**ND**			**ND**			**ND**		
N3391	9		5/26/04 0745	6/3/04 0715	ND			ND			ND			ND		
N3721	9		6/3/04 0715	6/17/04 1350	ND			ND			ND			ND		
N3868	9		6/17/04 1350	6/23/04 1840	ND			ND			ND			ND		
N4032	9		6/23/04 1840	6/29/04 1725	ND			ND			ND			ND		
N4230	9		6/29/04 1725	7/9/04 0820	ND			ND			ND			ND		
N4471	9		7/9/04 0820	7/18/04 1710	ND			ND			ND			ND		
N4653	9		7/18/04 1710	7/28/04 1735	ND			ND			ND			ND		
N4862	9		7/28/04 1735	8/5/04 1035	ND			ND			ND			ND		
N5025	9		8/5/04 1035	8/14/04 0800	512.6 (1)	0.794	bkg	ND			ND			ND		
N5294	9		8/14/04 0800	9/1/04 1245	514.0 (1)	1.34	bkg	ND			ND			ND		
N5890	9		9/1/04 1245	9/29/04 1426	515.0 (1)	1.01	bkg	ND			ND			ND		
N6643	9		9/29/04 1426	10/27/04 1345	ND			ND			ND			ND		
N8178	9		10/27/04 1345	1/13/05 1425	ND			ND			ND			ND		
N9658	9		1/13/05 1425	3/29/05 1637	ND			ND			ND			ND		

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
P0443	9		3/29/05 1637	4/14/05 1800	ND			ND			ND			ND		
N3226	**10**		**5/19/04 1630**	**5/26/04 1515**	**ND**			**ND**			**572.0 (1)**	**2.17**	**bkg**	**ND**		
N3392	10		5/26/04 1515	6/3/04 1245	ND			ND			ND			ND		
N3722	10		6/3/04 1245	6/16/04 1015	513.0 (1)	1.34	bkg	ND			571.2 (1)	4.98	bkg	ND		
N3869	10		6/16/04 1015	6/23/04 0920	512.0 (1)	1.06	bkg	ND			572.4 (1)	2.60	bkg	ND		
N4033	10		6/23/04 0920	6/29/04 1025	ND			ND			572.0 (1)	2.29	bkg	ND		
N4231	10		6/29/04 1025	7/8/04 0930	ND			ND			573.0 (1)	3.87	bkg	ND		
N4472	10		7/8/04 0930	7/18/04 0915	ND			ND			572.6 (1)	2.27	bkg	ND		
	10		7/18/04 0915	7/27/04 1655	(8)											
N4863	10		7/27/04 1655	8/4/04 1020	513.6	1.62	bkg	ND			ND			574.2 (1)	2.72	bkg
N5026	10		8/4/04 1020	8/13/04 0825	512.6 (1)	0.791	bkg	ND			573.2 (1)	3.97	bkg	ND		
N5295	10		8/13/04 0825	8/31/04 1055	512.8 (1)	5.02	bkg	ND			572.6 (1)	14.1	bkg	ND		
N5891	10		8/31/04 1055	9/27/04 1350	513.6 (1)	2.37	bkg	ND			569.8 (1)	5.44	bkg	ND		
N6014	10		9/27/04 1350	10/5/04 0904	512.6 (1)	1.41	bkg	ND			ND			ND		
N6267	10		10/5/04 0904	10/12/04 1135	ND			ND			ND			ND		
N6644	10		10/12/04 1135	10/25/04 1025	513.9	4.53	bkg	ND			571.0 (1)	4.91	bkg	ND		
N8004	10		10/25/04 1025	1/10/05 1555	516.6 (1)	2.95	bkg	ND			ND			ND		
N8179	10		1/10/05 1555	1/18/05 1105	515.0 (1)	1.06	bkg	ND			ND			ND		
N3227	**11**		**5/19/04 1720**	**5/26/04 1530**	**ND**			**ND**			**ND**			**ND**		
N3393	11		5/26/04 1530	6/3/04 1300	ND			ND			572.2 (1)	2.89	bkg	ND		
N3723	11		6/3/04 1300	6/16/04 1030	ND			ND			ND			ND		
N3870	11		6/16/04 1030	6/23/04 0930	ND			ND			ND			ND		
N4034	11		6/23/04 0930	6/29/04 1005	ND			ND			572.0 (1)	2.59	bkg	ND		
N4232	11		6/29/04 1005	7/8/04 0920	ND			ND			ND			ND		
N4473	11		7/8/04 0920	7/18/04 0905	ND			ND			ND			ND		
N4654	11		7/18/04 0905	7/27/04 1645	ND			ND			ND			ND		
N4864	11		7/27/04 1645	8/4/04 1010	514.0 (1)	0.702	bkg	ND			571.2 (1)	1.58	bkg	ND		
N5027	11		8/4/04 1010	8/13/04 0815	ND			ND			ND			ND		
N5296	11		8/13/04 0815	8/31/04 1038	513.2 (1)	1.75	bkg	ND			569.6 (1)	3.30	bkg	ND		
N5892	11		8/31/04 1038	9/27/04 1408	ND			ND			ND			ND		
N6015	11		9/27/04 1408	10/5/04 0920	ND			ND			ND			ND		
N6268	11		10/5/04 0920	10/12/04 1120	ND			ND			ND			ND		
N6645	11		10/12/04 1120	10/25/04 1102	515.2	2.42	bkg	ND			ND			ND		
N3228	**12**		**5/19/04 1910**	**5/26/04 1630**	**ND**			**ND**			**ND**			**ND**		
N3394	12		5/26/04 1630	6/3/04 1330	ND			ND			ND			ND		
N3724	12		6/3/04 1330	6/16/04 1110	516.2 (1)	0.478	bkg	ND			568.1	51.9	04-02	ND		
N3871	12		6/16/04 1110	6/23/04 1000	ND			ND			569.2	22.8	04-02	ND		
N4035	12		6/23/04 1000	6/29/04 1040	ND			ND			568.6	10.8	04-02	ND		
N4233	12		6/29/04 1040	7/8/04 0945	ND			ND			568.2	5.65	04-02	ND		
N4474	12		7/8/04 0945	7/18/04 0930	ND			ND			571.0 (1)	2.52	04-02			
N4655	12		7/18/04 0930	7/27/04 1720	ND			539.9	87.4	04-04	ND			ND		
N4865	12		7/27/04 1720	8/4/04 1020	ND			539.8	195	04-04	ND			ND		
N5028	12		8/4/04 1020	8/13/04 0720	ND			539.4	8.06	04-04	ND			ND		
N5297	12		8/13/04 0720	8/31/04 1115	515.2 (1)	0.985	bkg	539.1	6.17	04-04	ND			ND		
N5507	12		8/31/04 1115	9/9/04 0938	514.8 (1)	0.835	bkg	537.7	1.09	04-04	ND			ND		
N5662	12		9/9/04 0938	9/21/04 1000	514.2	16.9	04-07	ND			ND			ND		
N5893	12		9/21/04 1000	9/28/04 1416	514.6 (1)	0.989	bkg	ND			ND			ND		
N6016	12		9/28/04 1416	10/5/04 1052	514.8 (1)	0.607	bkg	ND			ND			ND		
N6269	12		10/5/04 1052	10/12/04 1150	513.0 (1)	0.557	bkg	ND			ND			ND		
N6646	12		10/12/04 1150	10/25/04 1443	515.1	3.29	04-07	535.8	1.59	04-04	ND			ND		
N3229	**13**		**5/20/04 0845**	**5/26/04 1645**	**ND**			**ND**			**ND**			**ND**		
N3395	13		5/26/04 1645	6/3/04 1345	ND			ND			ND			ND		
N3725	13		6/3/04 1345	6/17/04 1145	ND			539.8	12.7	04-01	ND			ND		
N3872	13		6/17/04 1145	6/23/04 1100	ND			539.5	4.35	04-01	ND			ND		
N4036	13		6/23/04 1100	6/29/04 1115	ND			ND			ND			ND		
N4234	13		6/29/04 1115	7/8/04 1030	ND			ND			ND			ND		
N4475	13		7/8/04 1030	7/18/04 1010	ND			ND			ND			ND		

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N4656	13		7/18/04 1010	7/28/04 0740	ND			ND			ND			575.4 (1)	1.02	bkg
N4866	13		7/28/04 0740	8/4/04 1200	ND			ND			568.5	25.3	04-05	ND		
N5029	13		8/4/04 1200	8/13/04 0910	ND			ND			568.1	42.5	04-05	ND		
N5298	13		8/13/04 0910	8/31/04 1320	514.3 (1)	1.49	bkg	ND			568.1	39.0	04-05	ND		
N5508	13		8/31/04 1320	9/9/04 1026	ND			ND			568.6	454	04-06	ND		
N5663	13		9/9/04 1026	9/21/04 1130	ND			ND			567.7	182	04-06	ND		
N5894	13		9/21/04 1130	9/28/04 1605	ND			ND			567.6	48.1	04-06	ND		
N6017	13		9/28/04 1605	10/5/04 1156	ND			ND			569.2	23.6	04-06	ND		
N6270	13		10/5/04 1156	10/12/04 1305	ND			ND			568.6	13.0	04-06	ND		
N6647	13		10/12/04 1305	10/25/04 1615	513.9 (1)	1.57	bkg	ND			567.8	11.9	04-06	ND		
N7774	13		10/25/04 1615	12/21/04 1346	515.0 (1)	1.24	bkg	ND			569.8	8.71	04-06	ND		
	13		12/21/04 1346	1/10/05 1425	(8)											
N8181	13		1/10/05 1425	1/17/05 1655	515.7	5.61	bkg	ND			ND			ND		
N8181D	13		1/10/05 1425	1/17/05 1655	516.1	5.06	bkg	ND			ND			ND		
N3230	**14**		**5/20/04 0930**	**5/26/04 1700**	**ND**			**539.3**	**3.05**	**bkg**	**ND**			**574.0 (1)**	**1.89**	**bkg**
N3396	14		5/26/04 1700	6/3/04 1400	ND			ND			ND			ND		
N3579	14		6/3/04 1400	6/11/04 1615	514.2	8.12	bkg	540.6	1.71	bkg	573.6 (1)	3.39	bkg	ND		
N3726	14		6/11/04 1615	6/16/04 1145	ND			ND			ND			ND		
N3726D	14		6/11/04 1615	6/16/04 1145	ND			ND			ND			ND		
N3873	14		6/16/04 1145	6/23/04 1130	514.0	1.96	bkg	538.2	1.43	bkg	ND			ND		
N4037	14		6/23/04 1130	6/29/04 1130	515.2 (1)	0.539	bkg	539.4	5.78	bkg	ND			ND		
N4235	14		6/29/04 1130	7/8/04 1040	515.4 (1)	0.657	bkg	539.5 (1)	1.48	bkg	ND			574.6	3.40	bkg
N4476	14		7/8/04 1040	7/18/04 1030	513.2 (1)	0.944	bkg	539.0 (1)	0.517	bkg	ND			576.8 (1)	1.61	bkg
N4657	14		7/18/04 1030	7/28/04 0750	513.7	0.891	bkg	539.2	1.13	bkg	ND			573.0 (1)	1.27	bkg
N4867	14		7/28/04 0750	8/4/04 1210	514.0 (1)	1.14	bkg	ND			569.6 (1)	3.71	bkg	ND		
N5030	14		8/4/04 1210	8/13/04 0920	517.2 (1)	0.395	bkg	538.3	1.06	bkg	571.2 (1)	2.21	bkg	ND		
N5299	14		8/13/04 0920	8/31/04 1335	514.3	4.91	bkg	536.0 (1)	2.58	bkg	570.0 (1)	5.67	bkg	ND		
N5509	14		8/31/04 1335	9/9/04 1020	514.2(1)	1.34	bkg	537.6 (1)	0.505	bkg	ND			ND		
N5664	14		9/9/04 1020	9/21/04 1215	513.8 (1)	0.825	bkg	540.4	2.46	bkg	ND			ND		
N5895	14		9/21/04 1215	9/28/04 1625	515.6 (1)	0.851	bkg	537.6 (1)	0.490	bkg	ND			ND		
N6018	14		9/28/04 1625	10/5/04 1212	516.9 (1)	0.735	bkg	537.0 (1)	0.727	bkg	ND			ND		
N6271	14		10/5/04 1212	10/12/04 1300	512.9 (1)	0.917	bkg	ND			ND			ND		
N6648	14		10/12/04 1300	10/25/04 1638	514.2	1.53	bkg	ND			ND			ND		
N3231	**15**		**5/20/04 1015**	**5/26/04 1345**	**ND**			**ND**			**ND**			**ND**		
N3397	15		5/26/04 1345	6/3/04 1215	ND			ND			ND			ND		
N3727	15		6/3/04 1215	6/16/04 1750	ND			539.6	42.5	04-01	ND			ND		
N3874	15		6/16/04 1750	6/23/04 1140	ND			539.3	9.63	04-01	ND			ND		
N4038	15		6/23/04 1140	6/29/04 1230	ND			ND			ND			ND		
N4236	15		6/29/04 1230	7/8/04 1145	ND			ND			ND			ND		
N4477	15		7/8/04 1145	7/18/04 1135	ND			ND			ND			ND		
N4658	15		7/18/04 1135	7/28/04 0855	ND			ND			ND			573.6 (1)	1.05	bkg
N4868	15		7/28/04 0855	8/4/04 1315	ND			ND			ND			573.0 (1)	1.41	bkg
N5031	15		8/4/04 1315	8/13/04 1010	ND			ND			ND			ND		
N5301	15		8/13/04 1010	8/31/04 1458	513.8 (1)	1.87	bkg	ND			569.0	17.1	04-05	ND		
N5301D	15		8/13/04 1010	8/31/04 1458	513.8 (1)	2.06	bkg	ND			568.8	12.8	04-05	ND		
N5510	15		8/31/04 1458	9/9/04 1057	ND			ND			568.4	1,020	04-06	ND		
N5665	15		9/9/04 1057	9/21/04 1240	ND			ND			567.8	151	04-06	ND		
N5665D	15		9/9/04 1057	9/21/04 1240	ND			ND			567.9	140	04-06	ND		
N5896	15		9/21/04 1240	9/29/04 0948	ND			ND			568.1	18.1	04-06	ND		
N6019	15		9/29/04 0948	10/5/04 1432	ND			ND			568.7	21.5	04-06	ND		
N6272	15		10/5/04 1432	10/12/04 1405	ND			ND			569.1	10.5	04-06	ND		
N6649	15		10/12/04 1405	10/26/04 0807	514.2 (1)	2.35	bkg	ND			568.0	29.3	04-06	ND		
N8005	15		10/26/04 0807	1/10/05 1405	515.6	2.83	bkg	ND			570.0	13.9	04-06	ND		
N8182	15		1/10/05 1405	1/18/05 1208	514.5 (1)	1.12	bkg	ND			ND			ND		
N8442	15		1/18/05 1208	2/1/05 1811	ND			ND			ND			ND		
N8539	15		2/1/05 1811	2/9/05 1818	516.2 (1)	0.908	bkg	ND			ND			ND		
N8539D	15		2/1/05 1811	2/9/05 1818	514.8 (1)	1.10	bkg	ND			ND			ND		

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N3232	**16**		**5/20/04 1040**	**5/26/04 1400**	**ND**			**ND**			**572.8 (1)**	**1.40**	**bkg**	**ND**		
N3398	16		5/26/04 1400	6/3/04 1230	ND			ND			ND			ND		
N3728	16		6/3/04 1230	6/16/04 1800	ND			ND			ND			ND		
N3875	16		6/16/04 1800	6/23/04 1145	ND			ND			ND			ND		
N4039	16		6/23/04 1145	6/29/04 1235	ND			ND			ND			ND		
N4237	16		6/29/04 1235	7/8/04 1150	ND			ND			ND			ND		
N4478	16		7/8/04 1150	7/18/04 1140	ND			ND			ND			ND		
N4659	16		7/18/04 1140	7/28/04 0900	ND			ND			568.4	6.72	04-05	ND		
N4869	16		7/28/04 0900	8/4/04 1320	ND			ND			568.6	222	04-05	ND		
N5032	16		8/4/04 1320	8/13/04 1015	ND			ND			568.3	129	04-05	ND		
N5302	16		8/13/04 1015	8/31/04 1453	ND			ND			568.4	36.0	04-05	ND		
N5511	16		8/31/04 1453	9/9/04 1055	ND			ND			568.2	26.2	04-05	ND		
N5666	16		9/9/04 1055	9/21/04 1245	ND			ND			567.7	25.6	04-05	ND		
N5897	16		9/21/04 1245	9/29/04 0955	ND			ND			ND			ND		
N6021	16		9/29/04 0955	10/5/04 1438	ND			ND			ND			ND		
N6021D	16		9/29/04 0955	10/5/04 1438	ND			ND			570.2 (1)	1.99	04-05	ND		
N6273	16		10/5/04 1438	10/12/04 1410	ND			ND			ND			ND		
N6650	16		10/12/04 1410	10/26/04 0815	514.6 (1)	1.39	bkg	ND			567.4	9.37	04-05	ND		
N8039	16		10/26/04 0815	1/10/05 1400	514.8 (1)	1.44	bkg	ND			570.6	13.5	04-05	ND		
N8039D	16		10/26/04 0815	1/10/05 1400	514.8 (1)	1.70	bkg	ND			570.2	16.3	04-05	ND		
N8183	16		1/10/05 1400	1/18/05 1204	516.0	43.4	05-13	ND			ND			ND		
N8443	16		1/18/05 1204	2/1/05 1815	515.9	16.5	05-13	ND			ND			ND		
N8541	16		2/1/05 1815	2/9/05 1822	514.0 (1)	1.00	05-13	ND			570.0 (1)	3.08	bkg	ND		
N8958	16		2/9/05 1822	2/25/05 1120	514.6 (1)	1.19	05-13	ND			570.6 (1)	3.40	bkg	ND		
N3233	**17**		**5/20/04 1130**	**5/26/04 1000**	**516.3**	**1.03**	**bkg**	**539.6 (1)**	**0.779**	**bkg**	**ND**			**ND**		
N3399	17		5/26/04 1000	6/3/04 1015	516.2 (1)	0.591	bkg	541.2 (1)	0.515	bkg	ND			ND		
N3729	17		6/3/04 1015	6/17/04 1700	517.0 (1)	0.871	bkg	ND			ND			ND		
N3876	17		6/17/04 1700	6/24/04 1140	515.0	0.593	bkg	ND			ND			ND		
N4041	17		6/24/04 1140	6/30/04 0940	516.0	1.51	bkg	ND			ND			ND		
N4238	17		6/30/04 0940	7/9/04 1215	516.3	0.990	bkg	ND			ND			ND		
N4479	17		7/9/04 1215	7/18/04 1930	515.4 (1)	0.638	bkg	ND						ND		
N4661	17		7/18/04 1930	7/28/04 1530	ND			ND			ND			ND		
N4661D	17		7/18/04 1930	7/28/04 1530	ND			ND			ND			ND		
N4870	17		7/28/04 1530	8/5/04 0930	515.0 (1)	0.532	bkg	ND			ND			ND		
N5033	17		8/5/04 0930	8/13/04 1455	514.0 (1)	0.916	bkg	ND			ND			ND		
N5303	17		8/13/04 1455	9/1/04 1535	514.6 (1)	1.63	bkg	ND			ND			ND		
N3234	**18**		**5/20/04 1505**	**5/26/04 1445**	**ND**			**ND**			**ND**			**ND**		
N3401	18		5/26/04 1445	6/3/04 1200	ND			ND			ND			ND		
N3730	18		6/3/04 1200	6/16/04 1840	ND			ND			ND			ND		
N3877	18		6/16/04 1840	6/23/04 1330	ND			ND			ND			ND		
N4042	18		6/23/04 1330	6/29/04 1305	ND			ND			ND			ND		
N4239	18		6/29/04 1305	7/8/04 1215	ND			ND			ND			ND		
N4481	18		7/8/04 1215	7/18/04 1215	ND			ND			ND			ND		
N4662	18		7/18/04 1215	7/28/04 0825	ND			ND			567.7	29,200	04-05	ND		
N4871	18		7/28/04 0825	8/4/04 1350	ND			ND			567.7	25,700	04-05	ND		
N5034	18		8/4/04 1350	8/13/04 1045	ND			ND			567.9	5,170	04-05	ND		
N5304	18		8/13/04 1045	8/31/04 1540	ND			ND			569.0	1,300	04-05	ND		
N5512	18		8/31/04 1540	9/9/04 1135	ND			ND			568.6	309	04-05	ND		
N5667	18		9/9/04 1135	9/21/04 1252	ND			ND			567.8	179	04-05	ND		
N5898	18		9/21/04 1252	9/29/04 1033	ND			ND			568.4	139	04-05	ND		
N6022	18		9/29/04 1033	10/5/04 1445	ND			ND			568.4	88.4	04-05	ND		
N6274	18		10/5/04 1445	10/12/04 1440	ND			ND			569.1	54.1	04-05	ND		
N6651	18		10/12/04 1440	10/26/04 0909	ND			ND			568.1	108	04-05	ND		
N6957	18		10/26/04 0909	11/8/04 1540	ND			ND			568.9	64.3	04-05	ND		
N7224	18		11/8/04 1540	11/17/04 1250	ND			ND			569.0	23.8	04-05	ND		
	18		11/17/04 1250	12/3/04 1642	(8)											
N8006	18		12/3/04 1642	1/10/05 1304	ND			ND			569.6	66.8	04-05	ND		

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N8184	18		1/10/05 1304	1/18/05 1216	514.4 (1)	0.674	bkg	ND			569.1	8.75	04-05	ND		
N3235	**19**		**5/20/04 1740**	**5/26/04 1315**	**512.4 (1)**	**0.988**	**bkg**	**ND**			**ND**			**575.8 (1)**	**2.65**	**bkg**
N3402	19		5/26/04 1315	6/3/04 1115	ND			ND			ND			575.0 (1)	1.88	bkg
N3731	19		6/3/04 1115	6/17/04 0950	ND			540.1	986	04-01	ND			ND		
N3878	19		6/17/04 0950	6/23/04 1350	ND			539.5	73.3	04-01	ND			ND		
N3878D	19		6/17/04 0950	6/23/04 1350	ND			539.5	77.4	04-01	ND			ND		
N4043	19		6/23/04 1350	6/29/04 1330	ND			539.5	55.4	04-01	ND			ND		
N4241	19		6/29/04 1330	7/8/04 1250	ND			539.4	27.6	04-01	ND			ND		
N4241D	19		6/29/04 1330	7/8/04 1250	ND			539.3	26.0	04-01	ND			ND		
N4482	19		7/8/04 1250	7/18/04 1305	515.6 (1)	0.880	bkg	539.2	3.56	04-01	ND			574.5 (1)	1.63	bkg
N4663	19		7/18/04 1305	7/28/04 1010	515.6 (1)	1.41	bkg	538.8	5.80	04-01	ND			575.2 (1)	2.81	bkg
N4872	19		7/28/04 1010	8/4/04 1620	515.2	1.68	bkg	538.8	5.60	04-01	ND			574.6 (1)	3.55	bkg
N5035	19		8/4/04 1620	8/13/04 1115	514.9	6.63	bkg	536.2	6.20	04-01	570.8 (1)	4.32	bkg	ND		
N5305	19		8/13/04 1115	8/30/04 1115	514.2	7.33	bkg	536.2	4.80	04-01	ND			575.0 (1)	5.73	bkg
N3236	**20**		**5/20/04 1800**	**5/26/04 1330**	**ND**			**ND**			**ND**			**ND**		
N3236D	20		5/20/04 1800	5/26/04 1330	ND			ND			ND			ND		
N3403	20		5/26/04 1330	6/3/04 1130	515.8 (1)	0.429	bkg	ND			ND			ND		
N3732	20		6/3/04 1130	6/17/04 1000	ND			ND			ND			ND		
N3879	20		6/17/04 1000	6/23/04 1400	514.6 (1)	0.458	bkg	ND			ND			ND		
N4044	20		6/23/04 1400	6/29/04 1335	514.4 (1)	0.318	bkg	ND			ND			ND		
N4044D	20		6/23/04 1400	6/29/04 1335	515.0 (1)	0.363	bkg	ND			ND			ND		
N4242	20		6/29/04 1335	7/8/04 1255	514.2 (1)	0.525	bkg	ND			ND			ND		
N4483	20		7/8/04 1255	7/18/04 1310	514.1 (1)	0.341	bkg	ND			ND			ND		
N4483D	20		7/8/04 1255	7/18/04 1310	511.8 (1)	0.444	bkg	ND			ND			ND		
N4664	20		7/18/04 1310	7/28/04 1015	512.6 (1)	0.425	bkg	ND			570.6 (1)	0.770	bkg	ND		
N4873	20		7/28/04 1015	8/4/04 1610	514.8 (1)	0.449	bkg	ND			565.4 (1)	0.619	bkg	ND		
N5036	20		8/4/04 1610	8/13/04 1120	512.5 (1)	1.38	bkg	ND			ND			ND		
N5306	20		8/13/04 1120	8/31/04 1620	513.2 (1)	1.48	bkg	ND			ND			ND		
N5668	20		8/31/04 1620	9/21/04 1320	514.6 (1)	1.40	bkg	ND			ND			ND		
N5899	20		9/21/04 1320	9/29/04 1718	513.8 (1)	1.17	bkg	ND			ND			ND		
N5899D	20		9/21/04 1320	9/29/04 1718	513.9 (1)	1.09	bkg	ND			ND			ND		
N6652	20		9/29/04 1718	10/25/04 0925	513.6 (1)	1.56	bkg	ND			ND			ND		
N3237	**21**		**5/21/04 0925**	**5/26/04 0915**	**516.2**	**0.998**	**bkg**	**ND**			**ND**			**ND**		
N3404	21		5/26/04 0915	6/3/04 0830	514.6 (1)	0.450	bkg	ND			ND			ND		
N3733	21		6/3/04 0830	6/17/04 1515	515.2	2.38	bkg	ND			ND			ND		
N3881	21		6/17/04 1515	6/24/04 0915	514.6 (1)	0.636	bkg	ND			ND			ND		
N4045	21		6/24/04 0915	6/30/04 0720	515.3	1.21	bkg	ND			ND			ND		
N4243	21		6/30/04 0720	7/9/04 1115	514.4	0.936	bkg	ND			ND			ND		
N4484	21		7/9/04 1115	7/18/04 1820	513.8 (1)	0.558	bkg	ND			ND			ND		
N4665	21		7/18/04 1820	7/28/04 1630	514.5	1.61	bkg	ND			567.1	4.27	bkg	ND		
N4874	21		7/28/04 1630	8/5/04 0815	515.0	3.92	bkg	ND			565.0 (1)	6.58	bkg	ND		
N5037	21		8/5/04 0815	8/13/04 1540	514.1	1.33	bkg	ND			565.0 (1)	1.44	bkg	ND		
N5307	21		8/13/04 1540	9/1/04 1405	514.2	4.47	bkg	ND			564.8 (1)	4.38	bkg	ND		
N5901	21		9/1/04 1405	9/29/04 1542	514.7	4.96	bkg	ND			565.0 (1)	3.67	bkg	ND		
N6653	21		9/29/04 1542	10/27/04 1059	514.2	6.39	bkg	ND			564.8 (1)	1.58	bkg	ND		
N7513	21		10/27/04 1059	12/3/04 1355	515.6	2.45	bkg	ND			ND			ND		
N7545	21		12/3/04 1355	12/7/04 1055	516.2 (1)	0.720	bkg	ND			ND			ND		
N7775	21		12/7/04 1055	12/21/04 1646	516.1	4.09	bkg	ND			ND			ND		
N8007	21		12/21/04 1646	1/5/05 1105	516.0	4.28	bkg	ND			ND			ND		
N8959	21		1/5/05 1105	2/25/05 1225	515.8 (1)	1.04	bkg	ND			568.6 (1)	1.89	bkg	ND		
N9438	21		2/25/05 1225	3/16/05 1620	517.0 (1)	0.804	bkg	ND			ND			ND		
N3238	**22**		**5/21/04 1010**	**5/26/04 0930**	**ND**			**ND**			**ND**			**ND**		
N3405	22		5/26/04 1930	6/3/04 0845	514.2 (1)	0.568	bkg	ND			ND			ND		
N3734	22		6/3/04 0845	6/17/04 1520	ND			ND			564.4 (1)	4.24	bkg	ND		
N3882	22		6/17/04 1520	6/24/04 0925	515.0 (1)	0.477	bkg	ND			566.2 (1)	2.33	bkg	ND		
N4046	22		6/24/04 0925	6/30/04 0730	514.8 (1)	0.334	bkg	ND			564.2 (1)	3.29	bkg	ND		
N4244	22		6/30/04 0730	7/9/04 1125	514.9 (1)	0.364	bkg	ND			565.0 (1)	3.13	bkg	ND		

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N4485	22		7/9/04 1125	7/18/04 1825	ND			ND			ND			ND		
N4666	22		7/18/04 1825	7/28/04 1640	513.8 (1)	0.407	bkg	ND			565.2 (1)	3.37	bkg	ND		
N4875	22		7/28/04 1640	8/5/04 0825	514.4 (1)	0.542	bkg	ND			564.0 (1)	3.83	bkg	ND		
N5038	22		8/5/04 0825	8/13/04 1545	ND			ND			564.4 (1)	3.85	bkg	ND		
N5308	22		8/13/04 1545	9/1/04 1410	512.6 (1)	0.966	bkg	ND			563.8 (1)	2.5	bkg	ND		
N5902	22		9/1/04 1410	9/29/04 1551	514.6 (1)	0.697	bkg	ND			566.1 (1)	3.10	bkg	ND		
N6654	22		9/29/04 1551	10/27/04 1105	514.2 (1)	0.995	bkg	ND			ND			ND		
N7514	22		10/27/04 1105	12/3/04 1402	514.8(1)	1.16	bkg	ND			ND			ND		
N7546	22		12/3/04 1402	12/7/04 1100	515.6 (1)	1.04	bkg	ND			ND			ND		
N7776	22		12/7/04 1100	12/21/04 1653	515.0 (1)	1.14	bkg	ND			ND			ND		
N8008	22		12/21/04 1653	1/11/05 1025	515.0	1.72	bkg	ND			ND			ND		
N8961	22		1/11/05 1025	2/25/05 1230	515.0	2.21	bkg	ND			566.8 (1)	2.80	bkg	ND		
N9439	22		2/25/05 1230	3/16/05 1644	515.8 (1)	1.46	bkg	ND			ND			ND		
N9439D	22		2/25/05 1230	3/16/05 1644	515.6 (1)	0.680	bkg	ND			ND			ND		
N3239	**23**		**5/21/04 1055**	**5/26/04 0945**	**ND**			**ND**			**ND**			**ND**		
N3406	23		5/26/04 0945	6/3/04 0900	ND			ND			ND			ND		
N3735	23		6/3/04 0900	6/17/04 1530	ND			ND			ND			ND		
N3883	23		6/17/04 1530	6/24/04 0935	ND			ND			ND			ND		
N4047	23		6/24/04 0935	6/30/04 0725	ND			ND			ND			ND		
N4245	23		6/30/04 0725	7/9/04 1130	ND			ND			ND			ND		
N4486	23		7/9/04 1130	7/18/04 1830	ND			ND			ND			ND		
N4667	23		7/18/04 1830	7/28/04 1645	ND			539.4 (1)	0.468	bkg	ND			ND		
N4876	23		7/28/04 1645	8/5/04 0830	ND			ND			ND			ND		
N5039	23		8/5/04 0830	8/13/04 1550	ND			ND			ND			ND		
N5309	23		8/13/04 1550	9/1/04 1420	513.2 (1)	0.524	bkg	ND			ND			ND		
N5903	23		9/1/04 1420	9/29/04 1600	515.0 (1)	0.812	bkg	ND			ND			ND		
N6655	23		9/29/04 1600	10/27/04 1112	513.6 (1)	0.613	bkg	ND			ND			ND		
N7515	23		10/27/04 1112	12/3/04 1407	ND			ND			ND			ND		
N7547	23		12/3/04 1407	12/7/04 1105	515.6 (1)	0.648	bkg	ND			ND			ND		
N7777	23		12/7/04 1105	12/21/04 1700	514.6 (1)	0.761	bkg	ND			ND			ND		
N8009	23		12/21/04 1700	1/11/05 1032	513.0 (1)	0.771	bkg	ND			ND			ND		
N8962	23		1/11/05 1032	2/25/05 1235	514.2 (1)	1.21	bkg	ND			ND			ND		
N8962D	23		1/11/05 1032	2/25/05 1235	513.8 (1)	1.04	bkg	ND			ND			ND		
N9441	23		2/25/05 1235	3/16/05 1651	514.4 (1)	0.918	bkg	ND			ND			ND		
N3241	**24**		**5/21/04 1545**	**5/26/04 1045**	**514.0 (1)**	**0.701**	**Viacom**	**ND**			**569.2**	**4.87**	**Viacom**	**ND**		
N3407	24		5/26/04 1045	6/3/04 1100	514.2 (1)	0.672	Viacom	ND			568.8	2.07	Viacom	ND		
N3581	24		6/3/04 1100	6/13/04 1515	513.4 (1)	1.11	Viacom	ND			567.3	8.24	Viacom	ND		
N3736	24		6/13/04 1515	6/17/04 0910	514.2 (1)	0.958	Viacom	ND			568.0	7.41	Viacom	ND		
N3884	24		6/17/04 0910	6/23/04 1615	514.1 (1)	0.751	Viacom	ND			568.6	5.99	Viacom	ND		
N4048	24		6/23/04 1615	6/29/04 1420	515.2 (1)	1.45	Viacom	ND			567.9	16.0	Viacom	ND		
N4246	24		6/29/04 1420	7/8/04 1340	514.8 (1)	1.44	Viacom	ND			567.9	15.0	Viacom	ND		
N4487	24		7/8/04 1340	7/18/04 1405	514.4 (1)	0.698	Viacom	ND			569.8 (1)	4.16	Viacom	ND		
N4668	24		7/18/04 1405	7/28/04 1110	513.4 (1)	1.36	Viacom	ND			569.0	8.60	Viacom	ND		
N4877	24		7/28/04 1110	8/4/04 1520	513.8	2.03	Viacom	ND			568.1	17.4	Viacom	ND		
N5041	24		8/4/04 1520	8/13/04 1145	513.9	3.51	Viacom	ND			568.2	21.3	Viacom	ND		
N5041D	24		8/4/04 1520	8/13/04 1145	514.1	3.44	Viacom	ND			568.0	18.7	Viacom	ND		
N5310	24		8/13/04 1145	8/31/04 1710	514.3	3.32	Viacom	ND			568.0	22.9	Viacom	ND		
N5513	24		8/31/04 1710	9/9/04 1143	513.9	3.15	Viacom	ND			568.1	17.4	Viacom	ND		
N5669	24		9/9/04 1143	9/21/04 1408	514.8	3.06	Viacom	ND			567.1	33.7	Viacom	ND		
N5904	24		9/21/04 1408	9/29/04 1136	514.9	3.39	Viacom	ND			567.5	33.0	Viacom	ND		
N6023	24		9/29/04 1136	10/5/04 1340	514.5	4.88	Viacom	ND			568.1	30.0	Viacom	ND		
N6275	24		10/5/04 1340	10/12/04 1650	513.9	4.53	Viacom	ND			568.5	21.0	Viacom	ND		
N6656	24		10/12/04 1650	10/26/04 1200	514.0	5.08	Viacom	ND			568.3	12.0	Viacom	ND		
N6958	24		10/26/04 1200	11/8/04 1005	516.0	1.92	Viacom	ND			ND			578.7	37.0	Viacom
N6958R	24		10/26/04 1200	11/8/04 1005	516.5	1.77	Viacom	ND			ND			578.4	23.4	Viacom
N7225	24		11/8/04 1005	11/17/04 1340	515.8	2.07	Viacom	ND			ND			578.2	61.8	Viacom
N7516	24		11/17/04 1340	12/3/04 1515	515.8	2.78	Viacom	ND			ND			578.9	27.0	Viacom

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N7778	24		12/3/04 1515	12/21/04 1453	516.9	3.86	Viacom	540.5	5.58	04-10	ND			577.9	34.1	Viacom
N3242	**25**		**5/21/04 1600**	**5/26/04 1015**	**515.3**	**1.04**	**Viacom**	**ND**			**567.7**	**22.5**	**Viacom**	**ND**		
N3408	25		5/26/04 1015	6/3/04 1030	518.6 (1)	0.790	Viacom	ND			567.8	5.82	Viacom	ND		
N3582	25		6/3/04 1030	6/13/04 1520	515.4	1.94	Viacom	ND			567.5	29.8	Viacom	ND		
N3737	25		6/13/04 1520	6/17/04 0850	514.4	2.44	Viacom	ND			567.3	34.8	Viacom	ND		
N3885	25		6/17/04 0850	6/23/04 1600	516.7	1.65	Viacom	ND			567.7	29.4	Viacom	ND		
N4049	25		6/23/04 1600	6/29/04 1455	516.3	2.74	Viacom	ND			567.7	42.0	Viacom	ND		
N4247	25		6/29/04 1455	7/8/04 1420	515.9	3.11	Viacom	ND			567.4	61.5	Viacom	ND		
N4488	25		7/8/04 1420	7/18/04 1425	515.5	1.14	Viacom	ND			567.7	15.3	Viacom	ND		
N4669	25		7/18/04 1425	7/28/04 1205	514.3	3.69	Viacom	ND			567.9	52.2	Viacom	ND		
N4878	25		7/28/04 1205	8/4/04 1510	514.5	7.13	Viacom	ND			567.9	103	Viacom	ND		
N5042	25		8/4/04 1510	8/13/04 1215	514.2	13.7	Viacom	ND			568.0	113	Viacom	ND		
N5311	25		8/13/04 1215	9/1/04 1040	514.9	11.7	Viacom	ND			567.9	156	Viacom	ND		
N5514	25		9/1/04 1040	9/9/04 1118	514.5	9.90	Viacom	ND			567.5	68.4	Viacom	ND		
N5670	25		9/9/04 1118	9/21/04 1437	515.1	10.7	Viacom	ND			567.0	116	Viacom	ND		
N5905	25		9/21/04 1437	9/29/04 1310	514.3	4.54	Viacom	ND			567.8	39.9	Viacom	ND		
N6024	25		9/29/04 1310	10/5/04 1546	514.4	12.2	Viacom	ND			568.1	68.4	Viacom	ND		
N6276	25		10/5/04 1546	10/12/04 1640	514.0	10.1	Viacom	ND			568.5	39.8	Viacom	ND		
N6657	25		10/12/04 1640	10/26/04 1135	514.7	7.13	Viacom	ND			567.5	54.9	Viacom	ND		
N6959	25		10/26/04 1135	11/8/04 1035	517.3	1.97	Viacom	ND			ND			577.5	52.1	Viacom
N6959R	25		10/26/04 1135	11/8/04 1035	517.6	1.56	Viacom	ND			ND			576.9	28.4	Viacom
N7226	25		11/8/04 1035	11/17/04 1345	516.9	1.85	Viacom	ND			ND			578.1	51.0	Viacom
N7517	25		11/17/04 1345	12/3/04 1455	517.6	2.49	Viacom	ND			ND			577.9	35.7	Viacom
N7779	25		12/3/04 1455	12/21/04 1526	515.8 (6)	2.06	Viacom	541.3	17.9	04-10	569.1	22.7	Viacom	ND		
N7779D	25		12/3/04 1455	12/21/04 1526	516.0 (6)	2.37	Viacom	541.7	25.5	04-10	569.1	30.9	Viacom	ND		
N8010	25		12/21/04 1526	1/11/05 1208	516.2	4.07	Viacom	541.5	36.3	04-10	567.9	46.1	Viacom	ND		
N8185	25		1/11/05 1208	1/18/05 1345	517.8	2.71	Viacom	541.0	10.9	04-10	569.0	12.3	Viacom	ND		
N8963	25		1/18/05 1345	2/24/05 1340	517.1	4.22	Viacom	541.3	3.53	04-10	569.1	45.0	Viacom	ND		
N9442	25		2/24/05 1340	3/16/05 1540	515.6	6.29	Viacom	ND			569.8	43.2	Viacom	ND		
N3243	**26**		**5/21/04 1645**	**5/26/04 1030**	**514.9**	**0.757**	**Viacom**	**ND**			**568.1**	**11.0**	**Viacom**	**ND**		
N3409	26		5/26/04 1030	6/3/04 1045	516.6 (1)	0.660	Viacom	ND			568.2	5.05	Viacom	ND		
N3583	26		6/3/04 1045	6/13/04 1530	515.4	1.40	Viacom	ND			567.1	14.6	Viacom	ND		
N3738	26		6/13/04 1530	6/17/04 0900	515.5	1.67	Viacom	ND			567.6	15.5	Viacom	ND		
N3886	26		6/17/04 0900	6/23/04 1605	515.5	0.890	Viacom	ND			567.8	10.4	Viacom	ND		
N4050	26		6/23/04 1605	6/29/04 1500	515.1	2.31	Viacom	ND			567.9	27.7	Viacom	ND		
N4248	26		6/29/04 1500	7/8/04 1425	516.3	2.58	Viacom	ND			ND			ND		
N4489	26		7/8/04 1425	7/18/04 1430	514.9	0.896	Viacom	ND			568.3	6.79	Viacom	ND		
N4670	26		7/18/04 1430	7/28/04 1210	514.9	1.69	Viacom	ND			567.9	13.4	Viacom	ND		
N4879	26		7/28/04 1210	8/4/04 1515	513.9	5.85	Viacom	ND			568.9	48.4	Viacom	ND		
N5043	26		8/4/04 1515	8/13/04 1220	514.3	6.62	Viacom	ND			567.9	43.5	Viacom	ND		
N5312	26		8/13/04 1220	9/1/04 1045	514.8	4.58	Viacom	ND			567.6	42.7	Viacom	ND		
N5515	26		9/1/04 1045	9/9/04 1122	514.3	3.07	Viacom	ND			568.1	16.4	Viacom	ND		
N5671	26		9/9/04 1122	9/21/04 1440	514.9	3.06	Viacom	ND			567.1	25.4	Viacom	ND		
N5906	26		9/21/04 1440	9/29/04 1313	514.5	14.3	Viacom	ND			567.7	133	Viacom	ND		
N6025	26		9/29/04 1313	10/5/04 1549	514.3	2.70	Viacom	ND			568.2	12.0	Viacom	ND		
N6277	26		10/5/04 1549	10/12/04 1645	514.1	3.25	Viacom	ND			568.2	11.5	Viacom	ND		
N6658	26		10/12/04 1645	10/26/04 1140	514.5	3.00	Viacom	ND			567.9	16.2	Viacom	ND		
N6961	26		10/26/04 1140	11/8/04 1040	517.1	1.04	Viacom	ND			ND			579.0	81.5	Viacom
N6961D	26		10/26/04 1140	11/8/04 1040	517.0	0.812	Viacom	ND			ND			578.7	50.8	Viacom
N6961R	26		10/26/04 1140	11/8/04 1040	517.6	1.06	Viacom	ND			ND			578.8	44.7	Viacom
	26		11/8/04 1040	11/17/04 1350	(8)											
N7518	26		11/17/04 1350	12/3/04 1458	517.4	1.20	Viacom	539.0 (1)	1.42	04-10	ND			578.9	34.3	Viacom
N7781	26		12/3/04 1458	12/21/04 1530	515.6 (6)	1.51	Viacom	541.5	6.37	04-10	ND			577.7	27.9	Viacom
N8011	26		12/21/04 1530	1/11/05 1215	516.4 (6)	2.76	Viacom	541.4	41.1	04-10	569.2	20.9	Viacom	ND		
N8186	26		1/11/05 1215	1/18/05 1350	517.6	2.51	Viacom	541.3	11.6	04-10	569.0	11.8	Viacom	ND		
N8964	26		1/18/05 1350	2/24/05 1345	515.8	2.70	Viacom	540.4 (1)	0.772	04-10	570.2	12.2	Viacom	ND		
N9443	26		2/24/05 1345	3/16/05 1545	516.1	1.93	Viacom	ND			571.5 (1)	5.64	Viacom	ND		

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N3410	**27**		**5/25/04 1400**	**6/3/04 0930**	**513.2 (1)**	**0.712**	**bkg**	**ND**			**ND**			**ND**		
N3584	27		6/3/04 0930	6/13/04 1710	517.6	6.92	bkg	ND			ND			ND		
N3739	27		6/13/04 1710	6/17/04 1540	516.3	3.49	bkg	ND			ND			ND		
N3887	27		6/17/04 1540	6/24/04 0945	516.4	4.73	bkg	ND			ND			ND		
N4051	27		6/24/04 0945	6/30/04 0800	516.3	3.19	bkg	ND			ND			ND		
N4249	27		6/30/04 0800	7/9/04 1140	515.3	1.52	bkg	ND			567.5	20.1	bkg	ND		
N4490	27		7/9/04 1140	7/18/04 1845	514.0	0.989	bkg	ND			ND			ND		
N4671	27		7/18/04 1845	7/28/04 1500	517.0	3.02	bkg	ND			ND			ND		
N4881	27		7/28/04 1500	8/5/04 0900	517.3	3.27	bkg	ND			ND			ND		
N5044	27		8/5/04 0900	8/13/04 1430	515.5	3.22	bkg	ND			565.5 (1)	3.03	bkg	ND		
N5313	27		8/13/04 1430	9/1/04 1503	513.2 (1)	2.63	bkg	ND			ND			ND		
N5907	27		9/1/04 1503	9/29/04 1648	513.0 (1)	1.68	bkg	ND			ND			ND		
N6659	27		9/29/04 1648	10/27/04 1008	516.4	9.28	bkg	ND			ND			ND		
N3411	**28**		**5/25/04 1445**	**6/3/04 0945**	**513.6 (1)**	**0.463**	**bkg**	**ND**			**ND**			**ND**		
N3585	28		6/3/04 0945	6/13/04 1720	517.5	15.5	bkg	ND			ND			ND		
N3741	28		6/13/04 1720	6/17/04 1550	516.1	4.40	bkg	ND			ND			ND		
N3888	28		6/17/04 1550	6/24/04 0955	516.1	3.32	bkg	ND			ND			ND		
N4052	28		6/24/04 0955	6/30/04 0810	516.2	3.10	bkg	ND			ND			ND		
N4250	28		6/30/04 0810	7/9/04 1145	515.9	1.44	bkg	ND			ND			ND		
N4491	28		7/9/04 1145	7/18/04 1850	516.0	1.98	bkg	ND			ND			ND		
N4672	28		7/18/04 1850	7/28/04 1505	517.3	4.89	bkg	ND			ND			ND		
N4882	28		7/28/04 1505	8/5/04 0905	516.9	8.15	bkg	ND			ND			ND		
N5045	28		8/5/04 0905	8/13/04 1425	517.2	5.99	bkg	ND			ND			ND		
N5314	28		8/13/04 1425	9/1/04 1500	513.6	2.00	bkg	ND			567.0 (1)	1.84	bkg	ND		
N5908	28		9/1/04 1500	9/29/04 1645	512.8 (1)	0.743	bkg	ND			ND			ND		
N6661	28		9/29/04 1645	10/27/04 1012	515.7	3.71	bkg	ND			ND			ND		
N6661D	28		9/29/04 1645	10/27/04 1012	515.8	3.60	bkg	ND			ND			ND		
N3412	**29**		**5/25/04 1530**	**6/3/04 1000**	**ND**			**ND**			**ND**			**ND**		
N3586	29		6/3/04 1000	6/13/04 1745	ND			ND			ND			ND		
N3586D	29		6/3/04 1000	6/13/04 1745	ND			ND			ND			ND		
N3742	29		6/13/04 1745	6/17/04 1630	ND			ND			ND			ND		
N3889	29		6/17/04 1630	6/24/04 1115	ND			ND			572.5	3.02	bkg	ND		
N4053	29		6/24/04 1115	6/30/04 0915	ND			ND			ND			ND		
N4251	29		6/30/04 0915	7/9/04 1200	ND			ND			ND			ND		
N4492	29		7/9/04 1200	7/18/04 1910	ND			ND			ND			ND		
N4673	29		7/18/04 1910	7/28/04 1515	ND			ND			573.0 (1)	1.76	bkg	ND		
N4673V	29		7/18/04 1910	7/28/04 1515	ND			ND			572.6 (1)	1.19	bkg	ND		
N4883	29		7/28/04 1515	8/5/04 0915	ND			ND			572.8 (1)	1.47	bkg	ND		
N4883D	29		7/28/04 1515	8/5/04 0915	ND			ND			574.0 (1)	1.50	bkg	ND		
N5046	29		8/5/04 0915	8/13/04 1440	ND			ND			ND			ND		
N5315	29		8/13/04 1440	9/1/04 1520	ND			ND			ND			ND		
N3413	**30**		**5/25/04 1730**	**6/3/04 0915**	**514.0 (1)**	**0.804**	**bkg**	**ND**			**ND**			**ND**		
N3413D	30		5/25/04 1730	6/3/04 0915	513.0 (1)	0.864	bkg	ND			ND			ND		
N3587	30		6/3/04 0915	6/13/04 1655	512.4 (1)	0.704	bkg	ND			566.2 (1)	1.80	bkg	ND		
N3743	30		6/13/04 1655	6/17/04 1450	ND			ND			ND			ND		
N3890	30		6/17/04 1450	6/24/04 0845	513.6 (1)	0.511	bkg	ND			ND			ND		
N4054	30		6/24/04 0845	6/30/04 0715	513.2 (1)	0.567	bkg	ND			ND			ND		
N4252	30		6/30/04 0715	7/9/04 1055	ND			540.2	27,000	04-03	ND			ND		
N4493	30		7/9/04 1055	7/18/04 1805	ND			539.6	204	04-03	ND			ND		
N4674	30		7/18/04 1805	7/28/04 1615	ND			540.1	1,910	04-03	ND			ND		
N4884	30		7/28/04 1615	8/5/04 0810	ND			539.7	548	04-03	ND			ND		
N5047	30		8/5/04 0810	8/13/04 1525	ND			539.7	548	04-03	ND			ND		
N5316	30		8/13/04 1525	9/1/04 1337	ND			539.7	453	04-03	ND			ND		
N5516	30		9/1/04 1337	9/9/04 1422	ND			539.3	161	04-03	ND			ND		
N5672	30		9/9/04 1422	9/21/04 1543	ND			539.6	218	04-03	ND			ND		
N5909	30		9/21/04 1543	9/29/04 1608	ND			539.4	248	04-03	ND			ND		
N6026	30		9/29/04 1608	10/5/04 1656	ND			539.3	182	04-03	ND			ND		

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N6278	30		10/5/04 1656	10/14/04 1000	ND			538.8	180	04-03	ND			ND		
N6662	30		10/14/04 1000	10/27/04 1130	ND (2)		bkg	538.5	49.2	04-03	ND			ND		
N6962	30		10/27/04 1130	11/8/04 1637	513.8 (2)	1.22	bkg	540.5	15.2	04-03	ND			ND		
N7227	30		11/8/04 1637	11/17/04 1440	515.8 (2)	2.25	bkg	540.3	22.8	04-03	ND			ND		
N7519	30		11/17/04 1440	12/3/04 1420	516.0 (2)	2.52	bkg	539.7	13.1	04-03	ND			ND		
N7519D	30		11/17/04 1440	12/3/04 1420	515.8 (2)	2.28	bkg	539.3	12.1	04-03	ND			ND		
N7548	30		12/3/04 1420	12/7/04 1112	515.8 (2)	1.26	bkg	541.5	13.6	04-03	ND			ND		
N7782	30		12/7/04 1112	12/21/04 1708	515.8 (2)	3.66	bkg	541.1	35.4	04-03	ND			ND		
N8012	30		12/21/04 1708	1/5/05 1125	515.8 (2)	5.94	bkg	540.7	40.3	04-03	ND			ND		
N8187	30		1/5/05 1125	1/18/05 1440	515.8 (1)	1.45	bkg	536.6 (1)	0.952	04-03	ND			ND		
N8965	30		1/18/05 1440	2/25/05 1245	516.0 (2)	4.97	bkg	541.0	40.5	04-03	ND			ND		
N9444	30		2/25/05 1245	3/16/05 1703	515.6 (2)	3.65	bkg	541.1	33.4	04-03	ND			ND		
N3414	**31**		**5/26/04 1115**	**6/3/04 1500**	**514.3**	**25.6**	**Viacom**	**ND**			**568.2**	**256**	**Viacom**	**ND**		
N3588	31		6/3/04 1500	6/14/04 0845	514.3	65.9	Viacom	ND			568.4	744	Viacom	ND		
N3744	31		6/14/04 0845	6/17/04 0830	513.8	41.3	Viacom	ND			569.0	252	Viacom	ND		
N3891	31		6/17/04 0830	6/23/04 1515	514.5	35.7	Viacom	ND			568.1	329	Viacom	ND		
N4055	31		6/23/04 1515	6/29/04 1440	514.5	84.9	Viacom	ND			568.2	1020	Viacom	ND		
N4253	31		6/29/04 1440	7/8/04 1400	514.7	73.0	Viacom	ND			567.7	814	Viacom	ND		
N4494	31		7/8/04 1400	7/19/04 1115	514.1	51.0	Viacom	ND			568.2	429	Viacom	ND		
N4675	31		7/19/04 1115	7/28/04 1140	514.2	59.4	Viacom	ND			568.5	807	Viacom	ND		
N4885	31		7/28/04 1140	8/4/04 1450	514.1	84.3	Viacom	ND			568.6	1140	Viacom	ND		
N5048	31		8/4/04 1450	8/13/04 1205	514.4	197	Viacom	ND			568.2	1,260	Viacom	ND		
N5317	31		8/13/04 1205	9/1/04 1018	515.0	298	Viacom	ND			567.5	1,730	Viacom	ND		
N5517	31		9/1/04 1018	9/9/04 1304	514.4	187	Viacom	ND			568.2	887	Viacom	ND		
N5673	31		9/9/04 1304	9/21/04 1425	514.6	55.3	Viacom	ND			567.4	309	Viacom	ND		
N5910	31		9/21/04 1425	9/29/04 1300	515.0	467	Viacom	ND			567.1	2,560	Viacom	ND		
N6027	31		9/29/04 1300	10/5/04 1523	514.5	221	Viacom	ND			568.3	1,020	Viacom	ND		
N6279	31		10/5/04 1523	10/12/04 1600	514.8	471	Viacom	ND			569.7	1440	Viacom	ND		
N6663	31		10/12/04 1600	10/26/04 1115	515.7	306	Viacom	ND			568.2	1,320	Viacom	ND		
N6963	31		10/26/04 1115	11/8/04 1022	516.3	66.7	Viacom	ND			569.1	244	Viacom	ND		
N7228	31		11/8/04 1022	11/17/04 1405	516.6	98.9	Viacom	ND			568.9	250	Viacom	ND		
N7521	31		11/17/04 1405	12/3/04 1442	515.6	105	Viacom	541.5	1,150	04-10	570.0	300	Viacom	ND		
N7549	31		12/3/04 1442	12/7/04 1156	517.7	51.2	Viacom	540.9	156	04-10	568.2	140	Viacom	ND		
N7549D	31		12/3/04 1442	12/7/04 1156	517.7	40.4	Viacom	541.1	121	04-10	568.2	108	Viacom	ND		
N7783	31		12/7/04 1156	12/21/04 1510	515.4 (6)	64.3	Viacom	541.8	4,140	04-10	570.6 (10)	860	Viacom	ND		
N8013	31		12/21/04 1510	1/11/05 1228	517.4	85.5	Viacom	541.6	415	04-10	568.5	732	Viacom	ND		
N8188	31		1/11/05 1228	1/18/05 1702	517.5	34.2	Viacom	541.1	83.2	04-10	567.9	129	Viacom	ND		
N8966	31		1/18/05 1702	2/24/05 1328	516.9	147	Viacom	541.4	102	04-10	569.3	1,190	Viacom	ND		
N8985	31		2/24/05 1328	3/1/05 1328	516.2	75.5	Viacom	541.8 (7)	20.3	04-10	569.4	399	Viacom	ND		
N9445	31		3/1/05 1328	3/16/05 1528	515.8	157	Viacom	541.4 (7)	57.3	04-10	569.6	932	Viacom	ND		
N3589	**32**		**6/7/04 1430**	**6/13/04 1755**	**ND**			**ND**			**ND**			**ND**		
N3745	32		6/13/04 1755	6/17/04 1645	ND			ND			ND			ND		
N3892	32		6/17/04 1645	6/24/04 1130	ND			ND			569.6 (1)	1.12	bkg	ND		
N4056	32		6/24/04 1130	6/30/04 0930	ND			ND			ND			575.0 (1)	0.722	bkg
N4254	32		6/30/04 0930	7/9/04 1210	ND			ND			ND			ND		
N4495	32		7/9/04 1210	7/18/04 1920	ND			ND			ND			574.8 (1)	0.844	bkg
N4676	32		7/18/04 1920	7/28/04 1535	ND			ND			571.4 (1)	1.01	bkg	ND		
N4886	32		7/28/04 1535	8/5/04 0925	ND			ND			ND			ND		
N5049	32		8/5/04 0925	8/13/04 1450	ND			ND			ND			ND		
N5318	32		8/13/04 1450	9/1/04 1528	ND			ND			569.8 (1)	2.51	bkg	ND		
N3590	**33**		**6/7/04 1440**	**6/13/04 1740**	**514.9**	**1.75**	**bkg**	**ND**			**564.4 (1)**	**4.01**	**bkg**	**ND**		
N3746	33		6/13/04 1740	6/17/04 1600	513.6	1.01	bkg	ND			ND			ND		
N3893	33		6/17/04 1600	6/24/04 1010	514.8	0.887	bkg	ND			ND			ND		
N4057	33		6/24/04 1010	6/30/04 0820	514.8	1.25	bkg	ND			ND			ND		
N4255	33		6/30/04 0820	7/9/04 1235	514.8	0.506	bkg	ND			ND			ND		
N4496	33		7/9/04 1235	7/19/04 1040	514.2	0.884	bkg	ND			ND			ND		
N4677	33		7/19/04 1040	7/28/04 1545	513.8	1.16	bkg	ND			565.8 (1)	2.86	bkg	ND		

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N4887	33		7/28/04 1545	8/5/04 0840	514.6	1.01	bkg	ND			565.4 (1)	1.79	bkg	ND		
N5050	33		8/5/04 0840	8/13/04 1510	513.9	2.65	bkg	ND			564.0 (1)	4.67	bkg	ND		
	33		8/13/04 1510	9/1/04 1433	(8)											
N5911	33		9/1/04 1433	9/29/04 1620	512.8 (1)	1.61	bkg	ND			ND			ND		
N6664	33		9/29/04 1620	10/27/04 1030	514.2	2.55	bkg	ND			ND			ND		
N3591	**34**		**6/7/04 1450**	**6/13/04 1750**	**514.0 (1)**	**0.443**	**bkg**	**ND**			**ND**			**ND**		
N3747	34		6/13/04 1750	6/17/04 1610	512.4 (1)	0.591	bkg	ND			ND			ND		
N3894	34		6/17/04 1610	6/24/04 1020	514.6	0.958	bkg	ND			ND			ND		
N4058	34		6/24/04 1020	6/30/04 0830	ND			ND			ND			ND		
N4256	34		6/30/04 0830	7/9/04 1240	ND			ND			ND			ND		
N4497	34		7/9/04 1240	7/19/04 1045	515.8 (1)	0.718	bkg	ND			ND			ND		
N4678	34		7/19/04 1045	7/28/04 1550	513.8 (1)	0.628	bkg	ND			ND			ND		
N4888	34		7/28/04 1550	8/5/04 0845	515.2 (1)	0.645	bkg	ND			ND			ND		
N5051	34		8/5/04 0845	8/13/04 1515	512.4 (1)	0.794	bkg	ND			ND			ND		
N5319	34		8/13/04 1515	9/1/04 1440	513.8	1.37	bkg	ND			ND			ND		
N5912	34		9/1/04 1440	9/29/04 1625	513.4 (1)	1.37	bkg	ND			ND			ND		
N6665	34		9/29/04 1625	10/27/04 1033	514.5 (1)	0.649	bkg	ND			ND			ND		
N3592	**35**		**6/7/04 1510**	**6/13/04 1640**	**512.6 (1)**	**0.977**	**bkg**	**ND**			**ND**			**ND**		
N3748	35		6/13/04 1640	6/17/04 1310	513.0 (1)	0.790	bkg	ND			570.4 (1)	1.39	bkg	ND		
N3895	35		6/17/04 1310	6/23/04 1815	513.2 (1)	0.623	bkg	ND			ND			ND		
N4059	35		6/23/04 1815	6/29/04 1645	514.0 (1)	0.585	bkg	ND			ND			ND		
N4257	35		6/29/04 1645	7/9/04 0730	514.4 (1)	0.466	bkg	ND			ND			ND		
N4498	35		7/9/04 0730	7/18/04 1630	512.9 (1)	0.629	bkg	ND			ND			ND		
N4679	35		7/18/04 1630	7/28/04 1700	513.6	1.25	bkg	ND			565.0 (1)	1.28	bkg	ND		
N4889	35		7/28/04 1700	8/5/04 0955	513.6 (1)	0.622	bkg	ND			ND			ND		
N5052	35		8/5/04 0955	8/13/04 1600	512.4 (1)	1.38	bkg	ND			ND			ND		
N5321	35		8/13/04 1600	9/1/04 1555	513.1 (1)	2.68	bkg	ND			ND			ND		
N5321D	35		8/13/04 1600	9/1/04 1555	513.5 (1)	3.25	bkg	ND			ND			ND		
N5913	35		9/1/04 1555	9/29/04 1332	513.2 (1)	1.39	bkg	ND			ND			ND		
N6666	35		9/29/04 1332	10/27/04 1145	514.9 (1)	1.81	bkg	ND			ND			ND		
N7550	35		10/27/04 1145	12/7/04 1130	515.2 (1)	1.21	bkg	ND			ND			ND		
N7784	35		12/7/04 1130	12/21/04 1550	513.6 (1)	0.854	bkg	ND			ND			ND		
N8014	35		12/21/04 1550	1/11/05 1140	515.4 (1)	0.902	bkg	ND			ND			ND		
N3749	**36**		**6/13/04 1615**	**6/17/04 1315**	**ND**			**ND**			**572.0 (1)**	**3.36**	**bkg**	**ND**		
N3749D	36		6/13/04 1615	6/17/04 1315	ND			ND			572.6 (1)	3.77	bkg	ND		
N3896	36		6/17/04 1315	6/23/04 1800	ND			ND			570.2 (1)	2.1	bkg	ND		
N4061	36		6/23/04 1800	6/29/04 1655	ND			ND			ND			ND		
N4258	36		6/29/04 1655	7/9/04 0745	ND			ND			ND			ND		
N4499	36		7/9/04 0745	7/18/04 1640	ND			ND			ND			575.2 (1)	1.82	bkg
N4681	36		7/18/04 1640	7/28/04 1705	ND			ND			ND			575.0 (1)	1.67	bkg
N4890	36		7/28/04 1705	8/5/04 1005	ND			ND			ND			ND		
N5053	36		8/5/04 1005	8/13/04 1610	ND			ND			567.2 (1)	1.31	bkg	ND		
N5322	36		8/13/04 1610	9/1/04 1128	ND			ND			571.8 (1)	8.46	bkg	ND		
N5914	36		9/1/04 1128	9/29/04 1346	ND			ND			ND			ND		
N6667	36		9/29/04 1346	10/27/04 1158	ND			ND			ND			ND		
N3593	**37**		**6/7/04 1700**	**6/13/04 1600**	**513.8 (1)**	**0.860**	**bkg**	**ND**			**ND**			**ND**		
N3750	37		6/13/04 1600	6/17/04 1325	513.0 (1)	0.728	bkg	ND			570.8 (1)	1.92	bkg	ND		
N3897	37		6/17/04 1325	6/23/04 1740	514.2	0.829	bkg	ND			ND			ND		
N4062	37		6/23/04 1740	6/29/04 1705	ND			ND			ND			ND		
N4259	37		6/29/04 1705	7/9/04 0750	516.8 (1)	0.693	bkg	ND			ND			ND		
N4501	37		7/9/04 0750	7/18/04 1650	513.2 (1)	0.528	bkg	ND			ND			ND		
N4682	37		7/18/04 1650	7/28/04 1715	513.4 (1)	0.75	bkg	ND			ND			ND		
N4682D	37		7/18/04 1650	7/28/04 1715	513.8 (1)	0.704	bkg	ND			ND			ND		
N4891	37		7/28/04 1715	8/5/04 1010	513.0 (1)	0.591	bkg	ND			ND			ND		
N5054	37		8/5/04 1010	8/13/04 1615	ND			ND			ND			ND		
N5323	37		8/13/04 1615	9/1/04 1138	513.2	3.00	bkg	ND			ND			ND		
N5915	37		9/1/04 1138	9/29/04 1355	513.4 (1)	0.749	bkg	ND			ND			ND		

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N6668	37		9/29/04 1355	10/27/04 1205	513.6 (1)	1.72	bkg	ND			ND			ND		
N3594	**38**		**6/7/04 1710**	**6/13/04 1610**	**513.6 (1)**	**1.00**	**bkg**	**ND**			**ND**			**ND**		
N3751	38		6/13/04 1610	6/17/04 1330	513.8	1.27	bkg	ND			ND			ND		
N3898	38		6/17/04 1330	6/23/04 1750	514.0	1.11	bkg	ND			ND			ND		
N4063	38		6/23/04 1750	6/29/04 1710	514.6 (1)	0.448	bkg	ND			ND			ND		
N4261	38		6/29/04 1710	7/9/04 0755	513.4 (1)	0.657	bkg	ND			ND			ND		
N4261D	38		6/29/04 1710	7/9/04 0755	514.4 (1)	0.802	bkg	ND			ND			ND		
N4502	38		7/9/04 0755	7/18/04 1655	513.2 (1)	0.642	bkg	ND			ND			ND		
N4683	38		7/18/04 1655	7/28/04 1720	513.6	0.699	bkg	ND			ND			ND		
N4892	38		7/28/04 1720	8/5/04 1015	513.6 (1)	0.661	bkg	ND			ND			ND		
N5055	38		8/5/04 1015	8/13/04 1620	513.2 (1)	1.02	bkg	ND			ND			ND		
N5324	38		8/13/04 1620	9/1/04 1142	513.8	2.76	bkg	ND			ND			ND		
N5916	38		9/1/04 1142	9/29/04 1357	513.4 (1)	1.17	bkg	ND			ND			ND		
N6669	38		9/29/04 1357	10/27/04 1209	514.8	1.40	bkg	ND			ND			ND		
N3595	**39**		**6/7/04 1745**	**6/13/04 1540**	**ND**			**ND**			**570.6 (1)**	**4.62**	**bkg**	**ND**		
N3752	39		6/13/04 1540	6/17/04 0840	512.0 (1)	1.55	bkg	ND			571.2 (1)	3.26	bkg	ND		
N3899	39		6/17/04 0840	6/23/04 1530	513.9	1.40	bkg	ND			ND			ND		
N4064	39		6/23/04 1530	6/29/04 1450	514.8	0.809	bkg	ND			ND			ND		
N4262	39		6/29/04 1450	7/8/04 1410	ND			ND			ND			ND		
N4503	39		7/8/04 1410	7/18/04 1435	512.6 (1)	1.08	bkg	ND			ND			ND		
N4503D	39		7/8/04 1410	7/18/04 1435	512.2 (1)	1.10	bkg	ND			ND			ND		
N4684	39		7/18/04 1435	7/28/04 1200	ND			ND			571.6 (1)	3.71	bkg	ND		
N4893	39		7/28/04 1200	8/4/04 1500	513.2 (1)	0.756	bkg	ND			ND			ND		
N5325	39		8/4/04 1500	9/1/04 1030	513.0 (1)	7.39	bkg	ND			569.4 (1)	8.59	bkg	ND		
N5917	39		9/1/04 1030	9/29/04 1155	512.7 (1)	0.626	bkg	ND			ND			ND		
N6670	39		9/29/04 1155	10/26/04 1125	514.7	4.16	bkg	ND			ND			ND		
N7785	39		10/26/04 1125	12/21/04 1520	516.1	5.52	bkg	ND			ND			ND		
N8015	39		12/21/04 1520	1/11/05 1240	516.6	3.62	bkg	ND			ND			ND		
N3596	**40**		**6/7/04 1330**	**6/13/04 1810**	**ND**			**ND**			**ND**			**ND**		
N3753	40		6/13/04 1810	6/17/04 1105	ND			ND			ND			574.8 (1)	2.48	bkg
N3901	40		6/17/04 1105	6/24/04 0820	ND			ND			ND			ND		
N3901D	40		6/17/04 1105	6/24/04 0820	ND			ND			ND			ND		
N4065	40		6/24/04 0820	6/29/04 1545	ND			ND			ND			ND		
N4065D	40		6/24/04 0820	6/29/04 1545	ND			ND			ND			ND		
N4263	40		6/29/04 1545	7/8/04 1450	ND			ND			ND			ND		
N4504	40		7/8/04 1450	7/18/04 1520	ND			ND			ND			ND		
N4685	40		7/18/04 1520	7/28/04 1350	ND			ND			570.8 (1)	1.55	bkg	ND		
N4894	40		7/28/04 1350	8/4/04 1720	ND			ND			ND			ND		
N5056	40		8/4/04 1720	8/13/04 1310	ND			ND			ND			ND		
N5326	40		8/13/04 1310	9/1/04 0828	ND			ND			569.2 (1)	5.40	bkg	ND		
N3597	**41**		**6/8/04 1040**	**6/13/04 1805**	**ND**			**ND**			**573.0 (1)**	**8.20**	**bkg**	**ND**		
N3754	41		6/13/04 1805	6/17/04 1055	ND			ND			571.4 (1)	7.38	bkg	ND		
N3902	41		6/17/04 1055	6/24/04 0830	ND			ND			570.0 (1)	5.58	bkg	ND		
N4066	41		6/24/04 0830	6/29/04 1535	512.6 (1)	0.629	bkg	ND			ND			ND		
N4264	41		6/29/04 1535	7/8/04 1440	513.7	3.11	bkg	ND			573.2 (1)	4.5	bkg	ND		
N4505	41		7/8/04 1440	7/18/04 1510	513.0 (1)	1.07	bkg	ND			573.4 (1)	2.52	bkg	ND		
N4686	41		7/18/04 1510	7/28/04 1340	514.1	9.32	bkg	ND			573.4 (1)	4.19	bkg	ND		
N4895	41		7/28/04 1340	8/4/04 1730	513.7	7.75	bkg	ND			573.8 (1)	4.51	bkg	ND		
N5057	41		8/4/04 1730	8/13/04 1300	513.9	1.28	bkg	ND			ND			ND		
N5327	41		8/13/04 1300	8/31/04 1735	511.6 (1)	5.98	bkg	ND			572.6 (1)	13.2	bkg	ND		
N5918	41		8/31/04 1735	9/27/04 1520	513.3 (1)	2.40	bkg	ND			569.0 (1)	2.59	bkg	ND		
N6028	41		9/27/04 1520	10/5/04 1600	513.0 (1)	2.60	bkg	ND			ND			ND		
N6281	41		10/5/04 1600	10/14/04 1020	512.4 (1)	4.90	bkg	ND			573.8 (1)	6.42	bkg	ND		
N6281D	41		10/5/04 1600	10/14/04 1020	512.2 (1)	5.67	bkg	ND			573.2 (1)	8.06	bkg	ND		
N6671	41		10/14/04 1020	10/27/04 0813	513.8	4.42	bkg	ND			571.3 (1)	5.64	bkg	ND		
N3598	**42**		**6/8/04 1115**	**6/13/04 1510**	**514.1**	**2.00**	**bkg**	**ND**			**ND**			**ND**		
N3755	42		6/13/04 1510	6/17/04 0915	513.6	2.16	bkg	ND			ND			ND		

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N3903	42		6/17/04 0915	6/23/04 1630	513.8	2.84	bkg	ND			ND			ND		
N4067	42		6/23/04 1630	6/29/04 1425	514.4	2.39	bkg	ND			ND			ND		
N4265	42		6/29/04 1425	7/8/04 1345	514.2	2.02	bkg	ND			ND			ND		
N4506	42		7/8/04 1345	7/18/04 1410	513.8	3.36	bkg	ND			ND			ND		
N4687	42		7/18/04 1410	7/28/04 1115	514.2	2.18	bkg	ND			ND			ND		
N4896	42		7/28/04 1115	8/4/04 1525	514.0	2.30	bkg	ND			ND			ND		
N5058	42		8/4/04 1525	8/13/04 1150	513.5 (1)	4.29	bkg	ND			ND			ND		
N5328	42		8/13/04 1150	8/31/04 1706	513.9	6.23	bkg	ND			ND			ND		
N5919	42		8/31/04 1706	9/29/04 1142	514.0	6.34	bkg	ND			ND			ND		
N5919D	42		8/31/04 1706	9/29/04 1142	514.1	4.96	bkg	ND			ND			ND		
N6672	42		9/29/04 1142	10/26/04 1205	513.9	1.52	bkg	ND			ND			ND		
N3599	**43**		**6/8/04 1315**	**6/13/04 1645**	**515.2**	**0.880**	**bkg**	**ND**			**ND**			**ND**		
N3756	43		6/13/04 1645	6/17/04 1415	514.6	0.790	bkg	ND			ND			ND		
N3904	43		6/17/04 1415	6/24/04 1220	514.6	1.22	bkg	ND			ND			ND		
N4068	43		6/24/04 1220	6/30/04 0630	515.6 (1)	0.747	bkg	ND			ND			ND		
N4266	43		6/30/04 0630	7/9/04 0845	ND			539.8	102	04-03	ND			ND		
N4507	43		7/9/04 0845	7/18/04 1735	ND			539.4	19.5	04-03	ND			ND		
N4688	43		7/18/04 1735	7/28/04 1755	515.8 (1)	0.637	bkg	539.3	8.48	04-03	ND			ND		
N4897	43		7/28/04 1755	8/5/04 1050	516.0 (1)	0.535	bkg	539.0	3.56	04-03	ND			ND		
N5059	43		8/5/04 1050	8/13/04 0810	517.4	1.31	bkg	535.2	2.24	04-03	ND			ND		
N5329	43		8/13/04 0810	9/1/04 1305	515.9	1.20	bkg	535.8	1.50	04-03	ND			ND		
N5518	43		9/1/04 1305	9/9/04 1346	514.7 (1)	1.99	bkg	535.2 (1)	1.47	04-03	ND			ND		
N5674	43		9/9/04 1346	9/21/04 1504	516.2	2.23	bkg	536.8	1.57	04-03	ND			ND		
N5921	43		9/21/04 1504	9/29/04 1451	515.8	1.65	bkg	ND			ND			ND		
N6029	43		9/29/04 1451	10/6/04 0900	514.1 (1)	0.986	bkg	ND			ND			ND		
N6282	43		10/6/04 0900	10/14/04 0930	514.2 (1)	0.959	bkg	ND			ND			ND		
N6673	43		10/14/04 0930	10/27/04 1512	515.3 (1)	1.67	bkg	535.2 (1)	1.21	bkg	ND			ND		
N6964	43		10/27/04 1512	11/8/04 1617	515.8 (1)	1.02	bkg	ND			ND			ND		
N7229	43		11/8/04 1617	11/17/04 1520	515.0 (1)	0.863	bkg	ND			ND			ND		
N7522	43		11/17/04 1520	12/3/04 1620	515.6 (1)	1.12	bkg	ND			ND			ND		
N7786	43		12/3/04 1620	12/21/04 1600	515.4 (1)	1.64	bkg	ND			ND			ND		
	43		12/21/04 1600	2/25/05 1300	(8)											
N9446	43		2/25/05 1300	3/16/05 1605	514.8 (1)	1.09	bkg	ND			ND			ND		
N9929	43		2/25/05 1300	4/7/05 1041	515.6 (1)	0.972	bkg	540.2	6.79	04-03	ND			ND		
P0444	43		4/7/05 1041	4/15/05 0957	516.1 (1)	1.21	bkg	536.6 (1)	1.09	04-03	ND			ND		
P0617	43		4/15/05 0957	4/20/05 1828	516.0 (1)	0.816	bkg	ND			ND			ND		
N3601	**44**		**6/8/04 1415**	**6/13/04 1545**	**514.8 (1)**	**0.999**	**IU**	**539.1**	**5.88**	**IU**	**ND**			**ND**		
N3757	44		6/13/04 1545	6/16/04 2000	515.4 (1)	0.623	IU	538.9	3.47	IU	ND			ND		
N3905	44		6/16/04 2000	6/23/04 1730	514.7	23.5	IU	537.9	20.4	IU	ND			ND		
N4069	44		6/23/04 1730	6/30/04 1410	ND (2)			539.5	77.0	IU	ND			ND		
N4267	44		6/30/04 1410	7/8/04 1325	515.6 (1)	1.13	bkg	539.3	9.85	IU	ND			ND		
N4508	44		7/8/04 1325	7/18/04 1345	515.6 (1)	0.987	bkg	539.1	9.81	IU	ND			574.4 (1)	2.82	bkg
N4689	44		7/18/04 1345	7/28/04 1100	ND			539.4	13.7	IU	ND			ND		
N4898	44		7/28/04 1100	8/4/04 1555	514.6 (1)	1.16	bkg	539.0	18.5	IU	ND			ND		
N5061	44		8/4/04 1555	8/13/04 1135	515.6 (6)	2.12	bkg	538.1	15.2	IU	ND			ND		
N5061D	44		8/4/04 1555	8/13/04 1135	515.8 (6)	1.69	bkg	538.1	11.6	IU	ND			ND		
N5330	44		8/13/04 1135	8/31/04 1656	514.5	14.2	bkg	537.0	15.8	IU	ND			ND		
N5519	44		8/31/04 1656	9/9/04 1152	516.0	2.75	bkg	538.5	12.9	IU	ND			ND		
N5519D	44		8/31/04 1656	9/9/04 1152	515.6	1.93	bkg	538.4	8.90	IU	ND			ND		
N5675	44		9/9/04 1152	9/21/04 1355	514.8 (6)	3.40	bkg	538.5	22.9	IU	ND			ND		
N5922	44		9/21/04 1355	9/29/04 1125	516.7	7.70	bkg	537.3	15.8	IU	ND			ND		
N6030	44		9/29/04 1125	10/5/04 1330	517.8	2.66	bkg	537.5	6.17	IU	ND			ND		
N6283	44		10/5/04 1330	10/12/04 1700	517.2	2.49	bkg	537.9	7.17	IU	ND			ND		
N6674	44		10/12/04 1700	10/26/04 1025	516.4	4.33	bkg	537.1	5.60	IU	ND			ND		
N6965	44		10/26/04 1025	11/8/04 0953	517.8	1.73	bkg	540.0	2.17	IU	ND			ND		
N7230	44		11/8/04 0953	11/17/04 1425	517.4 (1)	2.10	bkg	540.7	5.88	IU	ND			ND		
N7523	44		11/17/04 1425	12/3/04 1526	517.6 (1)	1.46	bkg	537.8	1.27	IU	ND			ND		

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N7787	44		12/3/04 1526	12/21/04 1440	517.8	2.54	bkg	540.5	10.0	IU	ND			ND		
N8189	44		12/21/04 1440	1/18/05 1330	517.6	5.55	bkg	540.5	22.3	IU	ND			ND		
N3602	**45**		**6/8/04 1530**	**6/13/04 1500**	**513.8 (1)**	**0.643**	**bkg**	**ND**			**ND**			**ND**		
N3758	45		6/13/04 1500	6/17/04 0910	513.4 (1)	0.490		ND			ND			ND		
N3906	45		6/17/04 0910	6/23/04 1645	514.0 (1)	0.497		ND			ND			ND		
N4070	45		6/23/04 1645	6/29/04 1400	ND			ND			ND			ND		
N4268	45		6/29/04 1400	7/8/04 1320	ND			ND			ND			ND		
N4509	45		7/8/04 1320	7/18/04 1340	512.8 (1)	0.355		ND			ND			ND		
N4690	45		7/18/04 1340	7/28/04 1050	ND			ND			ND			ND		
N4899	45		7/28/04 1050	8/4/04 1535	ND			ND			ND			ND		
N5062	45		8/4/04 1535	8/13/04 1130	ND			ND			ND			ND		
N5331	45		8/13/04 1130	8/31/04 1647	513.2 (1)	2.64	bkg	ND			569.4 (1)	4.71	bkg	ND		
N5923	45		8/31/04 1647	9/29/04 1113	513.6 (1)	1.11	bkg	ND			ND			ND		
N6675	45		9/29/04 1113	10/26/04 1015	513.4 (1)	1.34	bkg	ND			ND			ND		
N3603	**46**		**6/8/04 1615**	**6/13/04 1430**	**512.8 (1)**	**0.571**	**bkg**	**ND**			**ND**			**ND**		
N3759	46		6/13/04 1430	6/17/04 0930	ND			ND			ND			ND		
N3907	46		6/17/04 0930	6/24/04 0720	514.4 (1)	0.544	bkg	ND			ND			ND		
N4071	46		6/24/04 0720	6/29/04 1345	ND			ND			ND			ND		
N4269	46		6/29/04 1345	7/8/04 1300	ND			ND			ND			ND		
N4510	46		7/8/04 1300	7/18/04 1320	ND			ND			ND			ND		
N4691	46		7/18/04 1320	7/28/04 1035	ND			ND			ND			ND		
N5332	46		7/28/04 1035	8/31/04 1630	513.8 (1)	0.646	bkg	ND			ND			ND		
N6676	46		8/31/04 1630	10/26/04 0950	513.2 (1)	0.794	bkg	ND			ND			ND		
N3604	**47**		**6/8/04 1545**	**6/13/04 1445**	**ND**			**ND**			**ND**			**ND**		
N3761	47		6/13/04 1445	6/17/04 0940	514.0 (1)	0.541	bkg	ND			ND			ND		
N3908	47		6/17/04 0940	6/24/04 1715	ND			ND			ND			ND		
N4072	47		6/24/04 1715	6/29/04 1350	ND			ND			ND			ND		
N4270	47		6/29/04 1350	7/8/04 1310	ND			ND			ND			ND		
N4511	47		7/8/04 1310	7/18/04 1325	ND			ND			ND			ND		
N4692	47		7/18/04 1325	7/28/04 1040	ND			ND			ND			ND		
N5333	47		7/28/04 1040	8/31/04 1638	ND			ND			ND			ND		
N6677	47		8/31/04 1638	10/26/04 1002	ND			ND			ND			ND		
N3605	**48**		**6/9/04 0830**	**6/11/04 1510**	**ND**			**ND**			**ND**			**ND**		
N3762	48		6/11/04 1510	6/16/04 0830	512.2 (1)	0.481	bkg	ND			ND			ND		
N3909	48		6/16/04 0830	6/23/04 0830	ND			ND			ND			ND		
N4073	48		6/23/04 0830	6/29/04 0900	ND			ND			ND			ND		
N4271	48		6/29/04 0900	7/8/04 0825	512.6 (1)	0.490	bkg	ND			ND			ND		
N4512	48		7/8/04 0825	7/18/04 0810	ND			ND			ND			ND		
N4693	48		7/18/04 0810	7/27/04 1530	ND			ND			ND			ND		
N4901	48		7/27/04 1530	8/4/04 0915	ND			ND			ND			ND		
N5063	48		8/4/04 0915	8/13/04 0730	ND			ND			ND			ND		
N5334	48		8/13/04 0730	8/31/04 0902	514.0 (1)	2.24	bkg	ND			ND			ND		
N5676	48		8/31/04 0902	9/21/04 0935	514.2 (1)	1.93	bkg	ND			ND			ND		
N5924	48		9/21/04 0935	9/28/04 0944	513.0 (1)	0.746	bkg	ND			ND			ND		
N6031	48		9/28/04 0944	10/5/04 1016	512.8 (1)	1.05	bkg	ND			ND			ND		
N6284	48		10/5/04 1016	10/12/04 1000	ND			ND			ND			ND		
N6678	48		10/12/04 1000	10/25/04 1214	ND			ND			ND			ND		
N6966	48		10/25/04 1214	11/8/04 1325	514.4 (1)	0.901	bkg	ND			ND			ND		
N7231	48		11/8/04 1325	11/17/04 0930	ND			ND			ND			ND		
N7524	48		11/17/04 0930	12/6/04 0955	515.2 (1)	1.33	bkg	ND			ND			ND		
N7788	48		12/6/04 0955	12/20/04 0948	ND			541.2	9.82	04-11	ND			ND		
N8016	48		12/20/04 0948	1/5/05 1445	ND			541.2	89.6	04-11	ND			ND		
N8017	48		1/5/05 1445	1/10/05 1502	ND			541.6	12.6	04-11	ND			579.5	662	05-12
N8190	48		1/10/05 1502	1/18/05 1008	ND			541.3	12.6	04-11	ND			578.8	14.1	05-12
N8542	48		1/18/05 1008	2/11/05 0847	ND			541.1	23.0	04-11	ND			578.0	12.5	05-12
N8967	48		2/11/05 0847	2/25/05 0900	ND			541.3	10.2	04-11	ND			577.0 (1)	3.21	05-12
N8986	48		2/25/05 0900	3/1/05 1230	ND			539.4 (5)	9.26	04-11	569.6	799	05-17	ND		

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N9451	48		3/1/05 1230	3/16/05 1102	ND			539.0 57)	7.04	04-11	570.0	412	05-17	ND		
N9721	48		3/16/05 1102	3/23/05 1720	ND			541.1	5.74	04-11	570.0	13.5	05-17	ND		
N9763	48		3/23/05 1720	3/31/05 0902	515.8 (1)	1.03	bkg	540.9	5.90	04-11	569.3 (1)	8.51	05-17	ND		
P0483	48		3/31/05 0902	4/8/05 0949	515.6 (1)	0.815	bkg	539.8	3.47	04-11	569.4 (1)	4.27	05-17	ND		
N3606	**49**		**6/9/04 0850**	**6/11/04 1450**	**ND**			**ND**			**ND**			**ND**		
N3606D	49		6/9/04 0850	6/11/04 1450	ND			ND			ND			ND		
N3763	49		6/11/04 1450	6/16/04 0900	ND			ND			ND			ND		
N3910	49		6/16/04 0900	6/23/04 0845	513.6 (1)	0.414	bkg	ND			ND			ND		
N4074	49		6/23/04 0845	6/29/04 0910	ND			ND			ND			ND		
N4272	49		6/29/04 0910	7/8/04 0835	ND			ND			ND			ND		
N4513	49		7/8/04 0835	7/18/04 0825	513.6 (1)	0.566	bkg	ND			ND			ND		
N4694	49		7/18/04 0825	7/27/04 1550	513.4 (1)	0.506	bkg	ND			ND			ND		
N4902	49		7/27/04 1550	8/4/04 0930	512.0 (1)	0.644	bkg	ND			ND			ND		
N4902D	49		7/27/04 1550	8/4/04 0930	ND			ND			ND			ND		
N5064	49		8/4/04 0930	8/13/04 0745	ND			ND			ND			ND		
N5335	49		8/13/04 0745	8/31/04 0919	512.2 (1)	1.27	bkg	ND			567.2 (1)	1.47	bkg	ND		
N5531	49		8/31/04 0919	9/10/04 1512	ND			ND			ND			ND		
N5677	49		9/10/04 1512	9/21/04 0900	ND			ND			ND			ND		
N5925	49		9/21/04 0900	9/28/04 0915	ND			ND			ND			ND		
N6032	49		9/28/04 1915	10/5/04 0950	ND			ND			ND			ND		
N6285	49		10/5/04 0950	10/12/04 1040	ND			ND			ND			ND		
N6679	49		10/12/04 1040	10/25/04 1142	513.2 (1)	1.15	bkg	ND			ND			ND		
N6679D	49		10/12/04 1040	10/25/04 1142	512.8 (1)	1.61	bkg	ND			ND			ND		
N6967	49		10/25/04 1142	11/8/04 1155	516.0 (1)	0.906	bkg	ND			ND			ND		
N7232	49		11/8/04 1155	11/17/04 1015	ND			ND			ND			ND		
N7525	49		11/17/04 1015	12/6/04 0930	514.0 (1)	0.944	bkg	ND			ND			ND		
N7789	49		12/6/04 0930	12/21/04 1210	514.6 (1)	1.04	bkg	ND			ND			ND		
N8191	49		12/21/04 1210	1/18/05 1030	514.2 (1)	1.38	bkg	ND			ND			ND		
N8968	49		1/18/05 1030	2/25/05 0840	ND			ND			ND			ND		
N8987	49		2/25/05 0840	3/1/05 1300	ND			ND			ND			ND		
N3607	**50**		**6/9/04 0915**	**6/11/04 1445**	**ND**			**ND**			**ND**			**ND**		
N3764	50		6/11/04 1445	6/16/04 0910	ND			ND			ND			ND		
N3911	50		6/16/04 0910	6/23/04 0850	ND			ND			ND			ND		
N4075	50		6/23/04 0850	6/29/04 0915	ND			ND			ND			ND		
N4273	50		6/29/04 0915	7/8/04 0840	ND			ND			ND			ND		
N4514	50		7/8/04 0840	7/18/04 0830	ND			ND			ND			ND		
N4695	50		7/18/04 0830	7/27/04 1555	ND			ND			ND			ND		
N4903	50		7/27/04 1555	8/4/04 0935	ND			ND			ND			ND		
N5065	50		8/4/04 0935	8/13/04 0750	ND			ND			ND			ND		
N5336	50		8/13/04 0750	8/31/04 0924	ND			ND			ND			ND		
N5532	50		8/31/04 0924	9/10/04 1516	ND (4)			ND			ND			ND		
N5678	50		9/10/04 1515	9/21/04 0903	ND (4)			ND			ND			ND		
N5926	50		9/21/04 0903	9/28/04 0918	ND (4)			ND			ND			ND		
N6033	50		9/28/04 0918	10/5/04 0955	ND (4)			ND			ND			ND		
N6286	50		10/5/04 0955	10/12/04 1045	ND			ND			ND			ND		
N6681	50		10/12/04 1045	10/25/04 1146	ND			ND			ND			ND		
N6968	50		10/25/04 1146	11/8/04 1200	ND			ND			ND			ND		
N7233	50		11/8/04 1200	11/17/04 1020	ND			ND			ND			ND		
N7526	50		11/17/04 1020	12/6/04 0935	ND			ND			ND			ND		
N7790	50		12/6/04 0935	12/21/04 1213	ND			ND			ND			ND		
N8192	50		12/21/04 1213	1/18/05 1034	515.2 (1)	0.686	bkg	ND			ND			ND		
N3608	**51**		**6/9/04 1010**	**6/11/04 1330**	**ND**			**ND**			ND			**574.8 (1)**	**1.11**	**bkg**
N3765	51		6/11/04 1330	6/16/04 0930	ND			ND			ND			574.4 (1)	2.79	bkg
N3912	51		6/16/04 0930	6/23/04 0900	ND			ND			ND			ND		
N4076	51		6/23/04 0900	6/29/04 0925	ND			ND			570.8 (1)	1.95	bkg	ND		
N4274	51		6/29/04 0925	7/8/04 0850	ND			ND						ND		
N4515	51		7/8/04 0850	7/18/04 0840	ND			ND			ND			ND		

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N4696	51		7/18/04 0840	7/27/04 1610	ND			ND			573.2 (1)	3.41	bkg	ND		
N4904	51		7/27/04 1610	8/4/04 0945	513.2 (1)	1.55	bkg	ND			573.6 (1)	1.86	bkg	ND		
N5066	51		8/4/04 0945	8/13/04 0755	512.4 (1)	1.25	bkg	ND			ND			ND		
N5337	51		8/13/04 0755	8/31/04 0940	ND			ND			570.2 (1)	9.48	bkg	ND		
N5521	51		8/31/04 0940	9/9/04 0907	ND			ND			ND			ND		
N5679	51		9/9/04 0907	9/21/04 0915	ND			ND			ND			ND		
N5927	51		9/21/04 0915	9/28/04 1105	ND			ND			ND			ND		
N6034	51		9/28/04 1105	10/5/04 0938	ND			ND			ND			ND		
N6287	51		10/5/04 0938	10/12/04 1105	ND			ND			568.4 (1)	1.64	bkg	ND		
N6682	51		10/12/04 1105	10/25/04 1125	513.4 (1)	5.34	bkg	ND			569.8 (1)	3.22	bkg	ND		
N6969	51		10/25/04 1125	11/8/04 1143	515.4 (1)	1.23	bkg	ND			ND			ND		
N7234	51		11/8/04 1143	11/17/04 1040	515.0 (1)	0.973	bkg	ND			ND			ND		
N7527	51		11/17/04 1040	12/6/04 0917	515.5	5.08	bkg	ND			ND			ND		
N7791	51		12/6/04 0917	12/21/04 1225	515.0	1.66	bkg	ND			ND			ND		
N8018	51		12/21/04 1225	1/10/05 1540	513.4 (1)	1.24	bkg	ND			ND			ND		
N8193	51		1/10/05 1540	1/18/05 1045	515.8 (1)	0.673	bkg	ND			ND			ND		
N3609	**52**		**6/9/04 1030**	**6/11/04 1345**	**ND**			**ND**			**ND**			**ND**		
N3766	52		6/11/04 1345	6/16/04 0945	ND			ND			569.3	458	04-02	ND		
N3913	52		6/16/04 0945	6/23/04 0905	ND			ND			568.8	366	04-02	ND		
N4077	52		6/23/04 0905	6/29/04 0930	ND			ND			568.2	265	04-02	ND		
N4275	52		6/29/04 0930	7/8/04 0855	ND			ND			568.7	102	04-02	ND		
N4516	52		7/8/04 0855	7/18/04 0845	ND			ND			568.5	56.3	04-02	ND		
N4697	52		7/18/04 0845	7/27/04 1615	ND			540.2	7,240	04-04	ND			ND		
N4905	52		7/27/04 1615	8/4/04 0950	ND			540.1	7,130	04-04	ND			ND		
N5067	52		8/4/04 0950	8/13/04 0800	ND			540.3	1,150	04-04	ND			ND		
N5338	52		8/13/04 0800	8/31/04 0937	ND			540.1	764	04-04	ND			ND		
N5522	52		8/31/04 0937	9/9/04 0905	ND			539.9	186	04-04	ND			ND		
N5681	52		9/9/04 0905	9/21/04 0912	514.4 (6)	7.48	04-07	539.7	107	04-04	ND			ND		
N5928	52		9/21/04 0912	9/28/04 1108	516.4	8.24	04-07	539.4	44.3	04-04	ND			ND		
N6035	52		9/28/04 1108	10/5/04 0935	516.0	10.9	04-07	539.4	57.5	04-04	ND			ND		
N6288	52		10/5/04 0935	10/12/04 1100	515.4 (6)	3.74	04-07	539.6	59.4	04-04	ND			ND		
N6683	52		10/12/04 1100	10/25/04 1120	ND			539.8	82.0	04-04	ND			ND		
N6970	52		10/25/04 1120	11/8/04 1138	516.8	1,700	04-07	541.4 (7)	104	04-04	ND			ND		
N6970D	52		10/25/04 1120	11/8/04 1138	516.7	2,460	04-07	539.6 (7)	102	04-04	ND			ND		
N7235	52		11/8/04 1138	11/17/04 1035	515.4	2.87	04-07	541.5	54.8	04-04	ND			ND		
N7528	52		11/17/04 1035	12/6/04 0912	ND			541.7	62.3	04-04	ND			ND		
N7792	52		12/6/04 0912	12/21/04 1222	ND			541.9	90.5	04-04	ND			ND		
N8019	52		12/21/04 1222	1/10/05 1535	ND			541.5	62.8	04-04	ND			ND		
N8019D	52		12/21/04 1222	1/10/05 1535	ND			541.7	31.4	04-04	ND			ND		
N8194	52		1/10/05 1535	1/18/05 1050	ND			541.5	13.5	04-04	ND			ND		
N3610	**53**		**6/9/04 1200**	**6/11/04 1645**	**ND**			**ND**			**ND**			**ND**		
N3767	53		6/11/04 1645	6/16/04 1930	ND			ND			ND			ND		
N3914	53		6/16/04 1930	6/23/04 1150	ND			ND			ND			ND		
N4078	53		6/23/04 1150	6/29/04 1145	ND			ND			ND			ND		
N4276	53		6/29/04 1145	7/8/04 1055	ND			ND			ND			ND		
N4517	53		7/8/04 1055	7/18/04 1045	ND			ND			ND			ND		
N4698	53		7/18/04 1045	7/28/04 0810	ND			ND			ND			ND		
N4906	53		7/28/04 0810	8/4/04 1225	ND			ND			568.4	3.95	04-05	ND		
	53		8/4/04 1225	8/13/04 0800	(11)											
N5339	53		8/13/04 0800	8/31/04 1400	ND			ND			570.2	7.85	04-05	ND		
N5523	53		8/31/04 1400	9/9/04 1035	ND			ND			ND (4)			ND		
N6684	53		9/9/04 1035	10/25/04 1650	ND			ND			ND			ND		
N7793	53		10/25/04 1650	12/21/04 1414	516.3	5.12	bkg	ND			ND			ND		
N3611	**54**		**6/9/04 1545**	**6/11/04 1630**	**ND**			**ND**			**ND**			**ND**		
N3768	54		6/11/04 1630	6/17/04 1210	ND			539.5	7.02	04-01	ND			ND		
N3915	54		6/17/04 1210	6/23/04 1140	ND			539.4	2.12	04-01	ND			ND		
N4079	54		6/23/04 1140	6/29/04 1140	ND			ND			ND			ND		

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N4277	54		6/29/04 1140	7/8/04 1050	ND			ND			ND			ND		
N4518	54		7/8/04 1050	7/18/04 1040	ND			ND			ND			ND		
N4699	54		7/18/04 1040	7/28/04 0800	ND			ND			ND			ND		
N4907	54		7/28/04 0800	8/4/04 1220	ND			ND			568.0	18.0	04-05	ND		
N5068	54		8/4/04 1220	8/13/04 0930	ND			ND			568.1	53.1	04-05	ND		
N5341	54		8/13/04 0930	8/31/04 1350	512.0 (1)	1.64	bkg	ND			568.6	21.5	04-05	ND		
N5341D	54		8/13/04 0930	8/31/04 1350	512.2 (1)	1.76	bkg	ND			568.8	17.1	04-05	ND		
N5524	54		8/31/04 1350	9/9/04 1042	ND			ND			568.1	321	04-06	ND		
N5682	54		9/9/04 1042	9/21/04 1230	ND			ND			567.6	122	04-06	ND		
N5929	54		9/21/04 1230	9/29/04 0900	ND			ND			568.0	9.38	04-06	ND		
N6036	54		9/29/04 0900	10/5/04 1223	ND			ND			569.0	3.72	04-06	ND		
N6289	54		10/5/04 1223	10/12/04 1340	ND			ND			569.4 (1)	2.28	04-06	ND		
N6685	54		10/12/04 1340	10/25/04 1658	513.6 (1)	1.36	bkg	ND			567.8	9.09	04-06	ND		
N7794	54		10/25/04 1658	12/21/04 1420	516.7 (1)	1.84	bkg	ND			568.1 (1)	9.79	04-06	ND		
N8195	54		12/21/04 1420	1/18/05 1132	516.3	3.56	bkg	ND			ND			ND		
N3612	**55**		**6/9/04 1645**	**6/11/04 1545**	**ND**			**ND**			**ND**			**ND**		
N3769	55		6/11/04 1545	6/17/04 1145	ND			ND			ND			ND		
N3916	55		6/17/04 1145	6/23/04 1050	ND			ND			ND			ND		
N4081	55		6/23/04 1050	6/29/04 1105	ND			ND			ND			ND		
N4278	55		6/29/04 1105	7/8/04 1015	ND			ND			ND			ND		
N4519	55		7/8/04 1015	7/18/04 1000	ND			ND			ND			ND		
N4701	55		7/18/04 1000	7/28/04 0730	ND			ND			ND			ND		
N4701D	55		7/18/04 1000	7/28/04 0730	ND			ND			ND			ND		
N4908	55		7/28/04 0730	8/4/04 1145	ND			ND			ND			ND		
N5069	55		8/4/04 1145	8/13/04 0900	ND			ND			ND			ND		
N5342	55		8/13/04 0900	8/31/04 1230	ND			ND			567.0 (1)	1.50	bkg	ND		
N5683	55		8/31/04 1230	9/21/04 1122	513.6 (1)	0.540	bkg	ND			ND			ND		
N5683D	55		8/31/04 1230	9/21/04 1122	ND			ND			ND			ND		
N5930	55		9/21/04 1122	9/28/04 1555	513.4 (1)	0.691	bkg	ND			ND			ND		
N6037	55		9/28/04 1555	10/5/04 1150	ND			ND			ND			ND		
N6290	55		10/5/04 1150	10/12/04 1310	ND			ND			ND			ND		
N6686	55		10/12/04 1310	10/25/04 1600	513.8 (1)	0.871	bkg	ND			567.8 (1)	0.966	bkg	ND		
N6971	55		10/25/04 1600	11/8/04 1520	ND			ND			ND			ND		
	55		11/8/04 1520	11/17/04 1230	(8)											
N7529	55		11/17/04 1230	12/6/04 1118	ND			ND			ND			ND		
N7544	55		11/8/04 0000	12/6/04 1118	ND (12)			ND			ND			ND		
N7795	55		12/6/04 1118	12/21/04 1400	ND			ND			ND			ND		
N8021	55		12/21/04 1400	1/10/05 1420	ND			ND			ND			ND		
N8196	55		1/10/05 1420	1/17/05 1705	ND			ND			ND			ND		
N9452	55		1/17/05 1705	3/16/05 1040	ND			ND			ND			ND		
N9722	55		3/16/05 1040	3/23/05 1650	ND			ND			ND			ND		
N9764	55		3/23/05 1650	3/31/05 1223	ND			ND			ND			ND		
P0484	55		3/31/05 1223	4/8/05 1137	ND			ND			ND			ND		
N3613	**56**		**6/10/04 0845**	**6/11/04 1800**	**512.2 (1)**	**0.664**	**bkg**	**ND**			**ND**			**ND**		
N3770	56		6/11/04 1800	6/16/04 1730	ND			ND			ND			ND		
N3917	56		6/16/04 1730	6/23/04 1220	ND			ND			ND			ND		
N4082	56		6/23/04 1220	6/29/04 1220	ND			ND			ND			ND		
N4279	56		6/29/04 1220	7/8/04 1130	ND			ND			ND			ND		
N4521	56		7/8/04 1130	7/18/04 1120	ND			ND			ND			ND		
N4702	56		7/18/04 1120	7/28/04 0840	513.8 (1)	0.567	bkg	ND			ND			ND		
N4909	56		7/28/04 0840	8/4/04 1305	ND			ND			ND			ND		
N5070	56		8/4/04 1305	8/13/04 1005	ND			ND			ND			ND		
N5343	56		8/13/04 1005	8/31/04 1445	512.6 (1)	3.09	bkg	ND			568.6 (1)	4.85	bkg	ND		
N5931	56		8/31/04 1445	9/29/04 0940	ND			ND			ND			ND		
N6687	56		9/29/04 0940	10/26/04 0800	514.6 (1)	0.984	bkg	ND			ND			ND		
N8022	56		10/26/04 0800	1/11/05 1135	515.2 (1)	1.44	bkg	ND			ND			ND		
N8197	56		1/11/05 1135	1/18/05 1152	514.2 (1)	0.752	bkg	ND			ND			ND		

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N3614	**57**		**6/10/04 0915**	**6/11/04 1745**	**ND**			**ND**			**ND**			**ND**		
N3771	57		6/11/04 1745	6/16/04 1740	ND			ND			ND			ND		
N3918	57		6/16/04 1740	6/23/04 1230	ND			ND			ND			ND		
N4083	57		6/23/04 1230	6/29/04 1225	ND			ND			ND			ND		
N4281	57		6/29/04 1225	7/8/04 1135	ND			ND			ND			ND		
N4281D	57		6/29/04 1225	7/8/04 1135	ND			ND			ND			ND		
N4522	57		7/8/04 1135	7/18/04 1125	ND			ND			ND			ND		
N4703	57		7/18/04 1125	7/28/04 0835	ND			ND			ND			ND		
N4910	57		7/28/04 0835	8/4/04 1300	ND			ND			ND			ND		
N5071	57		8/4/04 1300	8/13/04 1000	ND			ND			ND			ND		
N5344	57		8/13/04 1000	8/31/04 1440	ND			ND			ND			ND		
N5932	57		8/31/04 1440	9/29/04 0935	ND			ND			ND			ND		
N6688	57		9/29/04 0935	10/26/04 0753	ND			ND			ND			ND		
N8023	57		10/26/04 0753	1/11/05 1128	ND			ND			ND			ND		
N8198	57		1/11/05 1128	1/18/05 1145	ND			ND			ND			ND		
N3615	**58**		**6/10/04 1045**	**6/11/04 1730**	**ND**			**ND**			**ND**			**ND**		
N3772	58		6/11/04 1730	6/16/04 1700	ND			ND			ND			ND		
N3919	58		6/16/04 1700	6/23/04 1155	ND			ND			ND			ND		
N4084	58		6/23/04 1155	6/29/04 1205	ND			ND			ND			ND		
N4282	58		6/29/04 1205	7/8/04 1110	ND			ND			ND			ND		
N4523	58		7/8/04 1110	7/18/04 1055	ND			ND			ND			ND		
N4523D	58		7/8/04 1110	7/18/04 1055	ND			ND			ND			ND		
N4704	58		7/18/04 1055	7/28/04 0815	ND			ND			ND			ND		
N4911	58		7/28/04 0815	8/4/04 1240	ND			ND			ND			ND		
N5072	58		8/4/04 1240	8/13/04 0945	ND			ND			ND			ND		
N5345	58		8/13/04 0945	8/31/04 1430	ND			ND			ND			ND		
N5933	58		8/31/04 1430	9/29/04 0922	ND			ND			ND			ND		
N6689	58		9/29/04 0922	10/25/04 1735	ND			ND			ND			ND		
N8024	58		10/25/04 1735	1/11/05 1112	513.2 (1)	1.41	bkg	ND			ND			ND		
N8199	58		1/11/05 1112	1/14/05 1015	513.4 (1)	0.923	bkg	ND			ND			ND		
N8199D	58		1/11/05 1112	1/14/05 1015	512.0 (1)	0.995	bkg	ND			ND			ND		
N9453	58		1/14/05 1015	3/16/05 1230	513.4 (1)	2.23	bkg	ND			ND			ND		
N3616	**59**		**6/10/04 1150**	**6/11/04 1715**	**ND**			**ND**			**ND**			**ND**		
N3773	59		6/11/04 1715	6/16/04 1715	ND			ND			ND			ND		
N3921	59		6/16/04 1715	6/23/04 1210	ND			ND			ND			ND		
N3921D	59		6/16/04 1715	6/23/04 1210	ND			ND			ND			ND		
N4085	59		6/23/04 1210	6/29/04 1155	ND			ND			ND			ND		
N4283	59		6/29/04 1155	7/8/04 1115	ND			ND			ND			ND		
N4524	59		7/8/04 1115	7/18/04 1105	ND			ND			ND			ND		
N4705	59		7/18/04 1105	7/28/04 1820	ND			ND			ND			ND		
N4912	59		7/28/04 1820	8/4/04 1250	ND			ND			ND			ND		
N5073	59		8/4/04 1250	8/13/04 0950	ND			ND			ND			ND		
N5346	59		8/13/04 0950	8/31/04 1422	513.8	1.64	bkg	ND			ND			ND		
N5934	59		8/31/04 1422	9/29/04 0915	ND			ND			ND			ND		
N6690	59		9/29/04 0915	10/25/04 1725	ND			ND			ND			ND		
N8025	59		10/25/04 1725	1/11/05 1105	ND			ND			ND			ND		
N8201	59		1/11/05 1105	1/14/05 1008	ND			ND			ND			ND		
N3617	**60**		**6/10/04 1350**	**6/11/04 1820**	**ND**			**ND**			**ND**			**ND**		
N3774	60		6/11/04 1820	6/17/04 1110	ND			ND			ND			ND		
N3922	60		6/17/04 1110	6/24/04 0810	ND			ND			ND			ND		
N4086	60		6/24/04 0810	6/29/04 1555	ND			ND			ND			ND		
N4086D	60		6/24/04 0810	6/29/04 1555	ND			ND			ND			ND		
N4284	60		6/29/04 1555	7/8/04 1505	ND			ND			ND			ND		
N4525	60		7/8/04 1505	7/18/04 1530	ND			ND			574.6 (1)	0.922	bkg	ND		
N4706	60		7/18/04 1530	7/28/04 1355	ND			ND			571.2 (1)	1.98	bkg	ND		
N4913	60		7/28/04 1355	8/4/04 1710	ND			ND			ND			ND		
N5074	60		8/4/04 1710	8/13/04 1315	ND			ND			ND			ND		

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N5347	60		8/13/04 1315	9/1/04 0840	ND			ND			568.6 (1)	4.31	bkg	ND		
N3618	**61**		**6/10/04 1440**	**6/13/04 1830**	**513.0 (1)**	**2.05**	**bkg**	**ND**			**573.2 (1)**	**5.28**	**bkg**	**ND**		
N3775	61		6/13/04 1830	6/17/04 1030	ND			ND			573.6 (1)	2.98	bkg			
N3923	61		6/17/04 1030	6/24/04 0750	ND			ND			572.6 (1)	4.30	bkg	ND		
N4087	61		6/24/04 0750	6/29/04 1615	ND			ND			ND			ND		
N4285	61		6/29/04 1615	7/8/04 1520	ND			ND			572.0 (1)	1.85	bkg	ND		
N4526	61		7/8/04 1520	7/18/04 1600	ND			ND			572.8 (1)	3.53	bkg	ND		
N4707	61		7/18/04 1600	7/28/04 1425	ND			ND			573.0 (1)	2.80	bkg	ND		
N4914	61		7/28/04 1425	8/4/04 1655	513.4 (1)	1.68	bkg	ND			574.2 (1)	3.08	bkg	ND		
N5075	61		8/4/04 1655	8/13/04 1330	515.0 (1)	0.396	bkg	ND			575.2 (1)	1.03	bkg	ND		
N5348	61		8/13/04 1330	9/1/04 0857	ND			ND			574.0 (1)	11.0	bkg	574.6 (1)	7.09	bkg
N5935	61		9/1/04 0857	9/28/04 1655	514.2 (1)	1.29	bkg	538.8 (1)	1.34	bkg	569.4 (1)	2.39	bkg	ND		
N6038	61		9/28/04 1655	10/5/04 1625	513.4 (1)	0.596	bkg	ND			ND			ND		
N6291	61		10/5/04 1625	10/14/04 1030	513.0 (1)	3.35	bkg	ND			573.0 (1)	3.85	bkg	ND		
N6691	61		10/14/04 1030	10/27/04 0825	514.2 (1)	3.11	bkg	ND			572.4 (1)	4.52	bkg	ND		
N3619	**62**		**6/10/04 1625**	**6/14/04 0915**	**ND**			**ND**			**ND**			**ND**		
N3776	62		6/14/04 0915	6/16/04 1815	ND			ND			ND			ND		
N3776D	62		6/14/04 0915	6/16/04 1815	ND			ND			ND			ND		
N3924	62		6/16/04 1815	6/23/04 1300	512.4 (1)	0.672	bkg	ND			ND			ND		
N4088	62		6/23/04 1300	6/29/04 1240	ND			ND			ND			ND		
N4286	62		6/29/04 1240	7/8/04 1155	ND			ND			ND			ND		
N4527	62		7/8/04 1155	7/18/04 1145	ND			ND			ND			ND		
N4708	62		7/18/04 1145	7/28/04 0905	ND			ND			ND			ND		
N4915	62		7/28/04 0905	8/4/04 1325	ND			ND			ND			ND		
N5076	62		8/4/04 1325	8/13/04 1225	ND			ND			ND			ND		
N5349	62		8/13/04 1225	8/31/04 1509	511.6 (1, 9)	0.816	bkg	ND			ND			ND		
N5936	62		8/31/04 1509	9/29/04 1005	ND			ND			ND			ND		
N6692	62		9/29/04 1005	10/26/04 0826	512.8 (1)	1.58	bkg	ND			ND			ND		
N8444	62		10/26/04 0826	2/1/05 1704	514.2 (1)	1.51	bkg	ND			ND			ND		
N3621	**63**		**6/10/04 1705**	**6/14/04 0955**	**ND**			**ND**			**571.8 (1)**	**1.55**	**bkg**	**ND**		
N3777	63		6/14/04 0955	6/17/04 1230	ND			ND			ND			ND		
N3925	63		6/17/04 1230	6/23/04 1345	ND			ND			ND			ND		
N4089	63		6/23/04 1345	6/29/04 1310	ND			ND			ND			ND		
N4287	63		6/29/04 1310	7/8/04 1225	ND			ND			ND			ND		
N4528	63		7/8/04 1225	7/18/04 1230	ND			ND			ND			ND		
N4709	63		7/18/04 1230	7/28/04 0850	ND			ND			569.0	5.84	04-05	ND		
	63		7/28/04 0850	2/1/05 1730	(13)											
N8543	63		2/1/05 1730	2/9/05 1801	515.2 (1)	0.930	bkg	ND			572.0 (1)	3.96	bkg	ND		
N8969	63		2/9/05 1801	2/25/05 1135	515.0 (1)	1.46	bkg	ND			571.2 (1)	5.02	bkg	ND		
N3622	**64**		**6/10/04 1750**	**6/14/04 1030**	**ND**			**ND**			**574.0 (1)**	**2.67**	**bkg**	**ND**		
N3778	64		6/14/04 1030	6/17/04 1010	ND			ND			ND			ND		
N3926	64		6/17/04 1010	6/23/04 1415	ND			ND			574.2 (1)	2.18	bkg	ND		
N4090	64		6/23/04 1415	6/29/04 1600	ND			ND			573.2 (1)	1.18	bkg	ND		
N4288	64		6/29/04 1600	7/8/04 1515	ND			ND			573.4 (1)	1.35	bkg	ND		
N4529	64		7/8/04 1515	7/18/04 1350	ND			ND			574.4 (1)	2.14	bkg	ND		
N4710	64		7/18/04 1350	7/28/04 1415	ND			ND			ND			576.4 (1)	1.37	bkg
N4916	64		7/28/04 1415	8/4/04 1645	ND			ND			ND			ND		
N5077	64		8/4/04 1645	8/13/04 1400	ND			ND			ND			ND		
N5350	64		8/13/04 1400	9/1/04 0912	512.8 (1)	2.71	bkg	ND			572.0 (1)	5.06	bkg	ND		
N5937	64		9/1/04 0912	9/27/04 1440	ND			ND			ND			ND		
N6039	64		9/27/04 1440	10/5/04 1412	ND			ND			ND			ND		
N6039D	64		9/27/04 1440	10/5/04 1412	ND			ND			ND			ND		
N6292	64		10/5/04 1412	10/14/04 1045	513.0 (1)	1.87	bkg	ND			573.0 (1)	2.01	bkg	ND		
N6693	64		10/14/04 1045	10/27/04 0912	513.8	2.97	bkg	ND			571.0 (1)	3.07	bkg	ND		
	64		10/27/04 0912	1/10/05 1225	(8)											
N8202	64		1/10/05 1225	1/18/05 1230	516.6 (1)	0.968	bkg	ND			ND			ND		
N8247	64		10/27/04 0912	1/18/05 1230	517.6 (1, 12)	1.25	bkg	ND			ND			ND		

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N3779	**65**		**6/15/04 1330**	**6/17/04 1040**	**ND**			**ND**			**571.8 (1)**	**1.58**	**bkg**	**ND**		
N3927	65		6/17/04 1040	6/24/04 0800	ND			ND			ND			ND		
N4091	65		6/24/04 0800	6/29/04 1620	ND			ND			ND			ND		
N4289	65		6/29/04 1620	7/8/04 1530	ND			ND			ND			ND		
N4530	65		7/8/04 1530	7/18/04 1610	ND			ND			571.6 (1)	1.22	bkg	ND		
N4711	65		7/18/04 1610	7/28/04 1435	ND			ND			ND			575.8 (1)	1.09	bkg
N4917	65		7/28/04 1435	8/4/04 1705	ND			ND			ND			ND		
N5078	65		8/4/04 1705	8/13/04 1325	ND			ND			ND			ND		
N5351	65		8/13/04 1325	9/1/04 0850	ND			ND			570.6 (1)	6.58	bkg	ND		
N3928	**66**		**6/17/04 1020**	**6/24/04 0755**	**515.8 (1)**	**0.463**	**bkg**	**ND**			**ND**			**ND**		
N4092	66		6/24/04 0755	6/29/04 1625	ND			ND			ND			ND		
N4290	66		6/29/04 1625	7/8/04 1525	ND			ND			ND			ND		
N4531	66		7/8/04 1525	7/18/04 1605	ND			ND			573.0 (1)	2.80	bkg	ND		
N4712	66		7/18/04 1605	7/28/04 1430	ND			ND			ND			ND		
N4918	66		7/28/04 1430	8/4/04 1700	ND			ND			ND			ND		
N5079	66		8/4/04 1700	8/13/04 1335	ND			ND			ND			ND		
N5352	66		8/13/04 1335	9/1/04 0900	ND			ND			570.4 (1)	10.2	bkg	ND		
N5938	66		9/1/04 0900	9/28/04 1700	ND			ND			ND			ND		
N6694	66		9/28/04 1700	10/27/04 0830	ND			ND			572.2 (1)	3.08	bkg	ND		
N3929	**67**		**6/18/04 0830**	**6/23/04 1030**	**514.8 (1)**	**0.459**	**bkg**	**ND**			**ND**			**ND**		
N4093	67		6/23/04 1030	6/29/04 1045	ND			ND			ND			ND		
N4291	67		6/29/04 1045	7/8/04 0955	ND			ND			ND			ND		
N4532	67		7/8/04 0955	7/18/04 0940	515.6 (1)	0.600	bkg	ND			ND			ND		
N4713	67		7/18/04 0940	7/27/04 1830	ND			ND			ND			ND		
N4919	67		7/27/04 1830	8/4/04 1120	516.0 (1)	0.443	bkg	ND			ND			ND		
N5081	67		8/4/04 1120	8/13/04 0655	ND			ND			ND			ND		
N5081D	67		8/4/04 1120	8/13/04 0655	ND			ND			ND			ND		
N5353	67		8/13/04 0655	8/31/04 1145	516.0 (1)	1.94	bkg	ND			ND			ND		
N5684	67		8/31/04 1145	9/21/04 1028	515.9 (1)	1.24	bkg	ND			ND			ND		
N5939	67		9/21/04 1028	9/28/04 1440	513.1 (1)	1.13	bkg	ND			ND			ND		
N5939D	67		9/21/04 1028	9/28/04 1440	513.6 (1)	1.26	bkg	ND			ND			ND		
N6041	67		9/28/04 1440	10/5/04 1110	513.8 (1)	0.967	bkg	ND			ND			ND		
N6293	67		10/5/04 1110	10/12/04 1225	515.7 (1)	0.980	bkg	ND			ND			ND		
N6695	67		10/12/04 1225	10/25/04 1513	514.4 (1)	1.05	bkg	ND			567.8	4.75	04-08	ND		
N6985	67		10/25/04 1513	11/8/04 1435	ND			ND			570.4	7.79	04-08	ND		
N7236	67		11/8/04 1435	11/17/04 1130	ND			ND			569.8	4.94	04-08	ND		
N7530	67		11/17/04 1130	12/6/04 1110	516.2 (1)	1.01	bkg	ND			569.2 (1)	5.62	04-08	ND		
N7796	67		12/6/04 1110	12/21/04 1335	ND			541.6	1,260	04-11	ND			ND		
N8026	67		12/21/04 1335	1/10/05 1705	ND			540.8	49.5	04-11	ND			ND		
N8203	67		1/10/05 1705	1/18/05 1120	ND			541.3	5.57	04-11	567.8 (1)	4.40	04-08	ND		
N8970	67		1/18/05 1120	2/25/05 1025	ND			540.4	6.42	04-11	566.6 (1)	6.66	04-08	ND		
N9454	67		2/25/05 1025	3/16/05 1215	515.6 (1)	0.781	bkg	540.6	1.87	04-11	570.8 (1)	3.37	04-08	ND		
N9723	67		3/16/05 1215	3/23/05 1635	ND			540.7	5.39	04-11	ND			ND		
N9765	67		3/23/05 1635	3/31/05 1617	ND			540.8	22.3	04-11	ND			ND		
P0485	67		3/31/05 1617	4/8/05 1017	ND			540.4	9.43	04-11	ND			ND		
N3930	**68**		**6/18/04 0900**	**6/23/04 1040**	**515.4 (1)**	**0.525**	**bkg**	**ND**			**569.5**	**32.8**	**04-02**	**ND**		
N4094	68		6/23/04 1040	6/29/04 1050	ND			ND			568.7	17.0	04-02	ND		
N4292	68		6/29/04 1050	7/8/04 1000	ND			ND			570.4	6.23	04-02	ND		
N4533	68		7/8/04 1000	7/18/04 0945	ND			ND			572.0 (1)	2.49	04-02	ND		
N4714	68		7/18/04 0945	7/27/04 1845	ND			540.8	2.92	04-04	ND			ND		
N4921	68		7/27/04 1845	8/4/04 1130	ND			540.3	164	04-04	ND			ND		
N4921D	68		7/27/04 1845	8/4/04 1130	ND			540.1	156	04-04	ND			ND		
N5082	68		8/4/04 1130	8/13/04 0650	ND			540.1	4.19	04-04	ND			ND		
N5354	68		8/13/04 0650	8/31/04 1155	515.8 (1)	1.18	bkg	539.4	6.49	04-04	569.0 (1)	3.76	bkg	ND		
N5525	68		8/31/04 1155	9/9/04 0950	515.5	1.17	bkg	538.1	1.49	04-04	568.4 (1)	2.57	bkg	ND		
N5685	68		9/9/04 0950	9/21/04 1035	514.2	6.10	bkg	541.0	2.61	04-04	ND			ND		
N5941	68		9/21/04 1035	9/28/04 1450	ND			ND			ND			ND		

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N6042	68		9/28/04 1450	10/5/04 1118	ND			ND			ND			ND		
N6294	68		10/5/04 1118	10/12/04 1235	515.5 (1)	0.897	bkg	ND			ND			ND		
N6696	68		10/12/04 1235	10/25/04 1525	515.8	2.26	bkg	537.2 (1)	1.58	bkg	ND			ND		
N4095	**69**		**6/25/04 1030**	**6/29/04 0940**	**ND**			**ND**			**ND**			**ND**		
N4293	69		6/29/04 0940	7/8/04 0910	ND			ND			ND			ND		
N4534	69		7/8/04 0910	7/18/04 0855	ND			ND			ND			ND		
N4715	69		7/18/04 0855	7/27/04 1640	ND			ND			ND			ND		
N4922	69		7/27/04 1640	8/4/04 1005	ND			ND			ND			ND		
N5083	69		8/4/04 1005	8/13/04 0810	ND			ND			ND			ND		
N5355	69		8/13/04 0810	8/31/04 1030	516.0 (1)	1.54	bkg	ND			569.4 (1)	2.10	bkg	ND		
N5942	69		8/31/04 1030	9/27/04 1405	ND			ND			ND			ND		
N6697	69		9/27/04 1405	10/25/04 1055	515.6 (1)	1.80	bkg	ND			ND			ND		
N4294	**70**		**6/30/04 1630**	**7/8/04 1240**	**ND**			**ND**			**ND**			**575.4 (1)**	**1.48**	**bkg**
N4535	70		7/8/04 1240	7/18/04 1255	ND			537.7 (1)	0.662	bkg	573.4 (1)	2.27	bkg	ND		
N4716	70		7/18/04 1255	7/28/04 0950	ND			ND			ND			574.6 (1)	1.78	bkg
N4923	70		7/28/04 0950	8/4/04 1415	ND			ND			ND			574.6 (1)	1.53	bkg
N5084	70		8/4/04 1415	8/13/04 1105	ND			ND			ND			573.8 (1)	2.31	bkg
N5356	70		8/13/04 1105	8/31/04 1615	514.8 (1)	2.24	bkg	ND			568.3	128	04-06	ND		
N5686	70		8/31/04 1615	9/21/04 1315	ND			ND			567.3	2,990	04-06	ND		
N5943	70		9/21/04 1315	9/29/04 1107	515.8 (1)	0.925	bkg	ND			567.5	195	04-06	ND		
N6043	70		9/29/04 1107	10/5/04 1506	516.8	1.31	bkg	ND			568.0	128	04-06	ND		
N6698	70		10/5/04 1506	10/26/04 0940	515.2	3.11	bkg	ND			568.3	152	04-06	ND		
N4295	**71**		**6/30/04 1645**	**7/8/04 1235**	**ND**			**ND**			**ND**			**ND**		
N4295D	71		6/30/04 1645	7/8/04 1235	ND			ND			ND			ND		
	71		7/8/04 1235	7/18/04 1240	(8)											
N4717	71		7/18/04 1240	7/28/04 0935	ND			ND			ND			ND		
N4924	71		7/28/04 0935	8/4/04 1400	ND			ND			ND			ND		
N5085	71		8/4/04 1400	8/13/04 1050	ND			ND			ND			ND		
N5357	71		8/13/04 1050	8/31/04 1604	514.2	1.89	bkg	ND			570.0 (1)	2.14	bkg	ND		
N5944	71		8/31/04 1604	9/29/04 1049	514.1 (1)	1.08	bkg	ND			567.4	22.1	?	ND		
N6295	71		9/29/04 1049	10/12/04 1455	ND			ND			ND			ND		
N6699	71		10/12/04 1455	10/26/04 0933	514.2	1.42	bkg	ND			ND			ND		
N8027	71		10/26/04 0933	1/11/05 1140	514.2 (1)	2.14	bkg	ND			ND			ND		
N4718	**72**		**7/26/04 1507**	**7/28/04 0940**	**ND**			**ND**			**ND**			**ND**		
N4925	72		7/28/04 0940	8/4/04 1405	ND			ND			ND			ND		
N5086	72		8/4/04 1405	8/13/04 1100	514.2	0.760	bkg	ND			ND			ND		
N5358	72		8/13/04 1100	8/31/04 1558	514.3	6.43	bkg	ND			ND			ND		
N5687	72		8/31/04 1558	9/21/04 1305	514.4	2.25	bkg	ND			ND			ND		
N5945	72		9/21/04 1305	9/29/04 1056	514.5	1.60	bkg	ND			ND			ND		
N6044	72		9/29/04 1056	10/5/04 1058	514.2 (1)	0.662	bkg	ND			ND			ND		
N6296	72		10/5/04 1058	10/12/04 1505	513.8	2.80	bkg	ND			ND			ND		
N6701	72		10/12/04 1505	10/26/04 0925	513.8	3.16	bkg	ND			ND			ND		
N6701D	72		10/12/04 1505	10/26/04 0925	514.0	2.94	bkg	ND			ND			ND		
N8028	72		10/26/04 0925	1/10/05 1248	515.8 (1)	1.18	bkg	ND			ND			ND		
N4719	**73**		**7/24/04 0900**	**7/27/04 1755**	**ND**			**ND**			**ND**			**ND**		
N4926	73		7/27/04 1755	8/4/04 1110	ND			ND			ND			ND		
N5087	73		8/4/04 1110	8/13/04 0705	ND			ND			ND			ND		
N5359	73		8/13/04 0705	8/31/04 1115	513.6 (1)	1.06	bkg	ND			ND			ND		
N5688	73		8/31/04 1125	9/21/04 1010	ND			ND			ND			ND		
N5946	73		9/21/04 1010	9/28/04 1425	ND			ND			ND			ND		
N6045	73		9/28/04 1425	10/5/04 1102	ND			ND			ND			ND		
N6297	73		10/5/04 1102	10/12/04 1215	ND			ND			ND			ND		
N6702	73		10/12/04 1215	10/25/04 1500	514.2 (1)	0.446	bkg	ND			566.8 (1)	1.45	bkg	ND		
N6972	73		10/25/04 1500	11/8/04 1410	ND			ND			ND			ND		
N7237	73		11/8/04 1410	11/17/04 1100	ND			ND			570.2 (1)	4.52	bkg	ND		
N7531	73		11/17/04 1100	12/6/04 1048	515.4 (1)	0.997	bkg	ND			568.8 (1)	3.74	bkg	ND		
N7797	73		12/6/04 1048	12/21/04 1317	ND			541.4	139	04-11	ND			ND		

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N8029	73		12/21/04 1317	1/10/05 1640	ND			540.8	37.9	04-11	ND			ND		
N8204	73		1/10/05 1640	1/17/05 1723	ND			ND			ND			ND		
N8971	73		1/17/05 1723	2/25/05 0955	ND			540.9	9.10	04-11	570.2 (1)	4.48	bkg	ND		
N9455	73		2/25/05 0955	3/16/05 1148	ND			539.8	1.26	04-11	ND			ND		
N9724	73		3/16/05 1148	3/23/05 1608	ND			540.8	4.54	04-11	ND			ND		
N9766	73		3/23/05 1608	3/31/05 1458	ND			541.1	17.6	05-18	ND			ND		
P0486	73		3/31/05 1458	4/8/05 1024	ND			540.5	5.24	05-18	ND			ND		
N4721	**74**		**7/24/04 1000**	**7/27/04 1805**	**ND**			**ND**			**ND**			**ND**		
N4721D	74		7/24/04 1000	7/27/04 1805	ND			ND			ND			ND		
N4927	74		7/27/04 1805	8/4/04 1100	ND			ND			ND			ND		
N5088	74		8/4/04 1100	8/13/04 0710	ND			ND			ND			ND		
N5361	74		8/13/04 0710	8/31/04 1132	ND			ND			ND			ND		
N5361D	74		8/13/04 0710	8/31/04 1132	ND			ND			ND			ND		
N5689	74		8/31/04 1132	9/21/04 1015	ND			ND			ND			ND		
N6703	74		9/21/04 1015	10/25/04 1505	ND			ND			567.4	139	04-08	ND		
N6973	74		10/25/04 1505	11/8/04 1420	ND			ND			569.1	44.5	04-08	ND		
N7238	74		11/8/04 1420	11/17/04 1110	ND			ND			568.6	17.6	04-08	ND		
N7532	74		11/17/04 1110	12/6/04 1055	ND			ND			569.7	25.1	04-08	ND		
N7798	74		12/6/04 1055	12/21/04 1324	ND			ND			568.8	35.0	04-08	ND		
N8030	74		12/21/04 1324	1/10/05 1650	ND			ND			569.4	17.2	04-08	ND		
N8205	74		1/10/05 1650	1/17/05 1730	ND			ND			569.0	24.7	04-08	ND		
N8972	74		1/17/05 1730	2/25/05 1015	ND			ND			568.6	35.9	04-08	ND		
N9456	74		2/25/05 1015	3/16/05 1153	ND			ND			568.7	26.6	04-08	ND		
N9725	74		3/16/05 1153	3/23/05 1618	ND			ND			570.7	3.84	04-08	ND		
N9767	74		3/23/05 1618	3/31/05 1519	ND			ND			569.4	17.1	04-08	ND		
P0487	74		3/31/05 1519	4/8/05 1050	ND			ND			568.8	18.5	04-08	ND		
N4722	**75**		**7/24/04 1045**	**7/27/04 1855**	**515.9**	**1.40**	**bkg**	**ND**			**ND**			**ND**		
N4928	75		7/27/04 1855	8/4/04 1040	516.4	1.90	bkg	ND			ND			ND		
N5089	75		8/4/04 1040	8/13/04 0845	517.0	0.758	bkg	ND			ND			ND		
N5362	75		8/13/04 0845	8/31/04 1215	516.7	3.89	bkg	538.8 (1)	2.67	bkg	566.4 (1)	3.17	bkg	ND		
N5690	75		8/31/04 1215	9/21/04 1110	517.3	3.64	bkg	538.6	3.57	bkg	ND			ND		
N5947	75		9/21/04 1110	9/28/04 1510	ND			ND			ND			ND		
N6046	75		9/28/04 1510	10/5/04 1142	ND			ND			ND			ND		
N6298	75		10/5/04 1142	10/12/04 1325	ND			ND			ND			ND		
N6704	75		10/12/04 1325	10/25/04 1408	ND			ND			ND			ND		
N6974	75		10/25/04 1408	11/8/04 1353	516.8	2.25	bkg	ND			ND			ND		
N7239	75		11/8/04 1353	11/17/04 1150	516.4	2.59	bkg	ND			ND			ND		
N7239D	75		11/8/04 1353	11/17/04 1150	517.6	1.36	bkg	ND			ND			ND		
N7533	75		11/17/04 1150	12/6/04 1030	516.5	2.49	bkg	ND			ND			ND		
N7799	75		12/6/04 1030	12/21/04 1300	ND			541.7	2,980	04-11	ND			ND		
N8031	75		12/21/04 1300	1/10/05 1615	515.8 (2)	2.73	bkg	540.3	31.7	04-11	ND			ND		
N8206	75		1/10/05 1615	1/17/05 1747	515.6 (1)	0.856	bkg	541.1	8.14	04-11	ND			ND		
N8973	75		1/17/05 1747	2/25/05 1100	517.8	2.66	bkg	540.8	12.1	04-11	ND			ND		
N9457	75		2/25/05 1100	3/16/05 1128	517.9 (1)	1.25	bkg	539.7	1.22	04-11	ND			ND		
N9726	75		3/16/05 1128	3/23/05 1500	ND			540.8	21.2	05-18	ND			ND		
N9768	75		3/23/05 1500	3/31/05 1136	ND			540.9	61.4	05-18	ND			ND		
P0488	75		3/31/05 1136	4/8/05 0839	ND			540.6	5.32	05-18	ND			ND		
N4723	**76**		**7/24/04 1030**	**7/27/04 1910**	**515.1**	**2.26**	**bkg**	**ND**			**ND**			**ND**		
N4929	76		7/27/04 1910	8/4/04 1035	514.8	10.1	bkg	ND			ND			ND		
N5090	76		8/4/04 1035	8/13/04 0840	515.0	8.29	bkg	ND			ND			ND		
N5363	76		8/13/04 0840	8/31/04 1208	514.9	1.63	bkg	ND			ND			ND		
N5691	76		8/31/04 1208	9/21/04 1102	515.1	43.3	bkg	ND			ND			ND		
N5948	76		9/21/04 1102	9/28/04 1505	515.0	19.7	bkg	ND			ND			ND		
N6047	76		9/28/04 1505	10/5/04 1136	514.4	4.12	bkg	ND			ND			ND		
N6299	76		10/5/04 1136	10/12/04 1320	513.8	0.931	bkg	ND			ND			ND		
N6705	76		10/12/04 1320	10/25/04 1412	514.9	5.38	bkg	ND			ND			ND		
N6975	76		10/25/04 1412	11/8/04 1400	516.6	4.14	bkg	ND			ND			ND		

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N7241	76		11/8/04 1400	11/17/04 1140	517.0	5.17	bkg	ND			ND			ND		
N7534	76		11/17/04 1140	12/6/04 1035	516.7	3.96	bkg	ND			ND			ND		
N7801	76		12/6/04 1035	12/21/04 1305	ND			541.7	7,210	04-11	ND			ND		
N7801D	76		12/6/04 1035	12/21/04 1305	ND			541.7	6,930	04-11	ND			ND		
N8032	76		12/21/04 1305	1/10/05 1622	516.2 (6)	7.90	bkg	540.7	105	04-11	ND			ND		
N8207	76		1/10/05 1622	1/17/05 1755	516.0 (1)	1.35	bkg	541.4	17.7	04-11	ND			ND		
N8974	76		1/17/05 1755	2/25/05 1040	515.8 (6)	3.73	bkg	541.0	27.4	04-11	ND			ND		
N9458	76		2/25/05 1040	3/16/05 1137	517.8	5.62	bkg	540.1	10.7	04-11	ND			ND		
N9727	76		3/16/05 1137	3/23/05 1514	514.2 (6)	3.87	bkg	540.7	57.9	05-18	ND			ND		
N9769	76		3/23/05 1514	3/31/05 1030	ND			540.9	101	05-18	ND			ND		
P0489	76		3/31/05 1030	4/8/05 0814	ND			540.8	225	05-18	ND			ND		
N5364	**77**		**7/26/04 1410**	**8/26/04 2100**	**ND (14)**			**ND**			**ND**			**ND**		
N5949	77		8/27/04 1242	9/23/04 0525	ND			ND			ND			ND		
N6048	77		9/23/04 1223	10/4/04 0547	ND			ND			ND			ND		
N6976	77		10/5/04 1236	10/28/04 0620	ND			ND			ND			ND		
N6977	77		10/28/04 0620	11/8/04 0630	ND			ND			ND			ND		
N7535	77		11/8/04 1355	12/3/04 0747	ND			ND			ND			ND		
N5365	**78**		**8/24/04 1712**	**8/30/04 1137**	**514.7**	**1.68**	**bkg**	**538.0**	**2.53**	**04-01**	**ND**			**ND**		
N5366	78		8/30/04 1137	9/2/04 0931	516.3	2.60	bkg	537.8	5.72	04-01	ND			ND		
N5526	78		9/2/04 0931	9/9/04 1112	515.6	2.84	bkg	538.3	9.49	04-01	ND			ND		
N5692	78		9/9/04 1112	9/21/04 1335	517.8 (6)	3.14	bkg	538.3	10.3	04-01	ND			ND		
N5950	78		9/21/04 1335	9/29/04 1735	516.0 (6)	3.88	bkg	538.1	17.1	04-01	ND			ND		
N6049	78		9/29/04 1735	10/5/04 1357	ND			537.0	11.4	04-01	ND			ND		
N6301	78		10/5/04 1357	10/12/04 1520	515.8 (6)	0.935	bkg	537.5	2.87	04-01	ND			ND		
N6301D	78		10/5/04 1357	10/12/04 1520	515.6	1.29	bkg	538.0	3.80	04-01	ND			ND		
N6706	78		10/12/04 1520	10/25/04 0958	514.3	8.75	bkg	539.4 (1)	1.79	04-01	ND			ND		
N6978	78		10/25/04 0958	11/8/04 1058	516.9	4.25	bkg	539.6	4.71	04-01	ND			ND		
N7242	78		11/8/04 1058	11/17/04 1315	518.2 (1)	2.59	bkg	540.4	2.23	04-01	ND			ND		
N7536	78		11/17/04 1315	12/6/04 1138	516.7	4.39	bkg	538.6 (1)	1.83	04-01	ND			ND		
N8208	78		12/6/04 1138	1/17/05 1605	517.6	3.38	bkg	540.9	15.3	04-01	ND			ND		
N5367	**79**		**8/24/04 1725**	**8/30/04 1141**	**512.8 (1)**	**4.00**	**bkg**	**ND**			**ND**			**573.6 (1)**	**4.51**	**bkg**
N5368	79		8/30/04 1141	9/2/04 0935	ND			ND			567.1	17,900	04-06	ND		
N5527	79		9/2/04 0935	9/9/04 1115	514.2	4.47	bkg	ND			568.5	240	04-06	ND		
N5693	79		9/9/04 1115	9/21/04 1340	514.4	4.91	bkg	ND			567.9	102	04-06	ND		
N5951	79		9/21/04 1340	9/29/04 1740	514.2	3.46	bkg	ND			568.3	50.4	04-06	ND		
N6050	79		9/29/04 1740	10/5/04 1400	514.9	3.40	bkg	ND			568.6	21.2	04-06	ND		
N6302	79		10/5/04 1400	10/12/04 1530	513.0 (1)	2.13	bkg	ND			569.4	17.2	04-06	ND		
N6707	79		10/12/04 1530	10/25/04 1002	513.9	12.8	bkg	ND			568.8	23.4	04-06	ND		
N6979	79		10/25/04 1002	11/8/04 1103	515.5	5.30	bkg	ND			571.6	9.46	04-06	ND		
N6979D	79		10/25/04 1002	11/8/04 1103	515.8	4.76	bkg	ND			571.2	7.93	04-06	ND		
N7243	79		11/8/04 1103	11/17/04 1310	516.0	5.31	bkg	ND			ND			575.2 (1)	2.98	bkg
N7537	79		11/17/04 1310	12/6/04 1144	515.9	11.4	bkg	ND			572.5 (1)	6.48	04-06	ND		
N8209	79		12/6/04 1144	1/17/05 1610	516.0	6.14	bkg	ND			ND			574.8 (1)	6.77	bkg
N5528	**80**		**8/27/04 1115**	**9/9/04 1010**	**515.1 (1)**	**1.19**	**bkg**	**ND**			**568.3**	**135**	04-06	**ND**		
N5694	80		9/9/04 1010	9/21/04 1055	ND			ND			567.4	55.6	04-06	ND		
N5952	80		9/21/04 1055	9/28/04 1619	516.1 (1)	1.14	bkg	ND			567.8	20.1	04-06	ND		
N6051	80		9/28/04 1619	10/5/04 1205	ND			539.2	1.71	bkg	567.4	4.23	04-06	ND		
N6303	80		10/5/04 1205	10/12/04 1250	ND			ND			569.2	3.44	04-06	ND		
N6708	80		10/12/04 1250	10/25/04 1625	514.1	2.72	bkg	ND			568.1	10.6	04-06	ND		
N8210	80		10/25/04 1625	1/17/05 1645	516.0	2.04	bkg	ND			570.4	7.90	04-06	ND		
N5529	**81**		**8/27/04 1210**	**9/9/04 0955**	**515.5 (9)**	**2.52**	**bkg**	**ND**			**ND**			**ND**		
N5695	81		9/9/04 0955	9/21/04 1043	516.8	24.9	bkg	ND			ND			575.8	16.0	bkg
N5953	81		9/21/04 1043	9/28/04 1455	ND			ND			ND			576.6	12.2	bkg
N6052	81		9/28/04 1455	10/5/04 1125	518.0 (1)	27.4	bkg	ND			ND			576.6	6.74	bkg
N6304	81		10/5/04 1125	10/12/04 1240	519.0 (1)	14.9	bkg	ND			ND			575.0 (1)	0.682	bkg
N6709	81		10/12/04 1240	10/25/04 1540	ND			ND			ND			ND		
N8211	81		10/25/04 1540	1/17/05 1635	519.4 (1)	9.83	bkg	ND			ND			576.5 (1)	7.87	bkg

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N5530	**82**		**9/3/04 1335**	**9/9/04 0930**	**ND**			**ND**			**ND**			**ND**		
N5696	82		9/9/04 0930	9/21/04 0955	ND			ND			ND			ND		
N5954	82		9/21/04 0955	9/28/04 1325	ND			ND			ND			ND		
N6710	82		9/28/04 1325	10/25/04 1428	515.4 (1)	0.918	bkg	ND			ND			ND		
N8975	82		10/25/04 1428	2/25/05 0945	515.2 (1)	1.16	bkg	ND			ND			ND		
N6053	**83**		**9/28/04 0955**	**10/5/04 1021**	**513.8**	**10.2**	**04-07**	**ND**			**ND**			**ND**		
N6305	83		10/5/04 1021	10/12/04 1020	514.1	26.6	04-07	ND			ND			ND		
N6711	83		10/12/04 1020	10/25/04 1220	514.3	48.9	04-07	ND			ND			ND		
N6981	83		10/25/04 1220	11/8/04 1330	515.8	13.7	04-07	ND			ND			ND		
N7244	83		11/8/04 1330	11/17/04 0940	516.3	12.3	04-07	ND			ND			ND		
N7538	83		11/17/04 0940	12/6/04 1000	516.1	11.9	04-07	ND			ND			ND		
N7802	83		12/6/04 1000	12/20/04 0953	516.1	9.62	04-07	ND			ND			ND		
N8033	83		12/20/04 0953	1/10/05 1507	515.0	6.20	04-07	ND			ND			ND		
N8212	83		1/10/05 1507	1/18/05 1012	516.2	1.42	04-07	ND			ND			ND		
N8544	83		1/18/05 1012	2/11/05 0852	515.5	10.9	04-07	ND			ND			ND		
N8976	83		2/11/05 0852	2/25/05 0905	515.7	6.00	04-07	ND			ND			ND		
N8988	83		2/25/05 0905	3/1/05 1236	515.5	3.83	04-07	ND			ND			ND		
N9459	83		3/1/05 1236	3/16/05 1107	515.8	6.31	04-07	ND			ND			ND		
N9459D	83		3/1/05 1236	3/16/05 1107	515.7	5.60	04-07	ND			ND			ND		
N9728	83		3/16/05 1107	3/23/05 1728	515.7	3.69	04-07	ND			ND			ND		
N9770	83		3/23/05 1728	3/31/05 0942	515.5	3.15	04-07	ND			ND			ND		
P0490	83		3/31/05 0942	4/8/05 0928	515.5	2.85	04-07	ND			ND			ND		
N6054	**84**		**9/28/04 1035**	**10/5/04 1030**	**514.2**	**319**	**04-07**	**ND**			**ND**			**ND**		
N6306	84		10/5/04 1030	10/12/04 1030	514.3	156	04-07	ND			ND			ND		
N6712	84		10/12/04 1030	10/25/04 1233	514.7	192	04-07	ND			ND			ND		
N6982	84		10/25/04 1233	11/8/04 1340	516.1	56.0	04-07	ND			ND			ND		
N7245	84		11/8/04 1340	11/17/04 0950	516.4	47.9	04-07	ND			ND			ND		
N7539	84		11/17/04 0950	12/6/04 1007	516.2	32.7	04-07	ND			ND			ND		
N7803	84		12/6/04 1007	12/20/04 0958	516.3	21.1	04-07	ND			ND			ND		
N8034	84		12/20/04 0958	1/10/05 1513	515.7	21.0	04-07	ND			ND			ND		
N8213	84		1/10/05 1513	1/18/05 1017	516.0	6.25	04-07	ND			ND			ND		
N8545	84		1/18/05 1017	2/11/05 0858	515.7	18.5	04-07	ND			ND			ND		
N8977	84		2/11/05 0858	2/25/05 0915	515.9	6.79	04-07	ND			ND			ND		
N8989	84		2/25/05 0915	3/1/05 1242	515.7	7.64	04-07	ND			ND			ND		
N9461	84		3/1/05 1242	3/16/05 1113	515.7	15.4	04-07	ND			ND			ND		
N9729	84		3/16/05 1113	3/23/05 1736	516.2	9.70	04-07	ND			ND			ND		
N9771	84		3/23/05 1736	3/31/05 0953	516.0	7.27	04-07	ND			ND			ND		
P0491	84		3/31/05 0953	4/8/05 0914	515.9	8.50	04-07	ND			ND			ND		
N6055	**85**		**9/28/04 1145**	**10/5/04 1024**	**515.1**	**18.8**	**04-07**	**537.9**	**20.7**	**04-04**	**ND**			**ND**		
N6307	85		10/5/04 1024	10/12/04 1010	515.3	12.6	04-07	537.7	11.9	04-04	ND			ND		
N6713	85		10/12/04 1010	10/25/04 1225	514.7	25.7	04-07	537.8	9.70	04-04	ND			ND		
N6056	**86**		**9/28/04 1335**	**10/5/04 1045**	**514.3**	**8.48**	**04-07**	**538.0**	**2.62**	**04-04**	**ND**			**ND**		
N6308	86		10/5/04 1045	10/12/04 1200	514.8	5.43	04-07	538.0	1.57	04-04	ND			ND		
N6714	86		10/12/04 1200	10/25/04 1435	514.9	17.5	04-07	538.0	9.31	04-04	ND			ND		
N6057	**87**		**9/29/04 1512**	**10/6/04 0915**	**ND**			**ND**			**567.0**	**20,500**	**04-09**	**ND**		
N6309	87		10/6/04 0915	10/14/04 0840	ND			ND			568.7	1,210	04-09	ND		
N6715	87		10/14/04 0840	10/27/04 1437	518.0 (1)	1.74	bkg	ND			568.2	341	04-09	ND		
N6983	87		10/27/04 1437	11/8/04 1555	515.7 (1)	0.566	bkg	ND			569.0	37.5	04-09	ND		
N7246	87		11/8/04 1555	11/17/04 1500	513.8(1)	0.793	bkg	ND			571.2	17.8	04-09	ND		
N7541	87		11/17/04 1500	12/3/04 1555	516.2 (1)	0.860	bkg	ND			569.8	6.17	04-09	ND		
N7541D	87		11/17/04 1500	12/3/04 1555	516.4 (1)	1.09	bkg	ND			569.6	10.7	04-09	ND		
N7804	87		12/3/04 1555	12/21/04 1613	516.2	4.90	bkg	ND			ND			ND		
N8035	87		12/21/04 1613	1/10/05 1720	514.8 (1)	1.13	bkg	ND			570.2	11.6	04-09	ND		
N8214	87		1/10/05 1720	1/14/05 1115	516.0	29.1	05-14	ND			ND			ND		
N8450	87		1/14/05 1115	1/21/05 0822	516.1	4.92	bkg	ND			ND			ND		
N8546	87		1/21/05 0822	2/11/05 1003	515.1	3.96	bkg	ND			569.4 (1)	10.5	04-09	ND		
N9447	87		2/11/05 1003	3/16/05 1250	515.1	3.04	bkg	ND			569.6 (1)	4.06	04-09	ND		

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N9659	87		3/16/05 1250	3/29/05 1555	515.6	2.02	bkg	ND			568.6	8.30	04-09	ND		
N9659D	87		3/16/05 1250	3/29/05 1555	515.6	1.91	bkg	ND			568.8	6.71	04-09	ND		
N9930	87		3/29/05 1555	4/7/05 1009	ND			540.9	96.9	05-24	ND			ND		
P0445	87		4/7/05 1009	4/14/05 1518	ND			540.7	12.6	05-24	ND			ND		
P0618	87		4/14/05 1518	4/20/05 1729	ND			540.5	4.82	05-24	ND			ND		
N6310	**88**		**10/6/04 1015**	**10/14/04 0850**	**512.0 (1)**	**1.35**	**bkg**	**ND**			**567.8 (1)**	**0.906**	**bkg**	**ND**		
N6716	88		10/14/04 0850	10/27/04 1420	514.0	2.46	bkg	ND			ND			ND		
N7805	88		10/27/04 1420	12/21/04 1625	516.6 (1)	1.46	bkg	ND			569.8	9.07	bkg	ND		
N8036	88		12/21/04 1625	1/5/05 1005	514.8	1.97	bkg	ND			ND			ND		
N8041	88		1/5/05 1005	1/10/05 1734	512.6 (1)	1.05	bkg	ND			ND			ND		
N8215	88		1/10/05 1734	1/14/05 1055	516.7	536	05-14	ND			ND			ND		
N8451	88		1/14/05 1055	1/21/05 0810	516.8	397	05-14	ND			ND			ND		
N8547	88		1/21/05 0810	2/11/05 0925	515.7	52.1	05-14	ND			ND			ND		
N9448	88		2/11/05 0925	3/16/05 1304	515.7	66.3	05-14	ND			ND			ND		
N9661	88		3/16/05 1304	3/29/05 1536	516.3	49.1	05-14	ND			ND			ND		
P0446	88		3/29/05 1536	4/15/05 0744	516.0	24.1	05-14	ND			ND			ND		
N6311	**89**		**10/6/04 1025**	**10/14/04 0910**	**ND**			**ND**			**568.9**	**520**	04-09	**ND**		
N6717	89		10/14/04 0910	10/27/04 1450	517.6 (1)	1.79	bkg	ND			568.0	134	04-09	ND		
N6984	89		10/27/04 1450	11/8/04 1605	ND			ND			570.4	7.74	04-09	ND		
N7247	89		11/8/04 1605	11/17/04 1510	ND			ND			569.8	6.94	04-09	ND		
N7542	89		11/17/04 1510	12/3/04 1605	514.0 (1)	0.748	bkg	ND			570.2	4.79	04-09	ND		
N9931	89		12/3/04 1605	4/7/05 1020	ND			540.7	11.0	05-24	572.4 (1)	4.03	04-09	ND		
P0447	89		4/7/05 1020	4/15/05 0933	ND			540.5	8.50	05-24	ND			ND		
P0619	89		4/15/05 0933	4/20/05 1753	ND			541.2	27.1	05-24	ND			ND		
P0619D	89		4/15/05 0933	4/20/05 1753	ND			540.6	1.24	05-24	ND			ND		
P0619V	89		4/15/05 0933	4/20/05 1753	ND			541.5	27.3	05-24	ND			ND		
P0619X	89		4/15/05 0933	4/20/05 1753	ND			541.0	1.17	05-24	ND			ND		
N7248	**90**		**11/8/04 1425**	**11/17/04 1115**	**516.2 (1)**	**1.27**	**bkg**	**ND**			**571.6**	**6.84**	04-08	**ND**		
N7543	90		11/17/04 1115	12/6/04 1058	516.6 (1)	1.29	bkg	ND			570.0 (1)	5.01	04-08	ND		
N7806	90		12/6/04 1058	12/21/04 1327	ND			541.7	1,590	04-11	ND			ND		
N8037	90		12/21/04 1327	1/10/05 1655	514.4 (2)	2.65	bkg	540.4	65.7	04-11	ND			ND		
N8216	90		1/10/05 1655	1/17/05 1735	ND			541.2	6.04	04-11	ND			ND		
N8978	90		1/17/05 1735	2/25/05 1005	515.6 (1)	2.15	bkg	540.5	15.6	04-11	ND			ND		
N9462	90		2/25/05 1005	3/16/05 1156	517.6 (1)	1.55	bkg	539.2	2.39	04-11	ND			ND		
N9730	90		3/16/05 1156	3/23/05 1621	ND			541.0	15.3	05-18	ND			ND		
N9772	90		3/23/05 1621	3/31/05 1528	ND			541.1	45.2	05-18	ND			ND		
P0492	90		3/31/05 1528	4/8/05 1044	ND			540.8	24.7	05-18	ND			ND		
N8038	**91**		**12/21/04 1630**	**1/10/05 1738**	**515.1 (1)**	**1.45**	**bkg**	**ND**			**ND**			**ND**		
N8217	91		1/10/05 1738	1/14/05 1100	516.7	688	05-14	ND			ND			ND		
N8452	91		1/14/05 1100	1/21/05 0815	516.3	18.7	05-14	ND			ND			ND		
N8548	91		1/21/05 0815	2/11/05 0930	515.5	11.9	05-14	ND			ND			ND		
N9449	91		2/11/05 0930	3/16/05 1307	515.6	22.8	05-14	ND			ND			ND		
N9662	91		3/16/05 1307	3/29/05 1540	515.8	4.56	05-14	ND			ND			ND		
P0448	91		3/29/05 1540	4/15/05 0748	515.2	3.59	05-14	ND			ND			ND		
N8218	**92**		**1/7/05 0905**	**1/19/05 1132**	**ND**			**ND**			**ND**			**ND**		
N8549	92		1/19/05 1132	2/9/05 1124	ND			ND			ND			ND		
N8981	92		2/9/05 1124	2/25/05 1028	513.4 (1)	0.844	bkg	ND			ND			ND		
N8981D	92		2/9/05 1124	2/25/05 1028	513.0 (1)	0.776	bkg	ND			ND			ND		
N9464	92		2/25/05 1028	3/22/05 1358	ND			ND			ND			ND		
N9867	92		3/22/05 1358	4/5/05 1331	ND			ND			ND			ND		
P0495	92		4/5/05 1331	4/13/05 1337	ND			ND			ND			ND		
N8219	**93**		**1/7/05 0918**	**1/19/05 1136**	**ND**			**ND**			**ND**			**ND**		
N8219D	93		01/07/05 0918	01/19/05 1136	ND			ND			ND			ND		
N8550	93		1/19/05 1136	2/9/05 1137	ND			ND			ND			ND		
N8982	93		2/9/05 1137	2/25/05 1033	514.3 (1)	1.00	bkg	ND			ND			ND		
N9465	93		2/25/05 1033	3/22/05 1458	ND (9)			ND			ND			ND		
N9868	93		3/22/05 1458	4/5/05 1403	ND			ND			ND			ND		

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
P0496	93		4/5/05 1403	4/13/05 1434	ND			ND			ND			ND		
N8221	**94**		**1/7/05 0930**	**1/19/05 1142**	**ND**			**ND**			**ND**			**ND**		
N8445	94		1/19/05 1142	2/4/05 1445	ND			ND			ND			ND		
N8551	94		2/4/05 1445	2/9/05 1140	ND			ND			568.6	417,000	05-16	ND		
N8983	94		2/9/05 1140	2/25/05 1038	ND			ND			568.9	4,940	05-16	ND		
N9466	94		2/25/05 1038	3/22/05 1450	ND			ND			570.0	1,400	05-16	ND		
N9869	94		3/22/05 1450	4/5/05 1425	ND			ND			569.1	316	05-16	ND		
P0497	94		4/5/05 1425	4/13/05 1348	ND			ND			569.4	323	05-16	ND		
P0581	94		4/13/05 1348	4/19/05 1651	ND			ND			569.6	246	05-16	ND		
N8222	**95**		**1/7/05 0942**	**1/19/05 1153**	**ND**			**ND**			**ND**			**ND**		
N8552	95		1/19/05 1153	2/9/05 1130	ND			ND			568.8 (1)	3.00	bkg	ND		
N9467	95		2/9/05 1130	3/22/05 1420	ND			ND			ND			ND		
N9870	95		3/22/05 1420	4/5/05 1417	ND			ND			ND			ND		
P0498	95		4/5/05 1417	4/13/05 1439	ND			ND			ND			ND		
N8223	**96**		**1/7/05 1008**	**1/19/05 1147**	**ND**			**ND**			**ND**			**ND**		
N8446	96		1/19/05 1147	2/4/05 1455	ND			ND			ND			ND		
N8553	96		2/4/05 1455	2/9/05 1145	ND			ND			571.6 (1)	2.69	bkg	ND		
N8984	96		2/9/05 1145	2/25/05 1042	ND			ND			ND			ND		
N9468	96		2/25/05 1042	3/22/05 1436	ND			ND			ND			ND		
N9871	96		3/22/05 1436	4/5/05 1459	ND			ND			ND			ND		
P0499	96		4/5/05 1459	4/13/05 1356	ND			ND			ND			ND		
P0499D	96		4/5/05 1459	4/13/05 1356	ND			ND			ND			ND		
N8224	**97**		**1/7/05 1040**	**1/19/05 1215**	**ND**			**ND**			**ND**			**ND**		
N8447	97		1/19/05 1215	2/4/05 1512	ND			ND			ND			ND		
N8554	97		2/4/05 1512	2/9/05 1205	ND			ND			ND			ND		
	97		2/9/05 1205	3/22/05 1526	(8)											
N9872	97		3/22/05 1526	4/5/05 1525	ND			ND			ND			ND		
P0501	97		4/5/05 1525	4/13/05 1518	ND			ND			ND			ND		
N8225	**98**		**1/7/05 1128**	**1/14/05 1600**	**ND**			**ND**			**ND**			**ND**		
N8555	98		1/14/05 1600	2/9/05 1410	513.0 (1)	1.20	bkg	ND			ND			ND		
N9673	98		2/9/05 1410	3/29/05 1203	513.8 (1)	1.21	bkg	ND			ND			ND		
N9873	98		3/29/05 1203	4/5/05 1633	ND			ND			ND			ND		
N8226	**99**		**1/7/05 1148**	**1/19/05 1431**	**ND**			**ND**			**ND**			**ND**		
N8556	99		1/19/05 1431	2/9/05 1457	ND			ND			ND			ND		
N9674	99		2/9/05 1457	3/29/05 1117	ND			ND			ND			ND		
N9874	99		3/29/05 1117	4/6/05 1743	ND			ND			ND			ND		
P0502	99		4/6/05 1743	4/13/05 1806	ND			ND			ND			ND		
N8227	**100**		**1/7/05 1203**	**1/19/05 1425**	**ND**			**ND**			**ND**			**ND**		
N8557	100		1/19/05 1425	2/9/05 1450	ND			ND			ND			ND		
N9675	100		2/9/05 1450	3/29/05 1112	ND			ND			ND			ND		
N9875	100		3/29/05 1112	4/4/05 1550	ND			ND			ND			ND		
P0503	100		4/4/05 1550	4/13/05 1752	ND			ND			ND			ND		
N8228	**101**		**1/7/05 1405**	**1/19/05 1422**	**ND**			**ND**			**ND**			**ND**		
N8558	101		1/19/05 1422	2/9/05 1442	ND			ND			ND			ND		
N9676	101		2/9/05 1442	3/29/05 1107	ND			ND			ND			ND		
N9876	101		3/29/05 1107	4/4/05 1540	ND			ND			ND			ND		
P0504	101		4/4/05 1540	4/13/05 1741	ND			ND			ND			ND		
P0582	101		4/13/05 1741	4/20/05 1008	ND			ND			ND			ND		
N8229	**102**		**1/7/05 1415**	**1/19/05 1453**	**ND**			**ND**			**ND**			**ND**		
N8559	102		1/19/05 1453	2/9/05 1523	ND			ND			ND			ND		
N9677	102		2/9/05 1523	3/29/05 1144	ND			541.3	3,230	05-19	ND			ND		
N9877	102		3/29/05 1144	4/4/05 1658	ND			540.2	1,270	05-19	567.8	14,700	05-23	ND		
P0505	102		4/4/05 1658	4/13/05 1851	ND			541.1	3,320	05-19	571.4 (10)	378	05-23	ND		
P0583	102		4/13/05 1851	4/20/05 1044	ND			540.8	254	05-19	571.6 (10)	56.5	05-23	ND		
N8230	**103**		**1/7/05 1430**	**1/19/05 1445**	**516.3**	**8.05**	**bkg**	**ND**			**ND**			**ND**		
N8561	103		1/19/05 1445	2/9/05 1513	516.0	28.2	bkg	ND			ND			ND		
N8561D	103		1/19/05 1445	2/9/05 1513	515.9	19.3	bkg	ND			ND			ND		

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N9678	103		2/9/05 1513	3/29/05 1134	516.5	48.6	bkg	ND			ND			ND		
N9878	103		3/29/05 1134	4/4/05 1722	515.9	11.3	bkg	ND			ND			ND		
P0506	103		4/4/05 1722	4/13/05 1832	515.7	35.0	bkg	ND			ND			ND		
P0584	103		4/13/05 1832	4/20/05 1031	515.8	18.0	bkg	ND			ND			ND		
N8231	**104**		**1/7/05 1440**	**1/19/05 1440**	**516.4**	**2.27**	**bkg**	**ND**			**ND**			**ND**		
N8562	104		1/19/05 1440	2/9/05 1508	515.7	2.50	bkg	ND			ND			ND		
N9679	104		2/9/05 1508	3/29/05 1127	515.3	3.30	bkg	ND			ND			ND		
N9679D	104		2/9/05 1508	3/29/05 1127	515.0	2.64	bkg	ND			ND			ND		
N9879	104		3/29/05 1127	4/4/05 1620	515.0 (1)	1.11	bkg	ND			ND			ND		
N9879D	104		3/29/05 1127	4/4/05 1620	515.2 (1)	1.29	bkg	ND			ND			ND		
P0507	104		4/4/05 1620	4/13/05 1822	515.2	1.42	bkg	ND			ND			ND		
P0585	104		4/13/05 1822	4/20/05 1021	514.4 (1)	1.31	bkg	ND			ND			ND		
N8232	**105**		**1/7/05 1523**	**1/14/05 1540**	**ND**			**ND**			**ND**			**ND**		
N8563	105		1/14/05 1540	2/9/05 1221	ND			ND			ND			ND		
N9681	105		2/9/05 1221	3/29/05 1350	ND			ND			ND			ND		
N9881	105		3/29/05 1350	4/5/05 1723	ND			ND			ND			ND		
N8233	**106**		**1/7/05 1540**	**1/14/05 1535**	**ND**			**ND**			**ND**			**ND**		
N8564	106		1/14/05 1535	2/9/05 1218	ND			ND			ND			ND		
N9682	106		2/9/05 1218	3/29/05 1346	ND			ND			ND			ND		
N9882	106		3/29/05 1346	4/5/05 1709	ND			ND			ND			ND		
N8234	**107**		**1/9/05 1158**	**1/14/05 1615**	**ND**			**ND**			**ND**			**ND**		
N8565	107		1/14/05 1615	2/9/05 1425	ND			ND			ND			ND		
N9683	107		2/9/05 1425	3/29/05 1224	ND			ND			ND			ND		
N9883	107		3/29/05 1224	4/5/05 1601	ND			ND			ND			ND		
N8235	**108**		**1/9/05 1315**	**1/19/05 1103**	**ND**			**ND**			**ND**			**ND**		
N8566	108		1/19/05 1103	2/9/05 0952	ND			ND			ND			ND		
N9684	108		2/9/05 0952	3/24/05 1700	515.0	2.82	bkg	ND			ND			ND		
N9884	108		3/24/05 1700	4/6/05 1521	514.6 (1)	1.30	bkg	ND			ND			ND		
P0508	108		4/6/05 1521	4/13/05 1547	514.6 (1)	1.11	bkg	ND			ND			ND		
N8236	**109**		**1/9/05 1332**	**1/19/05 1110**	**516.1**	**1.80**	**bkg**	**ND**			**ND**			**ND**		
N8567	109		1/19/05 1110	2/9/05 1006	515.7	5.21	bkg	ND			ND			ND		
N9685	109		2/9/05 1006	3/24/05 1712	515.7	13.8	bkg	ND			ND			ND		
N9885	109		3/24/05 1712	4/6/05 1537	516.1	13.0	bkg	ND			ND			ND		
P0509	109		4/6/05 1537	4/13/05 1558	515.6	8.68	bkg	ND			ND			ND		
N8237	**110**		**1/9/05 1353**	**1/19/05 1125**	**ND**			**ND**			**ND**			**ND**		
N8568	110		1/19/05 1125	2/9/05 1046	ND			ND			ND			ND		
N9686	110		2/9/05 1046	3/24/05 1810	513.2 (1)	1.07	bkg	ND			ND			ND		
N9886	110		3/24/05 1810	4/6/05 1434	ND			ND			ND			ND		
P0510	110		4/6/05 1434	4/13/05 1207	ND (4)			ND			ND			ND		
N8238	**111**		**1/9/05 1450**	**1/19/05 1520**	**ND**			**ND**			**ND**			**ND**		
N8569	111		1/19/05 1520	2/9/05 1618	ND			ND			ND			ND		
N9687	111		2/9/05 1618	3/24/05 1122	514.4 (1)	1.58	bkg	ND			ND			ND		
N9887	111		3/24/05 1122	4/5/05 1748	513.4 (1)	1.12	bkg	ND			ND			ND		
P0511	111		4/5/05 1748	4/12/05 1652	ND			ND			ND			ND		
P0586	111		4/12/05 1652	4/19/05 1444	ND			ND			ND			ND		
N8239	**112**		**1/9/05 1545**	**1/19/05 1540**	**ND**			**ND**			**ND**			**ND**		
N8570	112		1/19/05 1540	2/10/05 0955	ND			ND			ND			ND		
N9688	112		2/10/05 0955	3/24/05 1018	ND			ND			ND			ND		
N9888	112		3/24/05 1018	4/6/05 1053	ND			ND			ND			ND		
P0512	112		4/6/05 1053	4/12/05 1551	ND			ND			ND			ND		
P0587	112		4/12/05 1551	4/19/05 1353	ND			ND			ND			ND		
N8241	**113**		**1/9/05 1605**	**1/19/05 1542**	**ND**			**ND**			**ND**			**ND**		
N8241D	113		1/9/05 1605	1/19/05 1542	ND			ND			ND			ND		
N8571	113		1/19/05 1542	2/10/05 1000	ND			ND			ND			ND		
N9689	113		2/10/05 1000	3/24/05 1024	ND			ND			ND			ND		
N9889	113		3/24/05 1024	4/6/05 1048	ND			ND			ND			ND		
P0513	113		4/6/05 1048	4/12/05 1556	ND			ND			ND			ND		

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
P0588	113		4/12/05 1556	4/19/05 1358	ND			ND			ND			ND		
N8242	**114**		**1/9/05 1610**	**1/19/05 1544**	**ND**			**ND**			**ND**			**ND**		
N8572	114		1/19/05 1544	2/10/05 1003	ND			ND			ND			ND		
N9690	114		2/10/05 1003	3/24/05 1030	ND			ND			ND			ND		
N9890	114		3/24/05 1030	4/6/05 1117	ND			ND			ND			ND		
P0514	114		4/6/05 1117	4/12/05 1603	ND			ND			ND			ND		
P0589	114		4/12/05 1603	4/19/05 1403	ND			ND			ND			ND		
N8243	**115**		**1/9/05 1625**	**1/19/05 1550**	**ND**			**ND**			**ND**			**ND**		
N8573	115		1/19/05 1550	2/10/05 1018	ND			ND			ND			ND		
N9691	115		2/10/05 1018	3/24/05 1051	ND			ND			ND			ND		
N9891	115		3/24/05 1051	4/6/05 1138	ND			ND			ND			ND		
P0515	115		4/6/05 1138	4/12/05 1619	ND			ND			ND			ND		
P0590	115		4/12/05 1619	4/19/05 1418	ND			ND			ND			ND		
N8244	**116**		**1/9/05 1635**	**1/19/05 1555**	**ND**			**ND**			**ND**			**ND**		
N8574	116		1/19/05 1555	2/10/05 1024	ND			ND			ND			ND		
N9692	116		2/10/05 1024	3/24/05 1102	ND			ND			ND			ND		
N9892	116		3/24/05 1102	4/6/05 1149	ND			ND			ND			ND		
P0516	116		4/6/05 1149	4/12/05 1628	ND			ND			ND			ND		
N8248	**117**		**1/13/05 1345**	**1/18/05 1418**	**ND**			**ND**			**ND**			**ND**		
N9663	117		1/18/05 1418	3/29/05 1612	514.8 (1)	1.39	bkg	ND			ND			ND		
P0449	117		3/29/05 1612	4/14/05 1715	513.0 (1)	1.17	bkg	ND			ND			ND		
N8249	**118**		**1/14/05 1605**	**1/19/05 1225**	**ND**			**ND**			**ND**			**ND**		
N8575	118		1/19/05 1225	2/9/05 1415	514.9	1.54	bkg	ND			ND			ND		
N9693	118		2/9/05 1415	3/29/05 1209	514.8	1.75	bkg	ND			ND			ND		
N9893	118		3/29/05 1209	4/5/05 1623	514.2 (1)	1.18	bkg	ND			ND			ND		
N8576	**119**		**1/20/05 1050**	**2/9/05 1026**	**ND**			**ND**			**ND**			**ND**		
N9694	119		2/9/05 1026	3/24/05 1743	ND			ND			ND			ND		
N9894	119		3/24/05 1743	4/6/05 1634	ND			ND			ND			ND		
P0517	119		4/6/05 1634	4/13/05 1635	ND			ND			ND			ND		
N8577	**120**		**1/20/05 1107**	**2/9/05 1021**	**ND**			**ND**			**ND**			**ND**		
N9695	120		2/9/05 1021	3/24/05 1735	ND			ND			ND			ND		
N9895	120		3/24/05 1735	4/6/05 1651	ND			ND			ND			ND		
P0518	120		4/6/05 1651	4/13/05 1652	ND			ND			ND			ND		
N8578	**121**		**1/20/05 1126**	**2/9/05 1015**	**515.4 (1)**	**0.681**	**bkg**	**ND**			**ND**			**ND**		
N9696	121		2/9/05 1015	3/24/05 1725	516.2 (1)	1.04	bkg	ND			ND			ND		
N9896	121		3/24/05 1725	4/6/05 1703	514.4 (1)	1.09	bkg	ND			ND			ND		
P0519	121		4/6/05 1703	4/13/05 1707	ND			ND			ND			ND		
P0519D	121		4/6/05 1703	4/13/05 1707	ND			ND			ND			ND		
N8579	**122**		**2/1/05 1730**	**2/9/05 1755**	**515.0**	**1.40**	bkg	**ND**			**570.8 (1)**	**3.33**	**bkg**	**ND**		
N8579D	122		2/1/05 1730	2/9/05 1755	515.3	1.24	bkg	ND			ND			ND		
N8979	122		2/9/05 1755	2/25/05 1145	515.1	2.03	bkg	ND			571.8 (1)	5.36	bkg	ND		
N8581	**123**		**2/2/05 1615**	**2/9/05 0940**	**ND**			**ND**			**ND**			**ND**		
N9697	123		2/9/05 0940	3/29/05 1326	ND			ND			ND			ND		
N9897	123		3/29/05 1326	4/6/05 1306	ND			ND			ND			ND		
P0554	123		4/6/05 1306	4/13/05 0703	ND			ND			ND			ND		
N8582	**124**		**2/2/05 1805**	**2/9/05 1630**	**ND**			**ND**			**ND**			**ND**		
N9698	124		2/9/05 1630	3/24/05 1555	ND			ND			ND			ND		
N9898	124		3/24/05 1555	4/6/05 1234	ND			ND			ND			ND		
P0521	124		4/6/05 1234	4/13/05 0948	ND			ND			ND			ND		
P0591	124		4/13/05 0948	4/19/05 1548	ND			ND			ND			ND		
N8583	**125**		**2/2/05 1815**	**2/9/05 1635**	**ND**			**ND**			**ND**			**ND**		
N9699	125		2/9/05 1635	3/24/05 1602	ND			ND			ND			ND		
N9699D	125		2/9/05 1635	3/24/05 1602	ND			ND			ND			ND		
N9899	125		3/24/05 1602	4/6/05 1226	ND			ND			ND			ND		
N9899D	125		3/24/05 1602	4/6/05 1226	ND			ND			ND			ND		
P0522	125		4/6/05 1226	4/13/05 0942	ND			ND			ND			ND		
P0592	125		4/13/05 0942	4/19/05 1535	ND			ND			ND			ND		

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N8584	**126**		**2/3/05 0835**	**2/9/05 1645**	**516.7**	**29,300**	**05-15**	**ND**			**ND**			**ND**		
N9469	126		2/9/05 1645	3/17/05 1034	517.0	876	05-15	ND			ND			ND		
N9701	126		3/17/05 1034	3/24/05 1612	515.9	81.1	05-15	ND			ND			ND		
N9901	126		3/24/05 1612	4/5/05 1238	517.2	36.9	05-15	540.3	100	05-22	ND			ND		
P0523	126		4/5/05 1238	4/12/05 1447	516.7	23.4	05-15	539.5	21.2	05-22	ND			ND		
P0593	126		4/12/05 1447	4/19/05 1331	516.5	24.7	05-15	540.2	10.2	05-22	ND			ND		
N8585	**127**		**2/3/05 0850**	**2/9/05 1652**	**515.5**	**3.97**	**bkg**	**ND**			**ND**			**ND**		
N8585V	127		2/3/05 0850	2/9/05 1652	515.6	3.92	bkg	ND			ND			ND		
N9470	127		2/9/05 1652	3/17/05 1040	ND			ND			ND			ND		
N9702	127		3/17/05 1040	3/24/05 1622	ND			ND			ND			ND		
N9902	127		3/24/05 1622	4/5/05 1221	ND			ND			ND			ND		
P0524	127		4/5/05 1221	4/12/05 1436	ND			ND			ND			ND		
P0594	127		4/12/05 1436	4/19/05 1321	ND			ND			ND			ND		
N8586	**128**		**2/3/05 0905**	**2/9/05 1702**	**516.5**	**5,380**	**05-15**	**ND**			**ND**			**ND**		
N9471	128		2/9/05 1702	3/17/05 1100	517.1	410	05-15	ND			ND			ND		
N9703	128		3/17/05 1100	3/24/05 1631	516.2	9.36	05-15	ND			ND			ND		
N9903	128		3/24/05 1631	4/5/05 1211	517.2	13.6	05-15	539.9	19.8	05-22	ND			ND		
P0525	128		4/5/05 1211	4/12/05 1425	516.6	6.66	05-15	539.7	7.47	05-22	ND			ND		
P0595	128		4/12/05 1425	4/19/05 1311	516.3	5.80	05-15	539.4	2.31	05-22	ND			ND		
N8587	**129**		**2/3/05 0918**	**2/9/05 1708**	**515.9**	**1.48**	**bkg**	**ND**			**ND**			**ND**		
N9472	129		2/9/05 1708	3/17/05 1103	515.8 (1)	1.49	bkg	ND			ND			ND		
N9704	129		3/17/05 1103	3/24/05 1640	ND			ND			ND			ND		
N9904	129		3/24/05 1640	4/5/05 1156	515.2 (1)	0.895	bkg	ND			ND			ND		
P0526	129		4/5/05 1156	4/12/05 1414	ND			ND			ND			ND		
P0596	129		4/12/05 1414	4/19/05 1258	ND			ND			ND			ND		
N8588	**130**		**2/3/05 0945**	**2/9/05 1540**	**ND**			**ND**			**ND**			**ND**		
N9473	130		2/9/05 1540	3/17/05 1115	ND			ND			ND			ND		
N9705	130		3/17/05 1115	3/29/05 1436	ND			ND			ND			ND		
N9905	130		3/29/05 1436	4/5/05 1158	ND			ND			ND			ND		
P0527	130		4/5/05 1158	4/12/05 1321	ND			ND			ND			ND		
P0597	130		4/12/05 1321	4/19/05 1744	ND			ND			ND			ND		
N8589	**131**		**2/3/05 1000**	**2/9/05 1546**	**ND**			**ND**			**ND**			**ND**		
N9474	131		2/9/05 1546	3/17/05 1110	ND (9)			ND			ND			ND		
N9706	131		3/17/05 1110	3/29/05 1407	ND			541.0	18.6	05-19	ND			ND		
N9906	131		3/29/05 1407	4/4/05 1833	ND			542.0	6.41	05-19	568.9	33.6	05-23	ND		
P0528	131		4/4/05 1833	4/12/05 1309	ND			541.5	4.13	05-19	570.3	11.5	05-23	ND		
P0598	131		4/12/05 1309	4/19/05 1736	ND			541.4	2.97	05-19	570.4	7.13	05-23	ND		
N8590	**132**		**2/3/05 1022**	**2/9/05 1553**	**ND**			**ND**			**569.3**	**191**	**05-16**	**ND**		
N9475	132		2/9/05 1553	3/17/05 1120	ND			ND			569.7	332	05-16	ND		
N9707	132		3/17/05 1120	3/29/05 1443	ND			ND			569.3	45.9	05-16	ND		
N9907	132		3/29/05 1443	4/4/05 1819	ND			ND			569.0	39.1	05-16	ND		
P0529	132		4/4/05 1819	4/12/05 1256	ND			ND			568.8	25.2	05-16	ND		
P0599	132		4/12/05 1256	4/19/05 1705	ND			ND			569.1	18.4	05-16	ND		
P0599D	132		4/12/05 1256	4/19/05 1705	ND			ND			569.9	8.38	05-16	ND		
N8591	**133**		**2/3/05 1040**	**2/9/05 1600**	**ND**			**ND**			**ND**			**ND**		
N9476	133		2/9/05 1600	3/17/05 1126	ND			ND			ND			ND		
N9708	133		3/17/05 1126	3/29/05 1450	ND			ND			ND			ND		
N9908	133		3/29/05 1450	4/6/05 1331	ND			ND			ND			ND		
P0530	133		4/6/05 1331	4/12/05 1241	ND			ND			570.0 (1)	3.42	bkg	ND		
P0601	133		4/12/05 1241	4/19/05 1721	ND			ND			ND			ND		
N8592	**134**		**2/3/05 1155**	**2/10/05 1058**	**515.4 (1)**	**0.816**	bkg	**ND**			**ND**			**ND**		
N9709	134		2/10/05 1058	3/24/05 1535	ND			ND			ND			ND		
N9909	134		3/24/05 1535	4/5/05 1830	ND			ND			ND			ND		
P0531	134		4/5/05 1830	4/12/05 1725	ND			ND			ND			ND		
P0602	134		4/12/05 1725	4/19/05 1508	ND			ND			ND			ND		
N8593	**135**		**2/3/05 1215**	**2/10/05 1114**	**515.4 (1)**	**0.726**	bkg	**ND**			**ND**			**ND**		
N9710	135		2/10/05 1114	3/24/05 1140	514.4 (1)	1.14	bkg	ND			ND			ND		

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N9910	135		3/24/05 1140	4/5/05 1845	ND			541.3	3,740	05-22	ND			ND		
P0532	135		4/5/05 1845	4/12/05 1709	ND			541.2	685	05-22	ND			ND		
P0603	135		4/12/05 1709	4/19/05 1457	ND			540.7	167	05-22	ND			ND		
N8594	**136**		**2/4/05 0948**	**2/10/05 1053**	**ND**			**ND**			**ND**			**ND**		
N9711	136		2/10/05 1053	3/24/05 1517	515.4 (1)	1.49	bkg	ND			ND			ND		
N9911	136		3/24/05 1517	4/5/05 1806	516.2 (1)	1.04	bkg	ND			ND			ND		
P0533	136		4/5/05 1806	4/12/05 1744	515.5 (1)	0.930	bkg	ND			ND			ND		
N8595	**137**		**2/4/05 1008**	**2/10/05 1102**	**516.5**	**169,000**	**05-15**	**ND**			**ND**			**ND**		
N9477	137		2/10/05 1102	3/17/05 1012	517.1	2,710	05-15	ND			ND			ND		
N9712	137		3/17/05 1012	3/24/05 1527	517.2	499	05-15	ND			ND			ND		
N9912	137		3/24/05 1527	4/5/05 1859	516.5	235	05-15	ND			ND			ND		
P0534	137		4/5/05 1859	4/12/05 1733	515.9	238	05-15	ND			ND			ND		
P0604	137		4/12/05 1733	4/20/05 0929	ND			ND			ND			ND		
N8596	**138**		**2/4/05 1240**	**2/10/05 0948**	**515.7**	**15.5**	bkg	**ND**			**ND**			**ND**		
N9713	138		2/10/05 0948	3/24/05 0942	ND			ND			ND			ND		
N9913	138		3/24/05 0942	4/5/05 1111	ND			ND			ND			ND		
P0535	138		4/5/05 1111	4/12/05 1528	ND			ND			ND			ND		
P0605	138		4/12/05 1528	4/19/05 1227	ND			ND			ND			ND		
N8597	**139**		**2/4/05 1335**	**2/10/05 1013**	**515.7**	**5.35**	bkg	**ND**			**ND**			**ND**		
N9714	139		2/10/05 1013	3/24/05 1040	515.8	3.16	bkg	ND			ND			ND		
N9914	139		3/24/05 1040	4/6/05 1129	515.0	2.09	bkg	ND			ND			ND		
P0536	139		4/6/05 1129	4/12/05 1611	ND			ND			ND			ND		
P0606	139		4/12/05 1611	4/19/05 1411	ND			ND			ND			ND		
N9450	**140**		**2/11/05 0948**	**3/16/05 1259**	**ND**			**ND**			**ND**			**ND**		
N9664	140		3/16/05 1259	3/29/05 1531	ND			ND			ND			ND		
P0450	140		3/29/05 1531	4/14/05 1548	ND			ND			ND			ND		
N9715	**141**		**2/11/05 1025**	**3/24/05 0953**	**ND**			**ND**			**ND**			**ND**		
N9915	141		3/24/05 0953	4/5/05 1128	ND			ND			ND			ND		
P0537	141		4/5/05 1128	4/12/05 1511	ND			ND			ND			ND		
P0607	141		4/12/05 1511	4/19/05 1239	ND			ND			ND			ND		
N9716	**142**		**2/11/05 1103**	**3/24/05 0854**	**ND**			**ND**			**ND**			**ND**		
N9916	142		3/24/05 0854	4/5/05 0851	ND			ND			ND			ND		
P0538	142		4/5/05 0851	4/13/05 1112	ND			ND			ND			ND		
P0608	142		4/13/05 1112	4/20/05 0833	ND			ND			ND			ND		
N9717	**143**		**2/11/05 1120**	**3/24/05 0905**	**ND**			**ND**			**ND**			**ND**		
N9917	143		3/24/05 0905	4/5/05 0920	ND			ND			ND			ND		
P0539	143		4/5/05 0920	4/13/05 1128	ND			ND			ND			ND		
P0539D	143		4/5/05 0920	4/13/05 1128	ND			ND			ND			ND		
P0609	143		4/13/05 1128	4/20/05 0845	ND			ND			ND			ND		
N9718	**144**		**2/11/05 1144**	**3/24/05 0918**	**ND**			**ND**			**ND**			**ND**		
N9918	144		3/24/05 0918	4/5/05 0958	ND			ND			ND			ND		
P0541	144		4/5/05 0958	4/13/05 1146	ND			ND			ND			ND		
N9463	**145**		**2/25/05 1050**	**3/16/05 1132**	**517.6**	**1.41**	**bkg**	**ND**			**566.6**	**7.32**	**bkg**	**ND**		
N9731	145		3/16/05 1132	3/23/05 1511	ND			ND			ND			ND		
N9773	145		3/23/05 1511	3/31/05 1158	ND			ND			ND			ND		
P0493	145		3/31/05 1158	4/8/05 0822	ND			ND			ND			ND		
N9478	**146**		**2/25/05 1108**	**3/22/05 1550**	**514.4 (1)**	**1.06**	**bkg**	**ND**			**ND**			**ND**		
N9919	146		3/22/05 1550	4/4/05 1450	ND			ND			ND			ND		
N9919D	146		3/22/05 1550	4/4/05 1450	ND			ND			ND			ND		
P0542	146		4/4/05 1450	4/12/05 1351	513.6 (1)	1.13	bkg	ND			ND			ND		
P0610	146		4/12/05 1351	4/19/05 1148	ND			ND			ND			ND		
N9479	**147**		**2/25/05 1120**	**3/22/05 1553**	**ND**			**ND**			**ND**			**ND**		
N9479D	147		2/25/05 1120	3/22/05 1553	ND			ND			ND			ND		
N9921	147		3/22/05 1553	4/4/05 1502	ND			ND			ND			ND		
P0543	147		4/4/05 1502	4/12/05 1358	ND			ND			ND			ND		
P0611	147		4/12/05 1358	4/19/05 1154	ND			ND			ND			ND		
N9481	**148**		**2/25/05 1145**	**3/22/05 1640**	**513.6 (1)**	**1.19**	**bkg**	**ND**			**ND**			**ND**		

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N9719	148		3/22/05 1640	3/29/05 1503	ND			ND			568.7	373	05-20	ND		
N9719D	148		3/22/05 1640	3/29/05 1503	ND			ND			569.1	537	05-20	ND		
N9922	148		3/29/05 1503	4/5/05 1022	ND			ND			567.8	6,140	05-20	ND		
P0544	148		4/5/05 1022	4/13/05 1248	ND			ND			568.5	2,350	05-20	ND		
P0612	148		4/13/05 1248	4/20/05 1141	ND			ND			569.2	1,120	05-20	ND		
N9482	**149**		**2/25/05 1200**	**3/22/05 1700**	**ND**			**ND**			**ND**			**ND**		
N9923	149		3/22/05 1700	4/5/05 1047	ND			ND			ND			ND		
N9732	**150**		**3/15/05 1730**	**3/25/05 1320**	**ND**			**ND**			**ND**			**ND**		
N9774	150		3/25/05 1320	3/31/05 1212	ND			ND			ND			ND		
P0494	150		3/31/05 1212	4/8/05 1125	ND			ND			ND			ND		
N9924	**151**		**3/16/05 1635**	**4/4/05 1315**	**515.5**	**1.95**	**bkg**	**ND**			**ND**			**ND**		
N9743	**152**		**3/23/05 0920**	**3/30/05 1458**	**ND**			**ND**			**ND**			**ND**		
N9932	152		3/30/05 1458	4/7/05 1536	ND			ND			ND			ND		
P0451	152		4/7/05 1536	4/14/05 0941	ND			ND			ND			ND		
P0621	152		4/14/05 0941	4/20/05 1455	ND			ND			ND			ND		
N9933	**153**		**3/16/05 0850**	**4/7/05 1350**	**515.7 (1)**	**1.03**	**bkg**	**541.5 (1)**	**1.30**	**bkg**	**565.1 (1)**	**6.85**	**bkg**	**ND**		
N9934	**154**		**3/16/05 0920**	**4/7/05 1330**	**514.5 (1)**	**1.02**	**bkg**	**ND**			**ND**			**ND**		
N9935	**155**		**3/16/05 0930**	**4/7/05 1325**	**514.6 (1)**	**2.37**	**bkg**	**ND**			**ND**			**ND**		
N9665	**156**		**3/16/05 1020**	**3/25/05 0935**	**514.4 (1)**	**0.566**	**bkg**	**ND**			**ND**			**ND**		
N9936	156		3/25/05 0935	4/7/05 1638	513.8 (1)	1.01	bkg	ND			ND			ND		
P0452	156		4/7/05 1638	4/14/05 1101	ND			ND			ND			ND		
N9666	**157**		**3/16/05 1050**	**3/25/05 0916**	**ND**			**ND**			**ND**			**ND**		
N9937	157		3/25/05 0916	4/6/05 1832	ND			ND			ND			ND		
P0453	157		4/6/05 1832	4/14/05 1032	ND			ND			ND			ND		
N9667	**158**		**3/16/05 1120**	**3/25/05 0910**	**ND**			**ND**			**ND**			**ND**		
N9938	158		3/25/05 0910	4/6/05 1816	ND			ND			ND			ND		
P0454	158		4/6/05 1816	4/14/05 1027	ND			ND			ND			ND		
N9668	**159**		**3/16/05 1145**	**3/25/05 0856**	**ND**			**ND**			**ND**			**ND**		
N9939	159		3/25/05 0856	4/6/05 1848	ND			ND			ND			ND		
N9939D	159		3/25/05 0856	4/6/05 1848	ND			ND			ND			ND		
P0455	159		4/6/05 1848	4/14/05 1038	ND			ND			ND			ND		
P0622	159		4/14/05 1038	4/20/05 1728	ND			ND			ND			ND		
N9669	**160**		**3/16/05 1205**	**3/25/05 1025**	**ND**			**ND**			**ND**			**ND**		
N9941	160		3/25/05 1025	4/7/05 1343	ND			ND			ND			ND		
P0456	160		4/7/05 1343	4/14/05 1319	ND			ND			ND			ND		
P0623	160		4/14/05 1319	4/20/05 1614	ND			ND			ND			ND		
N9670	**161**		**3/16/05 1230**	**3/25/05 1013**	**ND**			**ND**			**ND**			**ND**		
N9942	161		3/25/05 1013	4/7/05 1411	ND			ND			ND			ND		
P0457	161		4/7/05 1411	4/14/05 1258	ND			ND			ND			ND		
P0624	161		4/14/05 1258	4/20/05 1633	ND			ND			ND			ND		
N9671	**162**		**3/16/05 1445**	**3/25/05 0948**	**ND**			**ND**			**ND**			**ND**		
N9943	162		3/25/05 0948	4/7/05 1651	ND			ND			ND			ND		
P0458	162		4/7/05 1651	4/14/05 1118	ND			ND			ND			ND		
N9744	**163**		**3/23/05 1000**	**3/30/05 1357**	**515.2 (1)**	**0.820**	**bkg**	**ND**			**ND**			**ND**		
N9944	163		3/30/05 1357	4/7/05 1507	ND			541.3	1,160	05-21	ND			ND		
P0459	163		4/7/05 1507	4/14/05 0925	ND			540.9	245	05-21	ND			ND		
P0459D	163		4/7/05 1507	4/14/05 0925	ND			541.1	357	05-21	ND			ND		
P0625	163		4/14/05 0925	4/20/05 1431	ND			541.1	76.9	05-21	ND			ND		
N9745	**165**		**3/23/05 1030**	**3/30/05 1348**	**ND**			**ND**			**ND**			**ND**		
N9945	165		3/30/05 1348	4/7/05 1459	ND			ND			ND			ND		
P0461	165		4/7/05 1459	4/14/05 0921	ND			ND			ND			ND		
P0626	165		4/14/05 0921	4/20/05 1423	ND			ND			ND			ND		
N9746	**166**		**3/23/05 1110**	**3/30/05 1425**	**ND**			**ND**			**ND**			**ND**		
N9946	166		3/30/05 1425	4/7/05 1516	ND			ND			ND			ND		
P0462	166		4/7/05 1516	4/14/05 0934	ND			ND			ND			577.4	4.11	05-26
P0627	166		4/14/05 0934	4/20/05 1448	ND			541.0	2.83	05-21	ND			577.0	4.86	05-26
N9747	**167**		**3/23/05 1312**	**3/30/05 1531**	**516.0**	**1.55**	**bkg**	**ND**			**ND**			**ND**		

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N9947	167		3/30/05 1531	4/7/05 1605	516.3	2.05	bkg	ND			ND			ND		
P0463	167		4/7/05 1605	4/14/05 1008	516.8	1.80	bkg	ND			ND			ND		
P0628	167		4/14/05 1008	4/20/05 1515	517.9	1.71	bkg	ND			ND			ND		
N9748	**168**		**3/23/05 1420**	**3/30/05 1517**	**ND**			**ND**			**ND**			**ND**		
N9948	168		3/30/05 1517	4/7/05 1551	ND			ND			ND			ND		
P0464	168		4/7/05 1551	4/14/05 0952	ND			ND			ND			ND		
P0629	168		4/14/05 0952	4/20/05 1503	ND			ND			ND			ND		
N9749	**169**		**3/23/05 1515**	**3/30/05 1412**	**ND**			**ND**			**ND**			**ND**		
N9949	169		3/30/05 1412	4/7/05 1450	517.0	18,700	05-25	ND			ND			ND		
P0465	169		4/7/05 1450	4/14/05 0914	516.9	833	05-25	ND			ND			ND		
P0630	169		4/14/05 0914	4/20/05 1409	516.9	579	05-25	ND			ND			ND		
N9750	**171**		**3/23/05 1600**	**3/30/05 1136**	**ND**			**ND**			**ND**			**ND**		
P0466	171		3/30/05 1136	4/14/05 0814	ND			ND			ND			ND		
P0631	171		4/14/05 0814	4/20/05 1331	ND			ND			ND			ND		
N9751	**172**		**3/23/05 1628**	**3/30/05 1143**	**ND**			**ND**			**ND**			**ND**		
P0467	172		3/30/05 1143	4/14/05 0820	ND			ND			569.1	14.0	05-28	ND		
N9752	**173**		**3/23/05 1640**	**3/30/05 1114**	**ND**			**ND**			**ND**			**ND**		
N9950	173		3/30/05 1114	4/7/05 1309	ND			ND			568.1	4,110	05-28	ND		
P0468	173		4/7/05 1309	4/14/05 0837	ND			ND			569.9	696	05-28	ND		
P0632	173		4/14/05 0837	4/20/05 1351	516.4 (1)	0.648	bkg	ND			568.8	218	05-28	ND		
N9753	**174**		**3/23/05 1645**	**3/30/05 1105**	**ND**			**ND**			**ND**			**ND**		
N9951	174		3/30/05 1105	4/7/05 1305	ND			ND			ND			ND		
P0469	174		4/7/05 1305	4/14/05 0842	ND			ND			ND			ND		
P0633	174		4/14/05 0842	4/20/05 1345	ND			ND			ND			ND		
N9754	**175**		**3/23/05 1635**	**3/30/05 1027**	**ND**			**ND**			**ND**			**ND**		
N9952	175		3/30/05 1027	4/7/05 1704	ND			ND			ND			ND		
P0470	175		4/7/05 1704	4/14/05 1141	ND			ND			ND			ND		
N9755	**176**		**3/23/05 1650**	**3/30/05 0912**	**ND**			**ND**			**ND**			**ND**		
N9953	176		3/30/05 0912	4/7/05 1234	ND			ND			ND			ND		
P0471	176		4/7/05 1234	4/14/05 0713	ND			ND			ND			ND		
P0634	176		4/14/05 0713	4/20/05 1236	ND			ND			ND			ND		
N9756	**177**		**3/23/05 1750**	**3/30/05 0925**	**ND**			**ND**			**ND**			**ND**		
N9954	177		3/30/05 0925	4/7/05 1152	ND			ND			ND			ND		
P0472	177		4/7/05 1152	4/14/05 0721	ND			ND			ND			ND		
P0635	177		4/14/05 0721	4/20/05 1244	ND			ND			ND			ND		
N9757	**178**		**3/23/05 1640**	**3/30/05 0932**	**ND**			**ND**			**ND**			**ND**		
N9955	178		3/30/05 0932	4/7/05 1157	ND			ND			ND			ND		
P0473	178		4/7/05 1157	4/14/05 0726	ND			ND			ND			ND		
P0636	178		4/14/05 0726	4/20/05 1256	ND			ND			ND			ND		
N9758	**179**		**3/23/05 1746**	**3/30/05 0941**	**ND**			**ND**			**ND**			**ND**		
N9956	179		3/30/05 0941	4/7/05 1202	ND			ND			ND			ND		
P0474	179		4/7/05 1202	4/14/05 0731	ND			ND			ND			ND		
P0637	179		4/14/05 0731	4/20/05 1251	ND			ND			ND			ND		
N9759	**180**		**3/23/05 1800**	**3/30/05 0951**	**ND**			**ND**			**ND**			**ND**		
N9759D	180		3/23/05 1800	3/30/05 0951	ND			ND			ND			ND		
N9957	180		3/30/05 0951	4/7/05 1209	ND			ND			ND			ND		
P0475	180		4/7/05 1209	4/14/05 0737	ND			ND			ND			ND		
P0638	180		4/14/05 0737	4/20/05 1301	ND			ND			ND			ND		
N9761	**181**		**3/23/05 1809**	**3/30/05 0958**	**ND**			**ND**			**ND**			**ND**		
N9958	181		3/30/05 0958	4/7/05 1215	ND			ND			ND			ND		
P0476	181		4/7/05 1215	4/14/05 0744	ND			ND			ND			ND		
P0639	181		4/14/05 0744	4/20/05 1308	ND			ND			ND			ND		
P0639D	181		4/14/05 0744	4/20/05 1308	ND			ND			ND			ND		
N9672	**182**		**3/16/05 1100**	**3/25/05 0840**	**ND**			**ND**			**ND**			**ND**		
N9959	182		3/25/05 0840	4/7/05 0830	ND			ND			ND			ND		
N9959D	182		3/25/05 0840	4/7/05 0830	ND			ND			ND			ND		
P0477	182		4/7/05 0830	4/14/05 1128	ND			ND			ND			ND		

OUL	Station	Station Name	Date/Time	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
#	#		Placed	Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N9762	**183**		**3/25/05 1033**	**3/30/05 1610**	**514.8 (1)**	**1.20**	**bkg**	**ND**			**570.2 (1)**	**1.67**		**ND**		
N9961	183		3/30/05 1610	4/7/05 1358	ND			540.8	56.6	05-24	ND			ND		
P0478	183		4/7/05 1358	4/14/05 1326	ND			540.7	6.74	05-24	ND			ND		
P0641	183		4/14/05 1326	4/20/05 1622	ND			541.1	2.68	05-24	ND			ND		
N9962	**184**		**3/30/05 1200**	**4/7/05 0845**	**ND**			**ND**			**ND**			**ND**		
P0479	184		4/7/05 0845	4/15/05 1056	515.4 (1)	1.24	bkg	ND			ND			ND		
P0479D	184		4/7/05 0845	4/15/05 1056	515.0 (1)	0.869	bkg	ND			ND			ND		
P0642	184		4/15/05 1056	4/20/05 1540	ND			ND			ND			ND		
N9963	**185**		**3/30/05 1228**	**4/7/05 0900**	**ND**			**541.3**	**2.55**	05-24	**ND**			**ND**		
P0481	185		4/7/05 0900	4/15/05 1127	ND			539.9	1.03	05-24	ND			ND		
N9926	**186**		**3/30/05 1358**	**4/6/05 1003**	**ND**			**ND**			**ND**			**ND**		
P0545	186		4/6/05 1003	4/13/05 1039	ND			ND			ND			ND		
N9925	**187**		**3/30/05 1408**	**4/6/05 0952**	**ND**			**ND**			**ND**			**ND**		
P0546	187		4/6/05 0952	4/13/05 1031	ND			ND			ND			ND		
P0613	187		4/13/05 1031	4/20/05 0914	ND			ND			ND			ND		
N9866	**188**		**3/30/05 1448**	**4/6/05 0805**	**ND**			**ND**			**ND**			**ND**		
P0547	188		4/6/05 0805	4/13/05 0725	ND			ND			ND			ND		
	189			**3/30/05 1658**	**(8)**											
N9856	**190**		**4/2/05 0900**	**4/7/05 0838**	**515.8**	**64.8**	**05-25**	**ND**			**ND**			**ND**		
N9857	**191**		**4/2/05 0915**	**4/7/05 0918**	**ND**			**ND**			**ND**			**ND**		
N9858	**192**		**4/2/05 0930**	**4/7/05 0815**	**ND**			**ND**			**ND**			**ND**		
P0482	192		4/7/05 0815	4/14/05 1409	ND			ND			ND			ND		
N9859	**193**		**4/3/05 1035**	**4/6/05 0821**	**ND**			**ND**			**ND**			**ND**		
N9859D	193		4/3/05 1035	4/6/05 0821	ND			ND			ND			ND		
P0548	193		4/6/05 0821	4/13/05 0757	ND			ND			ND			ND		
N9861	**194**		**4/3/05 1043**	**4/6/05 0826**	**ND**			**ND**			**ND**			**ND**		
P0549	194		4/6/05 0826	4/13/05 0751	ND			ND			ND			ND		
N9862	**195**		**4/3/05 1255**	**4/6/05 0926**	**ND**			**ND**			**ND**			**ND**		
P0550	195		4/6/05 0926	4/13/05 0917	ND			ND			ND			ND		
P0614	195		4/13/05 0917	4/20/05 0946	ND			ND			ND			ND		
N9863	**196**		**4/3/05 1308**	**4/6/05 0915**	**ND**			**ND**			**ND**			**ND**		
P0551	196		4/6/05 0915	4/13/05 0903	ND			ND			ND			ND		
N9864	**197**		**4/3/05 1355**	**4/6/05 0854**	**ND**			**ND**			**ND**			**ND**		
P0552	197		4/6/05 0854	4/13/05 0833	ND			ND			ND			ND		
P0615	197		4/13/05 0833	4/19/05 1618	ND			ND			ND			ND		
N9865	**198**		**4/3/05 1415**	**4/6/05 0847**	**ND**			**ND**			**568.6**	**5.37**	**05-27**	**ND**		
P0553	198		4/6/05 0847	4/13/05 0821	ND			539.0	4.17	bkg	569.4	333	05-27	ND		
P0616	198		4/13/05 0821	4/19/05 1630	ND			ND			568.4	278	05-27	ND		

Table 2.	Results for water samples analayzed for the presence of fluorescein, eosine, rhodamine WT (RWT) and sulforhodamine B (SRB) dyes.															
	Peak wavelengths are reported in nanometers (nm); dye concentrations are reported in parts per billion (ppb).															
OUL	**Station**	**Station Name**	**Date/Time**	**Fluorescein Results**		**Trace**	**Eosine Results**		**Trace**	**RWT Results**		**Trace**	**SRB Results**		**Trace**
Lab #	**#**		**Recovered**	**Peak nm**	**Conc. ppb**	**#**	**Peak nm**	**Conc. ppb**	**#**	**Peak nm**	**Conc. ppb**	**#**	**Peak nm**	**Conc. ppb**	**#**
N2384	**1**		**4/22/04 1010**	**ND**			**ND**			**ND**			**ND**		
N4936	1		8/4/04 1340	ND			ND			ND			ND		
N6105	1		9/29/04 1022	ND			ND			ND			ND		
N6812	1		10/26/04 0855	ND			ND			ND			ND		
N8042	1		1/10/05 1327	ND			ND			ND			ND		
N8265	1		01/13/05 1456	ND			ND			ND			ND		
N8745	1		2/9/05 1745	ND			ND			ND			ND		
N9004	1		2/25/05 1155	ND			ND			ND			ND		
N2385	**2**		**4/22/04 1015**	**ND**			**ND**			**ND**			**ND**		
N3452	2		6/3/04 1150	ND			ND			ND			ND		
N4937	2		8/4/04 1340	ND			ND			ND			ND		
N5417	2		8/31/04 1533	506.2 (3)	0.012	bkg	ND			ND			ND		
N6106	2		9/29/04 1026	507.0	0.030	bkg	ND			ND			ND		
N6813	2		10/26/04 0900	ND			ND			ND			ND		
N8043	2		1/10/05 1312	ND			ND			ND			ND		
N8266	2		01/13/05 1452	ND			ND			ND			ND		
N8476	2		1/21/05 0752	ND			ND			ND			ND		
N8453	2		2/1/05 1755	ND			ND			ND			ND		
N8746	2		2/9/05 1742	ND			ND			ND			ND		
N9005	2		2/25/05 1200	ND			ND			ND			ND		
N3047	**3**		**5/19/04 0955**	**ND**			**ND**			**ND**			**ND**		
N3931	3		6/24/04 1150	ND			ND			ND			ND		
N5096	3		8/14/04 0830	ND			ND			ND			ND		
N3048	**4**		**5/19/04 1050**	**ND**			**ND**			**ND**			**ND**		
N3272	4		5/26/04 0830	ND			ND			ND			ND		
N3932	4		6/24/04 1200	ND			ND			ND			ND		
N4310	4		7/9/04 0855	ND			533.4	0.227	04-03	ND			ND		
N4573	4		7/18/04 1745	ND			ND			ND			ND		
N4739	4		7/29/04 0800	ND			ND			ND			ND		
N4938	4		8/5/04 1110	ND			ND			ND			ND		
N5097	4		8/14/04 0815	ND			ND			ND			ND		
N7249	4		11/17/04 1540	ND			ND			ND			ND		
N3049	**5**		**5/19/04 1125**	**ND**			**ND**			**ND**			**ND**		
N3273	5		5/26/04 0900	ND			ND			ND			ND		
N3453	5		6/3/04 0815	ND			ND			ND			ND		
N3453R	5		6/3/04 0815	ND			ND			ND			ND		
N3933	5		6/24/04 0855	ND			ND			ND			ND		
N4311	5		7/9/04 1105	ND			533.6	7.80	04-03	ND			ND		
N4574	5		7/18/04 1815	ND (2)			531.2	2.10	04-03	ND			ND		
N4741	5		7/28/04 1625	ND (2)			532.2	1.37	04-03	ND			ND		
N4939	5		8/5/04 0805	ND (2)			531.9	1.66	04-03	ND			ND		
N5098	5		8/13/04 1530	507.8 (2)	0.106	bkg	531.7	1.35	04-03	ND			ND		
N5418	5		9/1/04 1355	507.2 (2)	0.026	bkg	532.4	0.352	04-03	ND			ND		
N5537	5		9/9/04 1415	507.2 (2)	0.051	bkg	532.5	0.659	04-03	ND			ND		
N5734	5		9/21/04 1532	510.6 (2)	0.103	bkg	531.6 (3)	0.503	04-03	ND			ND		
N6107	5		9/29/04 1605	ND			531.0 (3)	0.523	04-03	ND			ND		
N6135	5		10/5/04 1635	ND			531.1 (3)	0.500	04-03	ND			ND		
N6334	5		10/14/04 0955	ND			530.3 (3)	0.585	04-03	ND			ND		
N6814	5		10/27/04 1120	ND			533.2	0.097	04-03	ND			ND		
N7021	5		11/8/04 1632	ND			ND			ND			ND		
N7021R	5		11/8/04 1632	ND			ND			ND			ND		
N7568	5		12/3/04 1415	ND			ND			ND			ND		
P0189	5		4/7/05 1055	ND			ND			ND			ND		
P0706	5		4/15/05 1031	ND			ND			ND			ND		
N3050	**6**		**5/19/04 1225**	**ND**			**ND**			**ND**			**ND**		
N3274	6		5/26/04 0800	509.0 (1)	0.013	bkg	ND			ND			ND		

OUL	Station	Station Name	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
Lab #	#		Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N3781	6		6/17/04 1340	ND			ND			ND			ND		
N8267	6		01/13/05 1358	ND			ND			ND			ND		
P0707	6		4/14/05 1739	ND			ND			ND			ND		
N3051	**7**		**5/19/04 1445**	**ND**			**ND**			**ND**			**ND**		
N3275	7		5/26/04 0715	ND			ND			ND			ND		
N3454	7		6/3/04 0645	ND			ND			ND			ND		
N8268	7		01/18/05 1403	ND			ND			ND			ND		
N3052	**8**		**5/19/04 1500**	**ND**			**ND**			**ND**			**ND**		
N3053	**9**		**5/19/04 1525**	**ND**			**ND**			**ND**			**ND**		
N5099	9		8/14/04 0800	ND			ND			ND			ND		
N5099R	9		8/14/04 0800	ND			ND			ND			ND		
N3054	**10**		**5/19/04 1630**	**ND**			**ND**			**ND**			**ND**		
N4742	10		7/27/04 1655	ND			ND			ND			ND		
N4742R	10		7/27/04 1655	ND			ND			ND			ND		
N5101	10		8/13/04 0825	ND			ND			ND			ND		
N6815	10		10/25/04 1025	ND			ND			ND			ND		
N3055	**11**		**5/19/04 1720**	**ND**			**ND**			**ND**			**ND**		
N3055R	11		5/19/04 1720	ND			ND			ND			ND		
N3056	**12**		**5/19/04 1910**	**ND**			**ND**			**ND**			**ND**		
N3782	12		6/16/04 1110	ND			ND			574.5	0.410	04-02	ND		
N3934	12		6/23/04 1000	ND			ND			575.8 (3)	0.071	04-02	ND		
N4156	12		6/29/04 1040	ND			ND			ND			ND		
N4312	12		7/8/04 0945	ND			ND			ND			ND		
N4743	12		7/27/04 1720	ND			533.9	9.98	04-04	ND			ND		
N4941	12		8/4/04 1020	ND			533.8	0.242	04-04	ND			ND		
N5102	12		8/13/04 0720	ND			534.6	0.048	04-04	ND			ND		
N5419	12		8/31/04 1115	ND			ND			ND			ND		
N5419R	12		8/31/04 1115	ND			ND			ND			ND		
N5538	12		9/9/04 0938	ND			ND			ND			ND		
N5735	12		9/21/04 1000	507.2 (3)	0.012	04-10	ND			ND			ND		
N6816	12		10/25/04 1443	ND			ND			ND			ND		
N3057	**13**		**5/20/04 0845**	**ND**			**ND**			**ND**			**ND**		
N3783	13		6/17/04 1145	ND			532.7	0.238	04-01	ND			ND		
N3783R	13		6/17/04 1145	ND			532.4	0.255	04-01	ND			ND		
N3935	13		6/23/04 1100	ND			ND			ND			ND		
N4942	13		8/4/04 1200	ND			ND			574.8	0.134	04-05	ND		
N4942R	13		8/4/04 1200	ND			ND			576.4	0.166	04-05	ND		
N5103	13		8/13/04 0910	ND			ND			577.6 (3)	0.134	04-05	ND		
N5421	13		8/31/04 1320	ND			ND			ND			ND		
N5539	13		9/9/04 1026	ND			ND			574.3	0.938	04-06	ND		
N5736	13		9/21/04 1130	ND			ND			574.8	0.369	04-06	ND		
N6136	13		10/5/04 1156	ND			ND			574.8	0.072	04-06	ND		
N6335	13		10/12/04 1305	ND			ND			ND			ND		
N6817	13		10/25/04 1615	ND			ND			ND			ND		
N8044	13		1/10/05 1425	ND			ND			ND			ND		
N8269	13		01/17/05 1655	ND			ND			ND			ND		
N3058	**14**		**5/20/04 0930**	**ND**			**533.0**	**0.081**	**bkg**	**ND**			**ND**		
N3276	14		5/26/04 1700	ND			ND			ND			ND		
N3455	14		6/3/04 1400	ND			ND			ND			ND		
N3676	14		6/11/04 1615	ND			ND			ND			ND		
N3936	14		6/23/04 1130	ND			ND			ND			ND		
N4157	14		6/29/04 1130	ND			ND			ND			ND		
N4575	14		7/18/04 1030	ND			ND			ND			ND		
N4744	14		7/28/04 0750	508.6	0.023	bkg	ND			ND			ND		
N5104	14		8/13/04 0920	ND			ND			ND			ND		
N5422	14		8/31/04 1335	ND			ND			ND			ND		
N3059	**15**		**5/20/04 1015**	**ND**			**ND**			**ND**			**ND**		
N3784	15		6/16/04 1750	ND			533.3	0.369	04-01	ND			ND		

OUL	Station	Station Name	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
Lab #	#		Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N3937	15		6/23/04 1140	ND			ND			ND			ND		
N5423	15		8/31/04 1458	ND			ND			573.5	12.2	04-06	ND		
N5541	15		9/9/04 1057	ND			ND			573.9	3.28	04-06	ND		
N5737	15		9/21/04 1240	ND			ND			573.5	1.51	04-06	ND		
N6108	15		9/29/04 0948	ND			ND			573.9	0.711	04-06	ND		
N6137	15		10/5/04 1432	ND			ND			573.4	0.588	04-06	ND		
N6336	15		10/12/04 1405	ND			ND			574.0	0.375	04-06	ND		
N6818	15		10/26/04 0807	ND			ND			ND			ND		
N3061	**16**		**5/20/04 1040**	**ND**			**ND**			**ND**			**ND**		
N4745	16		7/28/04 0900	ND			ND			574.1	0.513	04-05	ND		
N4943	16		8/4/04 1320	ND			ND			573.7	1.52	04-05	ND		
N5105	16		8/13/04 1015	ND			ND			573.6	0.625	04-05	ND		
N5424	16		8/31/04 1453	ND			ND			575.2	0.235	04-05	ND		
N5542	16		9/9/04 1055	ND			ND			573.6 (3)	0.067	04-05	ND		
N5738	16		9/21/04 1245	ND			ND			573.6	0.136	04-05	ND		
N8270	16		01/18/05 1204	508.4	0.114	05-13	ND			ND			ND		
N8454	16		2/1/05 1815	ND			ND			ND			ND		
N3062	**17**		**5/20/04 1130**	**ND**			**ND**			**ND**			**ND**		
N3277	17		5/26/04 1000	ND			ND			ND			ND		
N3456	17		6/3/04 1015	ND			ND			ND			ND		
N3938	17		6/24/04 1140	ND			ND			ND			ND		
N4158	17		6/30/04 0940	ND			ND			ND			ND		
N4313	17		7/9/04 1215	ND			ND			ND			ND		
N3063	**18**		**5/20/04 1505**	**ND**			**ND**			**ND**			**ND**		
N4746	18		7/28/04 0825	ND			ND			573.4	140	04-05	ND		
N4944	18		8/4/04 1350	ND			ND			573.1	8.93	04-05	ND		
N5106	18		8/13/04 1045	ND			ND			573.0	5.96	04-05	ND		
N5425	18		8/31/04 1540	ND			ND			572.6	0.867	04-05	ND		
N5543	18		9/9/04 1135	ND			ND			573.2	0.685	04-05	ND		
N5739	18		9/21/04 1252	ND			ND			572.3	0.645	04-05	ND		
N6109	18		9/29/04 1033	ND			ND			572.0	0.607	04-05	ND		
N6138	18		10/5/04 1445	ND			ND			572.7	0.806	04-05	ND		
N6337	18		10/12/04 1440	ND			ND			573.9	0.886	04-05	ND		
N6819	18		10/26/04 0909	ND			ND			573.2	0.128	04-05	ND		
N6819R	18		10/26/04 0909	ND			ND			572.2	0.093	04-05	ND		
N7022	18		11/8/04 1540	ND			ND			ND			ND		
N7250	18		11/17/04 1250	ND			ND			ND			ND		
N7569	18		12/3/04 1642	ND			ND			ND			ND		
N8045	18		1/10/05 1304	ND			ND			ND			ND		
N8271	18		01/18/05 1216	ND			ND			ND			ND		
N3064	**19**		**5/20/04 1740**	**ND**			**ND**			**ND**			**ND**		
N3278	19		5/26/04 1315	ND			ND			ND			ND		
N3457	19		6/3/04 1115	ND			ND			ND			ND		
N3785	19		6/17/04 0950	ND			533.7	1.36	04-01	ND			ND		
N3939	19		6/23/04 1350	ND			533.7	0.333	04-01	ND			ND		
N4159	19		6/29/04 1330	ND			532.8	0.239	04-01	ND			ND		
N4314	19		7/8/04 1250	ND			ND			ND			ND		
N4576	19		7/18/04 1305	ND			532.2 (3)	0.039	04-01	ND			ND		
N4747	19		7/28/04 1010	ND			ND			ND			ND		
N4945	19		8/4/04 1620	ND			ND			ND			ND		
N5107	19		8/13/04 1115	ND			ND			ND			ND		
N5426	19		8/30/04 1115	ND			ND			ND			ND		
N3065	**20**		**5/20/04 1800**	**ND**			**ND**			**ND**			**ND**		
N5108	20		8/13/04 1120	ND			ND			ND			ND		
N3066	**21**		**5/21/04 0925**	**ND**			**ND**			**ND**			**ND**		
N3279	21		5/26/04 0915	ND			ND			ND			ND		
N3458	21		6/3/04 0830	ND			ND			ND			ND		
N3786	21		6/17/04 1515	ND			ND			ND			ND		

OUL	Station	Station Name	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
Lab #	#		Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N4161	21		6/30/04 0720	ND			ND			ND			ND		
N4161R	21		6/30/04 0720	ND			ND			ND			ND		
N4315	21		7/9/04 1115	ND			ND			ND			ND		
N4748	21		7/28/04 1630	ND			ND			ND			ND		
N4946	21		8/5/04 0815	ND			ND			ND			ND		
N5109	21		8/13/04 1540	ND			ND			ND			ND		
N5427	21		9/1/04 1405	ND			ND			ND			ND		
N6110	21		9/29/04 1542	ND			ND			ND			ND		
N6821	21		10/27/04 1059	ND			ND			ND			ND		
N7570	21		12/3/04 1355	ND			ND			ND			ND		
N7810	21		12/21/04 1646	ND			ND			ND			ND		
N8046	21		1/5/05 1105	ND			ND			ND			ND		
N3067	**22**		**5/21/04 1010**	**ND**			**ND**			**ND**			**ND**		
N3459	22		6/3/04 0845	ND			ND			ND			ND		
N5110	22		8/13/04 1545	ND			ND			ND			ND		
N3068	**23**		**5/21/04 1055**	**ND**			**ND**			**ND**			**ND**		
N3281	**24**		**5/26/04 1045**	**ND**			**ND**			**ND**			**ND**		
N3281R	24		5/26/04 1045	ND			ND			ND			ND		
N3461	24		6/3/04 1100	ND			ND			ND			ND		
N3677	24		6/13/04 1515	ND			ND			ND			ND		
N3787	24		6/17/04 0910	ND			ND			ND			ND		
N3941	24		6/23/04 1615	ND			ND			ND			ND		
N3941R	24		6/23/04 1615	ND			ND			ND			ND		
N4162	24		6/29/04 1420	ND			ND			ND			ND		
N4316	24		7/8/04 1340	ND			ND			ND			ND		
N4749	24		7/28/04 1110	ND			ND			ND			ND		
N4947	24		8/4/04 1520	ND			ND			ND			ND		
N5111	24		8/13/04 1145	ND			ND			ND			ND		
N5428	24		8/31/04 1710	ND			ND			ND			ND		
N5544	24		9/9/04 1143	ND			ND			ND			ND		
N5741	24		9/21/04 1408	ND			ND			574.2	0.085	Viacom	ND		
N6111	24		9/29/04 1136	ND			ND			575.6	0.110	Viacom	ND		
N6139	24		10/5/04 1340	ND			ND			572.8	0.423	Viacom	ND		
N6139D	24		10/5/04 1340	ND			ND			573.4	0.333	Viacom	ND		
N6338	24		10/12/04 1650	ND			ND			573.5	0.595	Viacom	ND		
N6822	24		10/26/04 1200	ND			ND			ND			ND		
N7023	24		11/8/04 1005	ND			ND			ND			582.2	1.58	Viacom
N7251	24		11/17/04 1340	ND			ND			ND			ND		
N7571	24		12/3/04 1515	ND			ND			ND			ND		
N7811	24		12/21/04 1453	ND			ND			ND			ND		
N3069	**25**		**5/21/04 1600**	**ND**			**ND**			**ND**			**ND**		
N3282	25		5/26/04 1015	ND			ND			576.6	0.076	Viacom	ND		
N3462	25		6/3/04 1030	ND			ND			ND			ND		
N3678	25		6/13/04 1520	ND			ND			574.8	0.101	Viacom	ND		
N3788	25		6/17/04 0850	ND			ND			ND			ND		
N3942	25		6/23/04 1600	ND			ND			ND			ND		
N4163	25		6/29/04 1455	ND			ND			575.0	0.125	Viacom	ND		
N4317	25		7/8/04 1420	ND			ND			ND			ND		
N4577	25		7/18/04 1425	ND			ND			ND			ND		
N5545	25		9/9/04 1118	ND			ND			575.6	0.142	Viacom	ND		
N5742	25		9/21/04 1437	ND			ND			573.5	0.586	Viacom	ND		
N6112	25		9/29/04 1310	ND			ND			574.8	0.345	Viacom	ND		
N7024	25		11/8/04 1035	ND			ND			ND			581.6	0.463	Viacom
N7572	25		12/3/04 1455	ND			ND			ND			ND		
N7812	25		12/21/04 1526	ND			ND			ND			ND		
N8047	25		1/11/05 1208	ND			ND			ND			ND		
N8272	25		01/18/05 1345	ND			ND			ND			ND		
N9006	25		2/24/05 1340	ND			ND			ND			ND		

OUL	Station	Station Name	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
Lab #	#		Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N9522	25		3/16/05 1540	ND			ND			ND			ND		
N3070	**26**		**5/21/04 1645**	**ND**			**ND**			**ND**			**ND**		
N3283	26		5/26/04 1030	ND			ND			ND			ND		
N3463	26		6/3/04 1045	ND			ND			ND			ND		
N3679	26		6/13/04 1530	ND			ND			ND			ND		
N3789	26		6/17/04 0900	ND			ND			ND			ND		
N3943	26		6/23/04 1605	ND			ND			ND			ND		
N4164	26		6/29/04 1500	ND			ND			575.6	0.098	Viacom	ND		
N4318	26		7/8/04 1425	ND			ND			ND			ND		
N4578	26		7/18/04 1430	ND			ND			ND			ND		
N5546	26		9/9/04 1122	ND			ND			ND			ND		
N5743	26		9/21/04 1440	ND			ND			574.0	0.405	Viacom	ND		
N6113	26		9/29/04 1313	ND			ND			574.1	0.271	Viacom	ND		
N7025	26		11/8/04 1040	ND			ND			ND			ND		
N7252	26		11/17/04 1350	ND			ND			ND			582.4	0.684	Viacom
N7573	26		12/3/04 1458	ND			ND			ND			ND		
N7813	26		12/21/04 1530	ND			ND			ND			ND		
N8048	26		1/11/05 1215	ND			ND			ND			ND		
N8273	26		01/18/05 1350	ND			ND			ND			ND		
N9523	26		3/16/05 1545	ND			ND			ND			ND		
N3284	**27**		**5/25/04 1400**	**ND**			**ND**			**ND**			**ND**		
N3681	27		6/13/04 1710	ND			ND			ND			ND		
N3790	27		6/17/04 1540	ND			ND			ND			ND		
N3944	27		6/24/04 0945	ND			ND			ND			ND		
N4165	27		6/30/04 0800	ND			ND			ND			ND		
N4319	27		7/9/04 1140	ND			ND			ND			ND		
N4579	27		7/18/04 1845	ND			ND			ND			ND		
N4579D	27		7/18/04 1845	ND			ND			ND			ND		
N4750	27		7/28/04 1500	ND			ND			ND			ND		
N4948	27		8/5/04 0900	ND			ND			ND			ND		
N6823	27		10/27/04 1008	ND			ND			ND			ND		
N3285	**28**		**5/25/04 1445**	**ND**			**ND**			**ND**			**ND**		
N3682	28		6/13/04 1720	ND			ND			ND			ND		
N3791	28		6/17/04 1550	ND			ND			ND			ND		
N3945	28		6/24/04 0955	ND			ND			ND			ND		
N4166	28		6/30/04 0810	ND			ND			ND			ND		
N4321	28		7/9/04 1145	ND			ND			ND			ND		
N4581	28		7/18/04 1850	ND			ND			ND			ND		
N4751	28		7/28/04 1505	ND			ND			ND			ND		
N4949	28		8/5/04 0905	ND			ND			ND			ND		
N5112	28		8/13/04 1425	ND			ND			ND			ND		
N5429	28		9/1/04 1500	ND			ND			ND			ND		
N6824	28		10/27/04 1012	ND			ND			ND			ND		
N3286	**29**		**5/25/04 1530**	**ND**			**ND**			**ND**			**ND**		
N3946	29		6/24/04 1115	ND			ND			ND			ND		
N3287	**30**		**5/25/04 1730**	**ND**			**ND**			**ND**			**ND**		
N3464	30		6/3/04 0915	ND			ND			ND			ND		
N3464R	30		6/3/04 0915	ND			ND			ND			ND		
N4322	30		7/9/04 1055	ND			533.9	1.50	04-03	ND			ND		
N4322R	30		7/9/04 1055	ND			533.8	1.48	04-03	ND			ND		
N4582	30		7/18/04 1805	ND			533.3	6.18	04-03	ND			ND		
N4752	30		7/28/04 1615	ND			533.5	3.25	04-03	ND			ND		
N4950	30		8/5/04 0810	ND			533.4	2.16	04-03	ND			ND		
N5113	30		8/13/04 1525	ND			533.0	1.79	04-03	ND			ND		
N5430	30		9/1/04 1337	ND			533.4	0.865	04-03	ND			ND		
N5547	30		9/9/04 1422	ND			533.4	1.05	04-03	ND			ND		
N5744	30		9/21/04 1543	ND			533.2	1.07	04-03	ND			ND		
N6114	30		9/29/04 1608	ND			533.3	1.15	04-03	ND			ND		

OUL	Station	Station Name	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
Lab #	#		Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N6143	30		10/5/04 1656	ND			533.2	1.28	04-03	ND			ND		
N6342	30		10/14/04 1000	ND			532.6	0.845	04-03	ND			ND		
N6825	30		10/27/04 1130	ND			533.6 (3)	0.036	04-03	ND			ND		
N7026	30		11/8/04 1637	ND			534.0	0.266	04-03	ND			ND		
N7253	30		11/17/04 1440	ND			534.0	0.208	04-03	ND			ND		
N7574	30		12/3/04 1420	ND			ND			ND			ND		
N7587	30		12/7/04 1112	ND			ND			ND			ND		
N7814	30		12/21/04 1708	ND			535.5	0.289	04-03	ND			ND		
N8049	30		1/5/05 1125	ND			ND			ND			ND		
N9007	30		2/25/05 1245	ND			536.6	0.092	04-03	ND			ND		
N9524	30		3/16/05 1703	ND			535.6	0.146	04-03	ND			ND		
N3288	**31**		**5/26/04 1115**	**ND**			**ND**			**573.5**	**1.61**	**Viacom**	**ND**		
N3465	31		6/3/04 1500	ND			ND			574.0	0.566	Viacom	ND		
N3683	31		6/14/04 0845	ND			ND			573.4	1.71	Viacom	ND		
N3792	31		6/17/04 0830	ND			ND			573.8	0.568	Viacom	ND		
N3947	31		6/23/04 1515	ND			ND			573.9	0.997	Viacom	ND		
N4167	31		6/29/04 1440	ND			ND			573.3	1.73	Viacom	ND		
N4323	31		7/8/04 1400	ND			ND			573.8	0.800	Viacom	ND		
N4583	31		7/19/04 1115	ND			ND			573.2	1.07	Viacom	ND		
N5548	31		9/9/04 1304	ND			ND			573.4	1.89	Viacom	ND		
N5745	31		9/21/04 1425	ND			ND			573.1	3.25	Viacom	ND		
N6115	31		9/29/04 1300	ND			ND			573.3	3.05	Viacom	ND		
N7027	31		11/8/04 1022	ND			ND			575.0	0.687	Viacom	ND		
N7575	31		12/3/04 1442	ND			534.3	1.20	04-10	576.0	0.260	Viacom	ND		
N7588	31		12/7/04 1156	ND			534.0	0.463	04-10	576.6 (3)	0.201	Viacom	ND		
N7832	31		12/7/04 1300	ND			534.7	44.2	04-10	ND			ND		
N7833	31		12/7/04 1400	ND			534.7	75.3	04-10	ND			ND		
N7834	31		12/7/04 1500	ND			534.7	63.2	04-10	ND			ND		
N7835	31		12/7/04 1600	ND			534.8	54.8	04-10	ND			ND		
N7815	31		12/21/04 1510	ND			ND			574.6	1.32	Viacom	ND		
N8050	31		1/11/05 1228	ND			ND			576.8	0.301	Viacom	ND		
N8274	31		01/18/05 1702	ND			ND			574.4	0.459	Viacom	ND		
N9008	31		2/24/05 1328	ND			ND			575.4	0.636	Viacom	ND		
N9026	31		3/1/05 1328	ND			534.1	1.00	04-10	576.3	0.426	Viacom	ND		
N9525	31		3/16/05 1528	ND			ND			574.8	1.21	Viacom	ND		
N3545	**32**		**6/7/04 1430**	**ND**			**ND**			**ND**			**ND**		
N3546	**33**		**6/7/04 1440**	**ND**			**ND**			**ND**			**ND**		
N3684	33		6/14/04 1740	ND			ND			ND			ND		
N3793	33		6/17/04 1600	ND			ND			ND			ND		
N3948	33		6/24/04 1010	ND			ND			ND			ND		
N4168	33		6/30/04 0820	506.0 (3)	0.018	bkg	ND			ND			ND		
N4753	33		7/28/04 1545	ND			ND			ND			ND		
N4951	33		8/5/04 0840	ND			ND			ND			ND		
N5114	33		8/13/04 1510	ND			ND			ND			ND		
N3547	**34**		**6/7/04 1450**	**ND**			**ND**			**ND**			**ND**		
N3949	34		6/24/04 1020	ND			ND			ND			ND		
N5115	34		8/13/04 1515	ND			ND			ND			ND		
N3548	**35**		**6/7/04 1510**	**ND**			**ND**			**ND**			**ND**		
N3549	**36**		**6/7/04 1640**	**ND**			**ND**			**ND**			**ND**		
N3685	36		6/13/04 1615	ND			ND			ND			ND		
N3550	**37**		**6/7/04 1700**	**ND**			**ND**			**ND**			**ND**		
N3950	37		6/23/04 1740	ND			ND			ND			ND		
N3551	**38**		**6/7/04 1710**	**ND**			**ND**			**ND**			**ND**		
N3551R	38		6/7/04 1710	ND			ND			ND			ND		
N3794	38		6/17/04 1330	ND			ND			ND			ND		
N3951	38		6/23/04 1750	ND			ND			ND			ND		
N5431	38		9/1/04 1142	ND			ND			ND			ND		
N3552	**39**		**6/7/04 1745**	**ND**			**ND**			**ND**			**ND**		

OUL	Station	Station Name	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
Lab #	#		Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N3952	39		6/23/04 1530	ND			ND			ND			ND		
N6826	39		10/26/04 1125	ND			ND			ND			ND		
N7816	39		12/21/04 1520	ND			ND			ND			ND		
N8051	39		1/11/05 1240	ND			ND			ND			ND		
N3553	**40**		**6/7/04 1330**	**ND**			**ND**			**ND**			**ND**		
N3554	**41**		**6/8/04 1040**	**ND**			**ND**			**ND**			**ND**		
N4324	41		7/8/04 1440	ND			ND			ND			ND		
N4754	41		7/28/04 1340	507.3	0.946	bkg	ND			ND			ND		
N4952	41		8/4/04 1730	507.0	0.035	bkg	ND			ND			ND		
N5116	41		8/13/04 1300	ND			ND			ND			ND		
N6827	41		10/27/04 0813	ND			ND			ND			ND		
N3555	**42**		**6/8/04 1115**	**506.2 (3)**	**0.016**	**bkg**	**ND**			**ND**			**ND**		
N3686	42		6/13/04 1510	505.8 (3)	0.018	bkg	ND			ND			ND		
N3795	42		6/17/04 0915	506.2 (3)	0.019	bkg	ND			ND			ND		
N3953	42		6/23/04 1630	507.0	0.018	bkg	ND			ND			ND		
N4169	42		6/29/04 1425	507.8 (3)	0.017	bkg	ND			ND			ND		
N4325	42		7/8/04 1345	506.8 (3)	0.018	bkg	ND			ND			ND		
N4584	42		7/18/04 1410	507.4 (3)	0.016	bkg	ND			ND			ND		
N4755	42		7/28/04 1115	506.6 (3)	0.014	bkg	ND			ND			ND		
N4953	42		8/4/04 1525	ND			ND			ND			ND		
N5117	42		8/13/04 1150	506.4 (3)	0.015	bkg	ND			ND			ND		
N5432	42		8/31/04 1706	507.0	0.021	bkg	ND			ND			ND		
N6116	42		9/29/04 1142	ND			ND			ND			ND		
N3556	**43**		**6/8/04 1315**	**ND**			**ND**			**ND**			**ND**		
N3687	43		6/13/04 1645	ND			ND			ND			ND		
N3796	43		6/17/04 1415	ND			ND			ND			ND		
N3954	43		6/24/04 1220	ND			ND			ND			ND		
N4326	43		7/9/04 0845	ND			533.0	0.258	04-03	ND			ND		
N4585	43		7/18/04 1735	ND			ND			ND			ND		
N4756	43		7/28/04 1755	ND			ND			ND			ND		
N4954	43		8/5/04 1050	ND			ND			ND			ND		
N5118	43		8/13/04 0810	ND			ND			ND			ND		
N5549	43		9/9/04 1346	ND			ND			ND			ND		
N5746	43		9/21/04 1504	ND			ND			ND			ND		
N6117	43		9/29/04 1451	ND			ND			ND			ND		
N9009	43		2/25/05 1300	ND			ND			ND			ND		
P0190	43		4/7/05 1041	ND			ND			ND			ND		
N3557	**44**		**6/8/04 1415**	**ND**			**ND**			**ND**			**ND**		
N3688	44		6/13/04 1545	ND			ND			ND			ND		
N3797	44		6/16/04 2000	ND			531.9	0.135	IU	ND			ND		
N3955	44		6/23/04 1730	ND			533.5	11.3	IU	ND			ND		
N4170	44		6/29/04 1410	ND			532.2 (3)	0.066	IU	ND			ND		
N4327	44		7/8/04 1325	ND			ND			ND			ND		
N4586	44		7/18/04 1345	ND			ND			ND			ND		
N4757	44		7/28/04 1100	ND			ND			ND			ND		
N4955	44		8/4/04 1555	507.0 (3)	0.018	bkg	532.7	0.297	IU	ND			ND		
N5119	44		8/13/04 1135	ND			530.0 (3)	0.158	IU	ND			ND		
N5119R	44		8/13/04 1135	ND			530.4 (3)	0.167	IU	ND			ND		
N5433	44		8/31/04 1656	506.4(3)	0.012	bkg	531.6 (3)	0.113	IU	ND			ND		
N5550	44		9/9/04 1152	ND			ND			ND			ND		
N5747	44		9/21/04 1355	507.4	0.282	bkg	532.2	0.312	IU	ND			ND		
N6118	44		9/29/04 1125	ND			ND			ND			ND		
N6344	44		10/12/04 1700	508.0	0.085	bkg	532.6 (3)	0.145	IU	ND			ND		
N6828	44		10/26/04 1025	ND			ND			ND			ND		
N7254	44		11/17/04 1425	ND			ND			ND			ND		
N7576	44		12/3/04 1526	ND			ND			ND			ND		
N7817	44		12/21/04 1440	ND			ND			ND			ND		
N8275	44		01/18/05 1330	ND			534.0	0.094	IU	ND			ND		

OUL	Station	Station Name	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
Lab #	#		Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N3558	**45**		**6/8/04 1530**	**ND**			**ND**			**ND**			**ND**		
N3559	**46**		**6/8/04 1615**	**ND**			**ND**			**ND**			**ND**		
N3561	**47**		**6/8/04 1645**	**ND**			**ND**			**ND**			**ND**		
N3562	**48**		**6/9/04 0830**	**ND**			**ND**			**ND**			**ND**		
N7818	48		12/20/04 0948	ND			535.7	0.298	04-11	ND			ND		
N8052	48		1/5/05 1445	ND			ND			ND			ND		
N8053	48		1/10/05 1502	ND			ND			ND			ND		
N8276	48		01/18/05 1008	ND			ND			ND			ND		
N8747	48		2/11/05 0847	ND			ND			ND			ND		
N9010	48		2/25/05 0900	ND			ND			ND			ND		
N9027	48		3/1/05 1230	ND			ND			574.9	14.8	05-17	ND		
N9531	48		3/16/05 1102	ND			ND			ND			ND		
N9814	48		3/23/05 1720	ND			533.4	0.123	04-11	576.4 (3)	0.329	05-17	ND		
N9841	48		3/31/05 0902	ND			533.4	0.078	04-11	ND			ND		
N3563	**49**		**6/9/04 0850**	**ND**			**ND**			**ND**			**ND**		
N3564	**50**		**6/9/04 0915**	**ND**			**ND**			**ND**			**ND**		
N6145	50		10/5/04 0955	ND			ND			ND			ND		
N3565	**51**		**6/9/04 1010**	**ND**			**ND**			**ND**			**ND**		
N4956	51		8/4/04 0945	ND			ND			ND			ND		
N5121	51		8/13/04 0755	ND			ND			ND			ND		
N6829	51		10/25/04 1125	ND			ND			ND			ND		
N7577	51		12/6/04 0917	ND			ND			ND			ND		
N3566	**52**		**6/9/04 1030**	**ND**			**ND**			**ND**			**ND**		
N3798	52		6/16/04 0945	ND			ND			574.1	5.39	04-02	ND		
N3956	52		6/23/04 0905	ND			ND			574.1	1.77	04-02	ND		
N4171	52		6/29/04 0930	ND			ND			576.4 (3)	0.114	04-02	ND		
N4328	52		7/8/04 0855	ND			ND			575.2	0.219	04-02	ND		
N4587	52		7/18/04 0845	ND			ND			ND			ND		
N4758	52		7/27/04 1615	ND			534.0	110	04-04	ND			ND		
N4957	52		8/4/04 0950	ND			534.1	4.02	04-04	ND			ND		
N5122	52		8/13/04 0800	ND			533.9	2.63	04-04	ND			ND		
N5434	52		8/31/04 0937	ND			534.2	1.39	04-04	ND			ND		
N5551	52		9/9/04 0905	ND			534.2	0.937	04-04	ND			ND		
N5748	52		9/21/04 0912	ND			533.7	0.566	04-04	ND			ND		
N6119	52		9/28/04 1108	ND			533.9	0.737	04-04	ND			ND		
N6119R	52		9/28/04 1108	ND			533.9	0.723	04-04	ND			ND		
N6146	52		10/5/04 0935	ND			533.7	0.699	04-04	ND			ND		
N6345	52		10/12/04 1100	ND			534.3	0.749	04-04	ND			ND		
N6830	52		10/25/04 1120	ND			533.7	0.494	04-04	ND			ND		
N7028	52		11/8/04 1138	ND			535.8	0.176	04-04	ND			ND		
N7255	52		11/17/04 1035	ND			535.2 (3)	0.075	04-04	ND			ND		
N7578	52		12/6/04 0912	ND			535.1	0.843	04-04	ND			ND		
N7819	52		12/21/04 1222	ND			535.4	0.137	04-04	ND			ND		
N7819R	52		12/21/04 1222	ND			535.8 (3)	0.087	04-04	ND			ND		
N8054	52		1/10/05 1535	ND			ND			ND			ND		
N8277	52		01/18/05 1050	ND			ND			ND			ND		
N3567	**53**		**6/9/04 1200**	**ND**			**ND**			**ND**			**ND**		
N5435	53		8/31/04 1400	ND			ND			ND			ND		
N7821	53		12/21/04 1414	ND			ND			ND			ND		
N3568	**54**		**6/9/04 1545**	**ND**			**ND**			**ND**			**ND**		
N3799	54		6/17/04 1210	ND			532.6	0.088	04-01	ND			ND		
N3957	54		6/23/04 1140	ND			ND			ND			ND		
N4958	54		8/4/04 1220	ND			ND			574.2	0.288	04-05	ND		
N4958R	54		8/4/04 1220	ND			ND			575.2	0.308	04-05	ND		
N5123	54		8/13/04 0930	ND			ND			575.0	0.246	04-05	ND		
N5436	54		8/31/04 1350	ND			ND			ND			ND		
N5552	54		9/9/04 1042	ND			ND			573.7	1.17	04-06	ND		
N5749	54		9/21/04 1230	ND			ND			574.5	0.349	04-06	ND		

OUL	Station	Station Name	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
Lab #	#		Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N6121	54		9/29/04 0900	ND			ND			574.2	0.231	04-06	ND		
N6147	54		10/5/04 1223	ND			ND			576.3	0.108	04-06	ND		
N6831	54		10/25/04 1658	ND			ND			ND			ND		
N8278	54		01/18/05 1132	ND			ND			ND			ND		
N3569	**55**		**6/9/04 1645**	**ND**			**ND**			**ND**			**ND**		
N7256	55		11/17/04 1230	ND			ND			ND			ND		
N3570	**56**		**6/10/04 0845**	**ND**			**ND**			**ND**			**ND**		
N3571	**57**		**6/10/04 0915**	**ND**			**ND**			**ND**			**ND**		
N3572	**58**		**6/10/04 1045**	**ND**			**ND**			**ND**			**ND**		
N3573	**59**		**6/10/04 1150**	**ND**			**ND**			**ND**			**ND**		
N5437	59		8/31/04 1422	ND			ND			ND			ND		
N3574	**60**		**6/10/04 1350**	**ND**			**ND**			**ND**			**ND**		
N3575	**61**		**6/10/04 1440**	**ND**			**ND**			**ND**			**ND**		
N3689	61		6/13/04 1830	ND			ND			ND			ND		
N4959	61		8/4/04 1655	ND			ND			ND			ND		
N3576	**62**		**6/10/04 1625**	**ND**			**ND**			**ND**			**ND**		
N3577	**63**		**6/10/04 1705**	**ND**			**ND**			**ND**			**ND**		
N3577R	63		6/10/04 1705	ND			ND			ND			ND		
N8455	63		2/1/05 1730	ND			ND			ND			ND		
N3578	**64**		**6/10/04 1730**	**ND**			**ND**			**ND**			**ND**		
N8055	64		1/10/05 1225	ND			ND			ND			ND		
N3690	**65**		**6/15/04 1330**	**ND**			**ND**			**ND**			**ND**		
N3801	**66**		**6/17/04 1020**	**ND**			**ND**			**ND**			**ND**		
N3802	**67**		**6/18/04 0830**	**ND**			**ND**			**ND**			**ND**		
N6148	67		10/5/04 1110	ND			ND			ND			ND		
N7822	67		12/21/04 1335	ND			535.0	0.156	04-11	ND			ND		
N8056	67		1/10/05 1705	ND			ND			ND			ND		
N8279	67		01/18/05 1120	ND			ND			ND			ND		
N8279R	67		01/18/05 1120	ND			ND			ND			ND		
N9011	67		2/25/05 1025	ND			ND			ND			ND		
N9815	67		3/23/05 1635	ND			534.5	0.953	05-18	ND			ND		
N9842	67		3/31/05 1617	ND			ND			ND			ND		
P0717	67		4/8/05 1017	ND			ND			ND			ND		
N3803	**68**		**6/18/04 0900**	**ND**			**ND**			**575.3**	**0.287**	**04-02**	**ND**		
N3958	68		6/23/04 1040	ND			ND			ND			ND		
N4172	68		6/29/04 1050	ND			ND			ND			ND		
N4329	68		7/8/04 1000	ND			ND			ND			ND		
N4759	68		7/27/04 1845	ND			534.1	1.93	04-04	ND			ND		
N4961	68		8/4/04 1130	ND			ND			ND			ND		
N5124	68		8/13/04 0650	ND			ND			ND			ND		
N5438	68		8/31/04 1155	ND			ND			ND			ND		
N5750	68		9/21/04 1035	ND			ND			ND			ND		
N4173	**70**		**6/30/04 1630**	**ND**			**ND**			**ND**			**ND**		
N5125	70		8/13/04 1105	ND			ND			ND			ND		
N5439	70		8/31/04 1615	ND			ND			573.7	27.8	04-06	ND		
N5439R	70		8/31/04 1615	ND			ND			573.6	27.7	04-06	ND		
N5751	70		9/21/04 1315	ND			ND			573.5	1.97	04-06	ND		
N6122	70		9/29/04 1107	ND			ND			573.9	0.863	04-06	ND		
N6149	70		10/5/04 1506	ND			ND			573.6	0.684	04-06	ND		
N6832	70		10/26/04 0940	ND			ND			575.4	0.069	04-06	ND		
N8057	70		1/11/05 1150	ND			ND			ND			ND		
N4174	**71**		**6/30/04 1645**	**ND**			**ND**			**ND**			**ND**		
N4588	71		7/18/04 1240	ND			ND			ND			ND		
N6123	71		9/29/04 1049	ND			ND			ND			ND		
N5126	**72**		**8/13/04 1100**	**506.6 (3)**	**0.011**	**bkg**	**ND**			**ND**			**ND**		
N5441	72		8/31/04 1558	ND			ND			ND			ND		
N5752	72		9/21/04 1305	507.3	0.020	bkg	ND			ND			ND		
N6124	72		9/29/04 1056	ND			ND			ND			ND		

OUL	Station	Station Name	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
Lab #	#		Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N6346	72		10/12/04 1505	507.2	0.032	bkg	ND			ND			ND		
N6833	72		10/26/04 0925	507.0 (3)	0.011	bkg	ND			ND			ND		
N7823	**73**		**12/21/04 1317**	**ND**			**536.6 (3)**	**0.093**	**04-11**	**ND**			**ND**		
N8058	73		1/10/05 1640	ND			ND			ND			ND		
N9012	73		2/25/05 0955	ND			ND			ND			ND		
N9816	73		3/23/05 1608	ND			534.9	0.513	05-18	ND			ND		
N9843	73		3/31/05 1458	ND			ND			ND			ND		
P0718	73		4/8/05 1024	ND			ND			ND			ND		
N6834	**74**		**10/25/04 1505**	**ND**			**ND**			**573.2**	**0.214**	**04-08**	**ND**		
N7029	74		11/8/04 1420	ND			ND			ND			ND		
N7257	74		11/17/04 1110	ND			ND			ND			ND		
N7579	74		12/6/04 1055	ND			ND			ND			ND		
N7579D	74		12/6/04 1055	ND			ND			ND			ND		
N7824	74		12/21/04 1324	ND			ND			ND			ND		
N8059	74		1/10/05 1650	ND			ND			573.8 (3)	0.086	04-08	ND		
N8059D	74		1/10/05 1650	ND			ND			ND			ND		
N8281	74		01/17/05 1730	ND			ND			ND			ND		
N9013	74		2/25/05 1015	ND			ND			ND			ND		
N9532	74		3/16/05 1153	ND			ND			ND			ND		
N9844	74		3/31/05 1519	ND			ND			ND			ND		
P0719	74		4/8/05 1050	ND			ND			ND			ND		
P0719R	74		4/8/05 1050	ND			ND			ND			ND		
N4761	**75**		**7/27/04 1855**	**ND**			**ND**			**ND**			**ND**		
N4962	75		8/4/04 1040	508	0.015	bkg	ND			ND			ND		
N5127	75		8/13/04 0845	ND			ND			ND			ND		
N5442	75		8/31/04 1215	ND			ND			ND			ND		
N5753	75		9/21/04 1110	ND			ND			ND			ND		
N7030	75		11/8/04 1353	ND			ND			ND			ND		
N7258	75		11/17/04 1150	ND			ND			ND			ND		
N7581	75		12/6/04 1030	ND			ND			ND			ND		
N7825	75		12/21/04 1300	ND			534.8	0.365	04-11	ND			ND		
N8061	75		1/10/05 1615	ND			532.8	0.093	04-11	ND			ND		
N8282	75		01/17/05 1747	ND			ND			ND			ND		
N9014	75		2/25/05 1100	ND			ND			ND			ND		
N9817	75		3/23/05 1500	ND			534.5	6.55	05-18	ND			ND		
N9845	75		3/31/05 1136	ND			534.6	0.380	05-18	ND			ND		
P0721	75		4/8/05 0839	ND			534.8	0.688	05-18	ND			ND		
N4762	**76**		**7/27/04 1910**	**508.8**	**0.037**	bkg	**ND**			**ND**			**ND**		
N4963	76		8/4/04 1035	508.8	0.041	bkg	ND			ND			ND		
N5128	76		8/13/04 0840	508.0	0.054	bkg	ND			ND			ND		
N5443	76		8/31/04 1208	507.4	0.031	bkg	ND			ND			ND		
N5754	76		9/21/04 1102	507.8	0.049	bkg	ND			ND			ND		
N6125	76		9/28/04 1505	508.6	0.029	bkg	ND			ND			ND		
N6150	76		10/5/04 1136	ND			ND			ND			ND		
N6835	76		10/25/04 1412	507.0	0.023	bkg	ND			ND			ND		
N7031	76		11/8/04 1400	ND			ND			ND			ND		
N7259	76		11/17/04 1140	ND			ND			ND			ND		
N7259R	76		11/17/04 1140	ND			ND			ND			ND		
N7582	76		12/6/04 1035	ND			ND			ND			ND		
N7826	76		12/21/04 1305	ND			534.6	0.546	04-11	ND			ND		
N8062	76		1/10/05 1622	ND			535.4	0.186	04-11	ND			ND		
N8283	76		01/17/05 1755	ND			533.2 (3)	0.083	04-11	ND			ND		
N9015	76		2/25/05 1040	ND			ND			ND			ND		
N9533	76		3/16/05 1137	ND			ND			ND			ND		
N9818	76		3/23/05 1514	ND			534.5	8.14	05-18	ND			ND		
N9846	76		3/31/05 1030	ND			534.2	0.641	05-18	ND			ND		
P0722	76		4/8/05 0814	ND			534.5	1.14	05-18	ND			ND		
N5450	**78**		**8/24/04 1712**	**ND**			**ND**			**ND**			**ND**		

OUL	Station	Station Name	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
Lab #	#		Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N5444	78		8/30/04 1137	ND			ND			ND			ND		
N5445	78		8/30/04 1611	ND			ND			ND			ND		
N5446	78		9/2/04 0931	ND			533.2	0.044	04-01	ND			ND		
N5553	78		9/9/04 1112	ND			532.4	0.067	04-01	ND			ND		
N5755	78		9/21/04 1335	ND			530.8 (3)	0.066	04-01	ND			ND		
N6126	78		9/29/04 1735	ND			532.8	0.050	04-01	ND			ND		
N6151	78		10/5/04 1357	ND			531.2 (3)	0.052	04-01	ND			ND		
N6347	78		10/12/04 1520	ND			531.4 (3)	0.013	04-01	ND			ND		
N6836	78		10/25/04 0958	ND			ND			ND			ND		
N7032	78		11/8/04 1058	ND			ND			ND			ND		
N7261	78		11/17/04 1315	ND			ND			ND			ND		
N7583	78		12/6/04 1138	ND			ND			ND			ND		
N8284	78		01/17/05 1605	ND			ND			ND			ND		
N5451	**79**		**8/24/04 1725**	**ND**			**ND**			**ND**			**ND**		
N5447	79		8/30/04 1141	ND			ND			ND			ND		
N5448	79		8/30/04 1612	ND			ND			573.8	1,820	04-06	ND		
N5449	79		9/2/04 0935	ND			ND			573.9	2.33	04-06	ND		
N5554	79		9/9/04 1115	ND			ND			575.3	0.163	04-06	ND		
N5756	79		9/21/04 1340	ND			ND			574.4	0.127	04-06	ND		
N6127	79		9/29/04 1740	508.8	0.019	bkg	ND			574.6	0.118	04-06	ND		
N6152	79		10/5/04 1400	ND			ND			ND			ND		
N6348	79		10/12/04 1530	ND			ND			ND			ND		
N6837	79		10/25/04 1002	508.8	0.022	bkg	ND			ND			ND		
N7033	79		11/8/04 1103	ND			ND			ND			ND		
N7262	79		11/17/04 1310	ND			ND			ND			ND		
N7584	79		12/6/04 1144	ND			ND			ND			ND		
N8285	79		01/17/05 1610	ND			ND			ND			ND		
N5555	**80**		**9/9/04 1010**	**ND**			**ND**			**574.1**	**0.477**	04-06	**ND**		
N5757	80		9/21/04 1055	ND			ND			574.7	0.088	04-06	ND		
N6128	80		9/28/04 1619	ND			ND			ND			ND		
N6838	80		10/25/04 1625	ND			ND			ND			ND		
N8286	80		01/17/05 1645	ND			ND			ND			ND		
N5556	**81**		**9/9/04 0955**	**ND**			**ND**			**ND**			**ND**		
N5758	81		9/21/04 1043	ND			ND			ND			579.9	1.20	bkg
N6129	81		9/28/04 1455	ND			ND			ND			581.6 (3)	0.115	bkg
N6839	81		10/25/04 1540	ND			ND			ND			ND		
N8287	81		01/17/05 1635	ND			ND			ND			ND		
N6130	**83**		**9/28/04 0955**	**507.9**	**0.462**	**04-07**	**ND**			**ND**			**ND**		
N6153	83		10/5/04 1021	507.3	0.300	04-07	ND			ND			ND		
N6349	83		10/12/04 1020	507.7	0.195	04-07	ND			ND			ND		
N6841	83		10/25/04 1220	508.2	0.060	04-07	ND			ND			ND		
N6841R	83		10/25/04 1220	507.4	0.061	04-07	ND			ND			ND		
N7034	83		11/8/04 1330	509.4	0.026	04-07	ND			ND			ND		
N7263	83		11/17/04 0940	510.4 (3)	0.021	04-07	ND			ND			ND		
N7585	83		12/6/04 1000	ND			ND			ND			ND		
N7827	83		12/20/04 0953	ND			ND			ND			ND		
N8063	83		1/10/05 1507	ND			ND			ND			ND		
N8748	83		2/11/05 0852	ND			ND			ND			ND		
N9016	83		2/25/05 0905	ND			ND			ND			ND		
N9028	83		3/1/05 1236	ND			ND			ND			ND		
N9534	83		3/16/05 1107	ND			ND			ND			ND		
N9819	83		3/23/05 1728	ND			ND			ND			ND		
N9819R	83		3/23/05 1728	ND			ND			ND			ND		
N9847	83		3/31/05 0942	ND			ND			ND			ND		
P0723	83		4/8/05 0928	ND			ND			ND			ND		
N6131	**84**		**9/28/04 1035**	**507.8**	**2.42**	04-07	**ND**			**ND**			**ND**		
N6154	84		10/5/04 1030	507.4	1.33	04-07	ND			ND			ND		
N6350	84		10/12/04 1030	507.8	1.07	04-07	ND			ND			ND		

OUL	Station	Station Name	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
Lab #	#		Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N6842	84		10/25/04 1233	507.9	0.244	04-07	ND			ND			ND		
N7035	84		11/8/04 1340	508.2	0.108	04-07	ND			ND			ND		
N7264	84		11/17/04 0950	509.3	0.102	04-07	ND			ND			ND		
N7586	84		12/6/04 1007	509.2	0.045	04-07	ND			ND			ND		
N7828	84		12/20/04 0958	508.0	0.061	04-07	ND			ND			ND		
N8064	84		1/10/05 1513	509.2	0.027	04-07	ND			ND			ND		
N8288	84		01/18/05 1017	509.4	0.030	04-07	ND			ND			ND		
N8749	84		2/11/05 0858	509.0	0.023	04-07	ND			ND			ND		
N9017	84		2/25/05 0915	508.0 (3)	0.017	04-07	ND			ND			ND		
N9029	84		3/1/05 1242	508.6 (3)	0.021	04-07	ND			ND			ND		
N9535	84		3/16/05 1113	508.6	0.025	04-07	ND			ND			ND		
N9821	84		3/23/05 1736	509.4 (3)	0.036	04-07	ND			ND			ND		
N9848	84		3/31/05 0953	ND			ND			ND			ND		
P0724	84		4/8/05 0914	ND			ND			ND			ND		
N6132	**85**		**9/28/04 1145**	**508.7**	**0.110**	04-07	**532.5**	**0.210**	**04-04**	**ND**			**ND**		
N6155	85		10/5/04 1024	ND			532.7	0.307	04-04	ND			ND		
N6351	85		10/12/04 1010	509.8	0.069	04-07	532.1	0.245	04-04	ND			ND		
N6843	85		10/25/04 1225	508.6	0.028	04-07	533.4	0.087	04-04	ND			ND		
N6133	**86**		**9/28/04 1335**	**508.4**	**0.061**	04-07	**533.2 (3)**	**0.033**	**04-04**	**ND**			**ND**		
N6156	86		10/5/04 1045	507.9	0.033	04-07	533.8 (3)	0.035	04-04	ND			ND		
N6352	86		10/12/04 1200	509.2	0.039	04-07	533.0	0.053	04-04	ND			ND		
N6844	86		10/25/04 1435	507.2	0.014	04-07	ND			ND			ND		
N6134	**87**		**9/29/04 1512**	**ND**			**ND**			**ND**			**ND**		
N6157	87		10/6/04 0915	ND			ND			573.0	25.8	04-09	ND		
N6353	87		10/14/04 0840	ND			ND			573.7	5.95	04-09	ND		
N6845	87		10/27/04 1437	ND			ND			575.2	0.105	04-09	ND		
N7036	87		11/8/04 1555	ND			ND			ND			ND		
N7265	87		11/17/04 1500	ND			ND			ND			ND		
N7829	87		12/21/04 1613	ND			ND			ND			ND		
N8289	87		01/14/05 1115	508.8	0.038	05-14	ND			ND			ND		
N8477	87		1/21/05 0822	ND			ND			ND			ND		
N8750	87		2/11/05 1003	ND			ND			ND			ND		
N9526	87		3/16/05 1250	ND			ND			ND			ND		
P0191	87		4/7/05 1009	ND			536.8	0.063	05-24	ND			ND		
P0708	87		4/14/05 1518	ND			ND			ND			ND		
P0765	87		4/20/05 1729	ND			ND			ND			ND		
N6158	**88**		**10/6/04 1015**	**ND**			**ND**			**ND**			**ND**		
N8065	88		1/5/05 1005	ND			ND			ND			ND		
N8290	88		01/14/05 1055	509.0	2.09	05-14	ND			ND			ND		
N8478	88		1/21/05 0810	509.9	0.087	05-14	ND			ND			ND		
N8751	88		2/11/05 0925	508.3	0.082	05-14	ND			ND			ND		
N9527	88		3/16/05 1304	ND			ND			ND			ND		
N9793	88		3/29/05 1536	508.0	0.070	05-14	ND			ND			ND		
P0709	88		4/15/05 0744	ND			ND			ND			ND		
N6159	**89**		**10/6/04 1025**	**ND**			**ND**			**573.0**	**14.2**	04-09	**ND**		
N6159R	89		10/6/04 1025	ND			ND			573.0	14.1	04-09	ND		
N6354	89		10/14/04 0910	ND			ND			573.6	4.45	04-09	ND		
N6354R	89		10/14/04 0910	ND			ND			573.3	3.66	04-09	ND		
N6846	89		10/27/04 1450	ND			ND			577.2 (3)	0.053	04-09	ND		
P0192	89		4/7/05 1020	ND			537.4 (3)	0.037	05-24	ND			ND		
P0710	89		4/15/05 0933	ND			ND			ND			ND		
P0766	89		4/20/05 1753	ND			ND			ND			ND		
N7037	**90**		**11/8/04 1425**	**ND**			**ND**			**ND**			**ND**		
N7830	90		12/21/04 1327	ND			534.8	0.249	04-11	ND			ND		
N8066	90		1/10/05 1655	ND			ND			ND			ND		
N8291	90		01/17/05 1735	ND			ND			ND			ND		
N9018	90		2/25/05 1005	ND			ND			ND			ND		
N9822	90		3/23/05 1621	ND			534.7	1.79	05-18	ND			ND		

OUL	Station	Station Name	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
Lab #	#		Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N9849	90		3/31/05 1528	ND			ND			ND			ND		
P0725	90		4/8/05 1044	ND			535.4	0.105	05-18	ND			ND		
N7831	**91**		**12/21/04 1630**	**ND**			**ND**			**ND**			**ND**		
N8292	91		01/14/05 1100	509.2	0.142	05-14	ND			ND			ND		
N8479	91		1/21/05 0815	ND			ND			ND			ND		
N8752	91		2/11/05 0930	509.1	0.028	05-14	ND			ND			ND		
N9528	91		3/16/05 1307	ND			ND			ND			ND		
N9794	91		3/29/05 1540	ND			ND			ND			ND		
P0711	91		4/15/05 0748	ND			ND			ND			ND		
N8067	**92**		**1/7/05 0905**	**ND**			**ND**			**ND**			**ND**		
N8068	**93**		**1/7/05 0918**	**ND**			**ND**			**ND**			**ND**		
N8069	**94**		**1/7/05 0930**	**ND**			**ND**			**ND**			**ND**		
N8753	94		2/9/05 1140	ND			ND			574.9	41.8	05-16	ND		
N9021	94		2/25/05 1038	ND			ND			574.6	4.22	05-16	ND		
N9537	94		3/22/05 1450	ND			ND			574.7	3.50	05-16	ND		
P0175	94		4/5/05 1425	ND			ND			575.5	0.777	05-16	ND		
P0726	94		4/13/05 1348	ND			ND			574.8	0.927	05-16	ND		
P0754	94		4/19/05 1651	ND			ND			575.0	1.74	05-16	ND		
N8070	**95**		**1/7/05 0942**	**ND**			**ND**			**ND**			**ND**		
N8071	**96**		**1/7/05 1008**	**ND**			**ND**			**ND**			**ND**		
N8072	**97**		**1/7/05 1040**	**ND**			**ND**			**ND**			**ND**		
N9538	97		3/17/05 1140	ND			ND			ND			ND		
N9530	97		3/22/05 1526	ND			ND			ND			ND		
N8073	**98**		**1/7/05 1128**	**ND**			**ND**			**ND**			**ND**		
N8074	**99**		**1/7/05 1148**	**ND**			**ND**			**ND**			**ND**		
N8075	**100**		**1/7/05 1203**	**ND**			**ND**			**ND**			**ND**		
N8076	**101**		**1/7/05 1405**	**ND**			**ND**			**ND**			**ND**		
N8077	**102**		**1/7/05 1415**	**ND**			**ND**			**ND**			**ND**		
N9804	102		3/29/05 1144	ND			534.4	11.7	05-19	ND			ND		
P0176	102		4/4/05 1658	ND			534.5	18.1	05-19	574.7	16.7	05-23	ND		
P0727	102		4/13/05 1851	ND			534.2	9.42	05-19	575.2	3.73	05-23	ND		
P0755	102		4/20/05 1044	ND			534.8	7.15	05-19	575.1	1.27	05-23	ND		
N8078	**103**		**1/7/05 1430**	**507.8 (3)**	**0.011**	**bkg**	**ND**			**ND**			**ND**		
N8293	103		01/19/05 1445	ND			ND			ND			ND		
N8754	103		2/9/05 1513	508.2 (3)	0.016	bkg	ND			ND			ND		
N9805	103		3/29/05 1134	ND			ND			ND			ND		
P0177	103		4/4/05 1722	ND			ND			ND			ND		
P0728	103		4/13/05 1832	506.4 (3)	0.022	bkg	ND			ND			ND		
P0756	103		4/20/05 1031	508.8	0.029	bkg	ND			ND			ND		
N8079	**104**		**1/7/05 1440**	**ND**			**ND**			**ND**			**ND**		
N8079D	104		1/7/05 1440	ND			ND			ND			ND		
N8294	104		01/19/05 1440	ND			ND			ND			ND		
N8755	104		2/9/05 1508	ND			ND			ND			ND		
P0729	104		4/13/05 1822	ND			ND			ND			ND		
N8081	**105**		**1/7/05 1523**	**ND**			**ND**			**ND**			**ND**		
N8082	**106**		**1/7/05 1540**	**ND**			**ND**			**ND**			**ND**		
N8756	106		2/9/05 1218	ND			ND			ND			ND		
N8083	**107**		**1/9/05 1158**	**ND**			**ND**			**ND**			**ND**		
N8084	**108**		**1/9/05 1315**	**ND**			**ND**			**ND**			**ND**		
N9806	108		3/24/05 1700	ND			ND			ND			ND		
N8085	**109**		**1/9/05 1332**	**ND**			**ND**			**ND**			**ND**		
N8295	109		01/19/05 1110	ND			ND			ND			ND		
N8757	109		2/9/05 1006	ND			ND			ND			ND		
N9807	109		3/24/05 1712	ND			ND			ND			ND		
P0178	109		4/6/05 1537	ND			ND			ND			ND		
P0730	109		4/13/05 1558	ND			ND			ND			ND		
N8086	**110**		**1/9/05 1353**	**ND**			**ND**			**ND**			**ND**		
N8087	**111**		**1/9/05 1450**	**ND**			**ND**			**ND**			**ND**		

OUL	Station	Station Name	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
Lab #	#		Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N8088	**112**		**1/9/05 1545**	**ND**			**ND**			**ND**			**ND**		
N8089	**113**		**1/9/05 1605**	**ND**			**ND**			**ND**			**ND**		
N8090	**114**		**1/9/05 1610**	**ND**			**ND**			**ND**			**ND**		
N8091	**115**		**1/9/05 1625**	**ND**			**ND**			**ND**			**ND**		
N8092	**116**		**1/9/05 1635**	**ND**			**ND**			**ND**			**ND**		
N8296	**117**		**01/13/05 1345**	**ND**			**ND**			**ND**			**ND**		
N8297	**118**		**01/14/05 1605**	**ND**			**ND**			**ND**			**ND**		
N8758	118		2/9/05 1415	ND			ND			ND			ND		
N8481	**119**		**1/20/05 1050**	**ND**			**ND**			**ND**			**ND**		
N8482	**120**		**1/20/05 1107**	**ND**			**ND**			**ND**			**ND**		
N8482R	120		1/20/05 1107	ND			ND			ND			ND		
N8483	**121**		**1/20/05 1126**	**ND**			**ND**			**ND**			**ND**		
N8456	**122**		**2/1/05 1741**	**ND**			**ND**			**ND**			**ND**		
N8457	**123**		**2/2/05 1615**	**ND**			**ND**			**ND**			**ND**		
N8458	**124**		**2/2/05 1805**	**ND**			**ND**			**ND**			**ND**		
N8459	**125**		**2/2/05 1815**	**ND**			**ND**			**ND**			**ND**		
N8461	**126**		**2/3/05 0835**	**ND**			**ND**			**ND**			**ND**		
N8461R	126		2/3/05 0835	ND			ND			ND			ND		
N8759	126		2/9/05 1645	508.4	2.87	05-15	ND			ND			ND		
N9539	126		3/17/05 1034	508.8	0.193	05-15	ND			ND			ND		
N9539R	126		3/17/05 1034	508.0	0.197	05-15	ND			ND			ND		
N9808	126		3/24/05 1612	508.8	0.065	05-15	ND			ND			ND		
P0179	126		4/5/05 1238	508.4 (3)	0.015	05-15	536.1	0.115	05-22	ND			ND		
P0179R	126		4/5/05 1238	508.2 (3)	0.013	05-15	537.0	0.084	05-22	ND			ND		
P0731	126		4/12/05 1447	509.4	0.076	05-15	534.0	0.130	05-22	ND			ND		
P0757	126		4/19/05 1331	508.8	0.026	05-15	ND			ND			ND		
N8462	**127**		**2/3/05 0850**	**ND**			**ND**			**ND**			**ND**		
N8761	127		2/9/05 1652	ND			ND			ND			ND		
N8463	**128**		**2/3/05 0905**	**ND**			**ND**			**ND**			**ND**		
N8475	128		2/5/05 1043	509.0	0.038	05-15	ND			ND			ND		
N8762	128		2/9/05 1702	508.7	0.247	05-15	ND			ND			ND		
N9541	128		3/17/05 1100	508.4	0.022	05-15	ND			ND			ND		
N9809	128		3/24/05 1631	ND			ND			ND			ND		
P0181	128		4/5/05 1211	ND			ND			ND			ND		
P0732	128		4/12/05 1425	ND			ND			ND			ND		
P0758	128		4/19/05 1311	ND			ND			ND			ND		
N8464	**129**		**2/3/05 0918**	**ND**			**ND**			**ND**			**ND**		
N8763	129		2/9/05 1708	ND			ND			ND			ND		
N8465	**130**		**2/3/05 0945**	**ND**			**ND**			**ND**			**ND**		
N8466	**131**		**2/3/05 1000**	**ND**			**ND**			**ND**			**ND**		
N9810	131		3/29/05 1407	ND			ND			ND			ND		
P0182	131		4/4/05 1833	ND			ND			575.4	0.830	05-23	ND		
P0733	131		4/12/05 1309	ND			535.2	0.214	05-19	ND			ND		
P0759	131		4/19/05 1736	ND			ND			ND			ND		
P0759R	131		4/19/05 1736	ND			ND			ND			ND		
N8467	**132**		**2/3/05 1022**	**ND**			**ND**			**ND**			**ND**		
N8764	132		2/9/05 1553	ND			ND			574.4	3.18	05-16	ND		
N9542	132		3/17/05 1120	ND			ND			ND			ND		
N9811	132		3/29/05 1443	ND			ND			578.4 (3)	0.194	05-16	ND		
P0183	132		4/4/05 1819	ND			ND			ND			ND		
P0734	132		4/12/05 1256	ND			ND			ND			ND		
P0761	132		4/19/05 1705	ND			ND			ND			ND		
N8468	**133**		**2/3/05 1040**	**ND**			**ND**			**ND**			**ND**		
N8469	**134**		**2/3/05 1155**	**ND**			**ND**			**ND**			**ND**		
N8470	**135**		**2/3/05 1215**	**ND**			**ND**			**ND**			**ND**		
P0184	135		4/5/05 1845	ND			534.5	22.2	05-22	ND			ND		
P0735	135		4/12/05 1709	ND			534.5	6.29	05-22	ND			ND		
P0762	135		4/19/05 1457	ND			534.5	4.52	05-22	ND			ND		

OUL	Station	Station Name	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
Lab #	#		Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
N8471	**136**		**2/4/05 0948**	**ND**			**ND**			**ND**			**ND**		
N8472	**137**		**2/4/05 1008**	**508.9**	**1,850**	**05-15**	**ND**			**ND**			**ND**		
N8765	137		2/10/05 1102	508.5	14.0	05-15	ND			ND			ND		
N8765V	137		2/10/05 1102	508.7	13.9	05-15	ND			ND			ND		
N9543	137		3/17/05 1012	508.8	1.20	05-15	ND			ND			ND		
P0185	137		4/5/05 1859	509.1	0.433	05-15	ND			ND			ND		
P0736	137		4/12/05 1733	508.7	0.537	05-15	ND			ND			ND		
N8473	**138**		**2/4/05 1240**	**ND**			**ND**			**ND**			**ND**		
N8766	138		2/10/05 0948	ND			ND			ND			ND		
N8474	**139**		**2/4/05 1335**	**ND**			**ND**			**ND**			**ND**		
N8767	139		2/10/05 1013	ND			ND			ND			ND		
N9812	139		3/24/05 1040	ND			ND			ND			ND		
P0186	139		4/6/05 1129	ND			ND			ND			ND		
N8768	**140**		**2/11/05 0948**	**ND**			**ND**			**ND**			**ND**		
N8769	**141**		**2/11/05 1025**	**ND**			**ND**			**ND**			**ND**		
N8770	**142**		**2/11/05 1103**	**ND**			**ND**			**ND**			**ND**		
N8771	**143**		**2/11/05 1120**	**ND**			**ND**			**ND**			**ND**		
N8772	**144**		**2/11/05 1144**	**ND**			**ND**			**ND**			**ND**		
N9019	**145**		**2/25/05 1050**	**ND**			**ND**			**ND**			**ND**		
N9019R	145		2/25/05 1050	ND			ND			ND			ND		
N9022	**146**		**2/25/05 1108**	**ND**			**ND**			**ND**			**ND**		
N9023	**147**		**2/25/05 1120**	**ND**			**ND**			**ND**			**ND**		
N9024	**148**		**2/25/05 1145**	**ND**			**ND**			**ND**			**ND**		
N9813	148		3/23/05 1411	ND			ND			ND			ND		
P0187	148		4/5/05 1022	ND			ND			574.6	32.3	05-20	ND		
P0737	148		4/13/05 1248	ND			ND			ND			ND		
P0763	148		4/20/05 1141	ND			ND			574.2	8.27	05-20	ND		
N9025	**149**		**2/25/05 1200**	**ND**			**ND**			**ND**			**ND**		
N9536	**150**		**3/15/05 1730**	**ND**			**ND**			**ND**			**ND**		
N9529	**151**		**3/16/05 1635**	**ND**			**ND**			**ND**			**ND**		
P0188	151		4/4/05 1315	ND			ND			ND			ND		
N9823	**152**		**3/23/05 0920**	**ND**			**ND**			**ND**			**ND**		
N9544	**153**		**3/16/05 0850**	**ND**			**ND**			**ND**			**ND**		
N9545	**154**		**3/16/05 0920**	**ND**			**ND**			**ND**			**ND**		
N9546	**155**		**3/16/05 0930**	**ND**			**ND**			**ND**			**ND**		
N9547	**156**		**3/16/05 1020**	**ND**			**ND**			**ND**			**ND**		
N9548	**157**		**3/16/05 1050**	**ND**			**ND**			**ND**			**ND**		
N9549	**158**		**3/16/05 1120**	**ND**			**ND**			**ND**			**ND**		
N9550	**159**		**3/16/05 1145**	**ND**			**ND**			**ND**			**ND**		
N9551	**160**		**3/16/05 1205**	**ND**			**ND**			**ND**			**ND**		
N9552	**161**		**3/16/05 1230**	**ND**			**ND**			**ND**			**ND**		
N9553	**162**		**3/16/05 1445**	**ND**			**ND**			**ND**			**ND**		
N9824	**163**		**3/23/05 1000**	**ND**			**ND**			**ND**			**ND**		
P0193	163		4/7/05 1507	ND			534.4	59.6	05-21	ND			ND		
P0712	163		4/14/05 0925	ND			534.6	2.92	05-21	ND			ND		
P0767	163		4/20/05 1431	ND			534.7	2.20	05-21	ND			ND		
N9825	**164**		**3/23/05 1012**	**ND**			**ND**			**ND**			**ND**		
N9825V	164		3/23/05 1012	ND			ND			ND			ND		
N9826	**165**		**3/23/05 1030**	**ND**			**ND**			**ND**			**ND**		
N9827	**166**		**3/23/05 1110**	**ND**			**ND**			**ND**			**ND**		
P0768	166		4/20/05 1448	ND			ND			ND			ND		
N9828	**167**		**3/23/05 1312**	**ND**			**ND**			**ND**			**ND**		
P0194	167		4/7/05 1605	ND			ND			ND			ND		
P0769	167		4/20/05 1515	ND			ND			ND			ND		
N9829	**168**		**3/23/05 1420**	**ND**			**ND**			**ND**			**ND**		
N9830	**169**		**3/23/05 1515**	**ND**			**ND**			**ND**			**ND**		
P0195	169		4/7/05 1450	508.8	4.78	05-25	ND			ND			ND		
P0713	169		4/14/05 0914	508.4	1.46	05-25	ND			ND			ND		

OUL	Station	Station Name	Date/Time	Fluorescein Results		Trace	Eosine Results		Trace	RWT Results		Trace	SRB Results		Trace
Lab #	#		Recovered	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#	Peak nm	Conc. ppb	#
P0770	169		4/20/05 1409	508.7	1.01	05-25	ND			ND			ND		
N9831	**170**		**3/23/05 1535**	**ND**			**ND**			**ND**			**ND**		
N9832	**171**		**3/23/05 1600**	**ND**			**ND**			**ND**			**ND**		
N9833	**172**		**3/23/05 1628**	**ND**			**ND**			**ND**			**ND**		
P0714	172		4/14/05 0820	ND			ND			ND			ND		
N9834	**173**		**3/23/05 1640**	**ND**			**ND**			**ND**			**ND**		
P0196	173		4/7/05 1309	ND			ND			574.9	43.8	05-28	ND		
P0715	173		4/14/05 0837	ND			ND			574.6	10.7	05-28	ND		
P0771	173		4/20/05 1351	ND			ND			575.0	5.70	05-28	ND		
N9835	**174**		**3/23/05 1645**	**ND**			**ND**			**ND**			**ND**		
N9796	**175**		**3/23/05 1635**	**ND**			**ND**			**ND**			**ND**		
N9797	**176**		**3/23/05 1650**	**ND**			**ND**			**ND**			**ND**		
N9798	**177**		**3/23/05 1750**	**ND**			**ND**			**ND**			**ND**		
N9799	**178**		**3/23/05 1640**	**ND**			**ND**			**ND**			**ND**		
N9799R	178		3/23/05 1640	ND			ND			ND			ND		
N9801	**179**		**3/23/05 1746**	**ND**			**ND**			**ND**			**ND**		
N9802	**180**		**3/23/05 1800**	**ND**			**ND**			**ND**			**ND**		
N9803	**181**		**3/23/05 1809**	**ND**			**ND**			**ND**			**ND**		
N9851	181		3/30/05 0958	ND			ND			ND			ND		
N9795	**183**		**3/25/05 1033**	**ND**			**ND**			**ND**			**ND**		
P0197	183		4/7/05 1358	ND			ND			ND			ND		
P0716	183		4/14/05 1326	ND			ND			ND			ND		
P0772	183		4/20/05 1622	ND			ND			ND			ND		
P0161	**184**		**3/30/05 1200**	**ND**			**ND**			**ND**			**ND**		
P0162	**185**		**3/30/05 1228**	**ND**			**ND**			**ND**			**ND**		
P0198	185		4/7/05 0900	ND			ND			ND			ND		
P0163	**186**		**3/30/05 1358**	**ND**			**ND**			**ND**			**ND**		
P0164	**187**		**3/30/05 1408**	**ND**			**ND**			**ND**			**ND**		
P0165	**188**		**3/30/05 1448**	**ND**			**ND**			**ND**			**ND**		
N9850	**189**		**3/30/05 1658**	**ND**			**ND**			**ND**			**ND**		
P0166	**190**		**4/2/05 0900**	**ND**			**ND**			**ND**			**ND**		
P0167	**191**		**4/2/05 0915**	**ND**			**ND**			**ND**			**ND**		
P0168	**192**		**4/2/05 0930**	**ND**			**ND**			**ND**			**ND**		
P0169	**193**		**4/3/05 1035**	**ND**			**ND**			**ND**			**ND**		
P0170	**194**		**4/3/05 1043**	**ND**			**ND**			**ND**			**ND**		
P0171	**195**		**4/3/05 1255**	**ND**			**ND**			**ND**			**ND**		
P0172	**196**		**4/3/05 1308**	**ND**			**ND**			**ND**			**ND**		
P0173	**197**		**4/3/05 1355**	**ND**			**ND**			**ND**			**ND**		
P0174	**198**		**4/3/05 1415**	**ND**			**ND**			**ND**			**ND**		
P0159	198		4/6/05 0847	ND			ND			576.2 (3)	0.162	05-27	ND		
P0159R	198		4/6/05 0847	ND			ND			575.8 (3)	0.194	05-27	ND		
P0738	198		4/13/05 0821	ND			ND			574.5	2.55	05-27	ND		
P0764	198		4/19/05 1630	ND			ND			574.3	1.54	05-27	ND		

FOOTNOTES:

ND = no dye detected

bkg = background fluorescence

(1) = a fluorescence peak is present which does not meet all the criteria for a positive dye result, but has been calculated as though it were dye for background purposes.

(2) = Fluorescein dye ***may be*** present in this sample. However, due to the large concentration of eosine dye, the fluorescein cannot be accurately quantified.

(3) = A fluorescence peak is present which does not meet all the criteria for a positive dye result, but has been calculated as though it were dye because some dye was found in the corresponding charcoal sample.

(4) = No flow

(5) = Eosine dye ***is*** present in this sample. However, due to the large concentration of rhodamine WT dye, the eosine cannot be accurately quantified.

(6) = Fluorescein dye ***is*** present in this sample. However, due to the large concentration of eosine, the fluorescein dye cannot be accurately quantified.

(7) = Eosine dye ***is*** present in this sample. However, due to the large concentration of fluorescein dye, the eosine dye cannot be accurately quantified.

(8) = Only a water sample was collected during this sampling period.

(9) = Both charcoal samplers were found out of the water.

(10) = Rhodamine WT (RWT) **is** present in this sample. However, due to the greater concentration of eosine, the RWT cannot be accurately quantified.

(11) = No charcoal or water collected. Site dry.

(12) = An old charcoal packet was recovered and analyzed.

(13) = No sampling occurred during this period.

(14) = The landowner collected these samples and reported dates and times placed and collected.

Viacom = The fluorescence in this sample is related to Viacom activities.

IU = The fluorescence in this sample is from Indiana University activities.

Appendix C

PROCEDURES AND CRITERIA
ANALYSIS OF FLUORESCEIN, EOSINE, RHODAMINE WT,
SULFORHODAMINE B, AND PYRANINE
DYES IN WATER AND CHARCOAL SAMPLERS

March 21, 2005

Ozark UNDERGROUND LABORATORY 1572 Aley Lane Protem, MO 65733 (417) 785-4289 fax (417) 785-4290 oul@tri-lakes.net

PROCEDURES AND CRITERIA
ANALYSIS OF FLUORESCEIN, EOSINE, RHODAMINE WT, SULFORHODAMINE B, AND PYRANINE DYES IN WATER AND CHARCOAL SAMPLERS

March 21, 2005

Thomas Aley, PHG 179
President
Ozark Underground Laboratory, Inc.

PROCEDURES

Introduction

This document describes standard procedures and criteria currently in use at the Ozark Underground Laboratory as of the date shown on the title page. Some samples may be subjected to different procedures and criteria because of unique conditions; such non-standard procedures and criteria are identified in reports for those samples. Standard procedures and criteria change as knowledge and experience increases and as equipment is improved or up-graded. The Ozark Underground Laboratory maintains a summary of changes in standard procedures and criteria.

Dye Nomenclature

Fluorescein is C.I. Acid yellow 73, Color Index Number 45350. Rhodamine WT is Acid Red 388; there is no assigned Color Index Number for this dye. Eosine (sometimes called eosin) is Acid Red 87, Color Index Number 45380. Sulforhodamine B is C.I. Acid Red 52, Color Index Number 45100. Pyranine is Solvent Green 7 (also called D&C Green 8), Color Index Number 59040.

Description of the Samplers

The charcoal samplers are packets of fiberglass screening partially filled with approximately 4.25 grams of activated coconut charcoal. The charcoal used by the Ozark Underground Laboratory is Barnebey and Sutcliffe coconut shell carbon, 6 to 12 mesh, catalog type AC.

The most commonly used samplers are about 4 inches long by two inches wide. A cigar-shaped sampler is made for use in very small diameter wells (such as 1 inch diameter wells); this is a special order item and should be specifically requested when it is needed. All of the samplers are closed by heat sealing.

Placement of Samplers

Samplers (also called charcoal packets) are placed so as to be exposed to as much water as possible. In springs and streams they are typically attached to a rock or other anchor in a riffle area. Attachment of the packets often uses plastic tie wires. In swifter water galvanized wire (such as electric fence wire) is often used. Other types of anchoring wire can be used. Electrical wire with plastic insulation is also good. Packets are attached so that they extend outward from the anchor rather than being flat against it. Two or more separately anchored packets are typically used for sampling springs and streams. The use of fewer packets is discouraged except when the spring or stream is so small that there is not appropriate space for placing multiple packets.

When pumping wells are being sampled, the samplers are placed in sample holders made of PVC pipe fittings. Brass hose fittings are installed at the end of the sample holders so that the sample holders can be installed on outside hose bibs and water which has run through the samplers can be directed to waste through a connected garden hose.

The samplers can be unscrewed in the middle so that charcoal packets can be changed. The middle portions of the samplers consists of 1.5 inch diameter pipe and pipe fittings.

Charcoal packets can also be lowered into monitoring wells for sampling purposes. In general, if the well is screened, samplers should be placed approximately in the middle of the screened interval. Some sort of weight should be added near the charcoal packet to insure that it will not float. The weight should be of such a nature that it will not affect water quality. One common approach is to anchor the packets with a plastic cable tie to the top of a dedicated weighted disposable bailer. We typically run nylon cord from the top of the well to the charcoal packet and its weight. Nylon fishing line should not be used since it can be readily cut by a sharp projection in the well.

In some cases, especially with narrow wells and appreciable well depths, the weighted disposable bailers sink very slowly or may even fail to sink because of friction and floating of the anchoring cord. In such cases a stainless steel weight may be added to the top of the disposable bailer. We have had good success with two to three ounce segments of stainless steel pipe which have an outside diameter of 1.315 inches and an inside diameter of 1.049 inches; such pipe weighs about 1.7 pounds per linear foot. The weight of the stainless steel is approximately 497 pounds per cubic foot. The pipe segments can be attached over the anchoring cord at the top of the bailer. All weights should be cleaned prior to use; the cleaning approach should comply with decontamination procedures in use at the project site.

Placement of samplers requires adjustment to field conditions. The above placement comments are intended as guidance, not firm requirements.

Rinsing of Charcoal Packets Prior to Sampling

Charcoal packets routinely contain some fine powder that washes off rapidly when they are placed in water. Since such material could remain in monitoring wells, charcoal packets to be placed in such wells are triple rinsed with distilled, demineralized, or reagent water known to be free of tracer dyes. This rinsing is typically done by soaking. With this approach, approximately 25 packets are placed in one gallon of water and soaked for at least 10 minutes. The packets are then removed from the water and excess water is shaken off the packets. The packets are then placed in a second gallon of water and again soaked for at least 10 minutes. After this soaking they are removed from the water and excess water is shaken off the packets. The packets are then placed in a third gallon of water and the procedure is again repeated. Rinsed packets are placed in plastic bags and are placed at sampling stations within three days. Packets can also be rinsed in jets of water for about one minute; this requires more water and is typically difficult to do in the field with water known to be free of tracer dyes.

Collection and Replacement of Samplers

Samplers are routinely collected and replaced from each of the sampling stations. The frequency of sampler collection and replacement is determined by the nature of the study. Collections at one week intervals are common, but shorter or longer collection frequencies are acceptable and sometimes more appropriate. Shorter sampling frequencies are often used in the early phases of a study to better characterize time of travel. As an

illustration, we often collect and change charcoal packets 1, 2, 4, and 7 days after dye injection. Subsequent sampling is then weekly.

Where convenient, the collected samplers should be briefly rinsed in the water being sampled. This is typically not necessary with well samples. The packets are shaken to remove excess water. Next, the packet (or packets) are placed in a plastic bag (Whirl-Pak bags are ideal). The bag is labeled on the outside with a permanent type felt marker pen. Use only pens that have black ink; colored inks may contain fluorescent dyes. The notations include station name or number and the date and time of collection. Labels are not inserted inside the sample bags.

For most projects the Ozark Underground Laboratory supplies the Whirl-Pak bags. Prior to use, 1% of the new bags are randomly selected. Each bag is soaked in the standard eluting solution and then analyzed for the presence of any of the tracer dyes being used.

Collected samplers are kept in the dark to minimize algal growth on the charcoal prior to analysis work. We prefer (and in some studies require) that samples be placed on "blue ice" or ice upon collection and that they be shipped refrigerated with "blue ice" by overnight express. Do not ship samplers packed in ice since this can create a potential for cross contamination when the ice melts. Our experience indicates that it is not essential for samplers to be maintained under refrigeration, yet maintaining them under refrigeration clearly minimizes some potential problems. A product known as "green ice" should not be used for maintaining the samples in a refrigerated condition since this product contains a dye which could contaminate samples if the "green ice" container were to break or leak.

New charcoal samplers are routinely placed when used charcoal packets are collected. The last set of samplers placed at a stream or spring is commonly not collected.

Water samples are often collected. They should be collected in either glass or plastic; the Ozark Underground Laboratory routinely uses 50 ml research grade polypropylene copolymer Perfector Scientific vials (Catalog Number 2650) for such water samples. The vials should be placed in the dark and refrigerated immediately after collection. They should be refrigerated until shipment. For most projects the Ozark Underground Laboratory supplies the vials. Prior to use, 1% of the new vials are randomly selected. Each vial is soaked in the standard eluting solution and then analyzed for the presence of any of the tracer dyes being used.

When water or charcoal samplers are collected for shipment to the Ozark Underground Laboratory they should be shipped promptly. We receive good overnight and second day air service from both UPS and Fed Ex; Airborne Service is excessively slow, and the Postal Service does not provide next day service to us.

Each shipment of charcoal samplers or water samples must be accompanied by a sample tracking sheet. These sheets (which bear the title "Samples for Fluorescence Analysis") are provided by the Ozark Underground Laboratory and summarize placement and collection data. These sheets can be augmented by a client's chain of custody forms or any other relevant documentation. Figure 1 is one of our blank sample forms.

Receipt of Samplers

Samplers shipped to the Ozark Underground Laboratory are refrigerated upon receipt. Prior to cleaning and analysis, samplers are assigned a laboratory identification number. All samples are logged in upon receipt.

It sometimes occurs that there are discrepancies between the chain-of-custody sheets and the actual samples received. When this occurs, a "Discrepancy Sheet" form is completed and sent to the shipper of the sample for resolution. A copy of this form is enclosed as Figure 2. The purpose of the form is to help resolve discrepancies, even when they may be minor.

Cleaning of Samplers

Samplers are cleaned by spraying them with jets of clean water. At the Laboratory we use unchlorinated water for the cleansing to minimize dye deterioration. Effective cleansing cannot generally be accomplished simply by washing in a conventional laboratory sink even if the sink is equipped with a spray unit.

The duration of packet washing depends upon the condition of the sampler. Very clean samplers may require less than a minute of washing; dirtier samplers may require several minutes of washing.

After washing, the packets are shaken to remove excess water. Next, the packets are cut open and the charcoal is emptied into a new disposable plastic beaker. The beaker has been pre-labeled with the laboratory identification number. The charcoal is now ready for elution. The emptied fiberglass screen packet is discarded. At stations where two or more charcoal packets are collected, one is selected for analysis and the other is frozen and retained until the end of the study. In some studies the analysis protocol stipulates that a fixed percentage (often 5%) of the samples should be duplicates; in these cases the second charcoal packet is separately analyzed. Note that these are duplicate samples, not replicate samples since each packet is, of necessity, placed in a somewhat different location and is therefore exposed to somewhat different conditions.

Cleaning of Glassware

Most of our work uses disposable plastic containers. A small amount of glassware is occasionally used for preparation of standards. It is dedicated to this use. In the event that any glassware does come in contact with tracer dyes it will be carefully cleaned before re-use. To do this cleaning, containers are rinsed several times in clean water. Glassware that may be contaminated with dyes is washed with detergent, and then again rinsed. Next, the glassware is soaked for one hour or more in a bleach and water solution. Upon removal from this soaking, the glassware is rinsed again and allowed to air dry.

Figure 1. Sample Collection Data Sheet

OZARK UNDERGROUND LABORATORY, INC.

1572 Aley Lane Protem, MO 65733 (417) 785-4289 fax (417) 785-4290 email: oul@tri-lakes.net

SAMPLE COLLECTION DATA SHEET for FLUORESCENCE ANALYSIS

Project:_____**Week No:** _____ **Samples Collected By:**_____

Samples Shipped By:_____**Samples Received By:**_____

Date Samples Shipped:____/____/____ **Date Samples Received:**____/____/____ **Time Samples Received:**_____:_____ **Return Cooler? Yes** _____**No**_____

Bill to:_____**Send Results to:** _____

Analyze for: Fluorescein_____**Eosine**_____**Rhodamine WT**_____**Other**_____**Ship cooler to:** _____

OUL use only		***Please indicate stations where dye was visible in the field*** *for field technician use - use black ink only*						*OUL use only*
# CHAR REC'D	**LAB NUMBER**	**STATION NUMBER** 1-4 Numbers	**STATION NAME**	**PLACED**		**COLLECTED**		**# WATER REC'D**
				DATE	**TIME**	**DATE**	**TIME**	

COMMENTS:_____

_____

This sheet filled out by OUL staff? Yes_____**No**_____**Charts for samples on this page proofed by OUL:**_____

Page _____ **of** _____

Figure 2. Discrepancy Sheet

OZARK UNDERGROUND LABORATORY, INC.

DISCREPANCIES BETWEEN CHAIN-OF-CUSTODY SHEETS AND ACTUAL SAMPLES RECEIVED **Page _____ of _____**

Company & Project Name: **Date Rec'd by OUL:** **Wk # _____**

Lab #	Sta #	Station Name	Date Pulled	Problem	Solution

Comments:

Elution of the Charcoal

There are various eluting solutions that can be used for the recovery of tracer dyes. The solutions typically include an alcohol, some water, and a strong basic solution such as aqueous ammonia.

The standard elution solution now used at the Ozark Underground Laboratory is a mixture of 5% aqua ammonia and 95% isopropyl alcohol solution and sufficient potassium hydroxide flakes to saturate the solution. The isopropyl alcohol is 70% alcohol and 30% water. The aqua ammonia solution is 29% ammonia. The potassium hydroxide is added until a super-saturated layer is visible in the bottom of the container. This super-saturated layer is not used for elution. Preparation of eluting solutions uses dedicated glassware which is never used in contact with dyes or dye solutions.

The eluting solution we use will elute fluorescein, eosine, rhodamine WT, sulforhodamine B, and pyranine dyes. It is also suitable for separating fluorescein peaks from peaks of some naturally present materials found in some samplers.

Fifteen ml of the eluting solution is poured over the washed charcoal in a disposable sample beaker. The sample beaker is capped. The sample is allowed to stand for 60 minutes. After this time, the liquid is carefully poured off the charcoal into a new disposable beaker which has been appropriately labeled with the laboratory identification number. A few grains of charcoal may inadvertently pass into the second beaker; no attempt is made to remove these from the second sample beaker. After the pouring, a small amount of the elutant will remain in the initial sample beaker. After the transfer of the elutant to the second sample beaker, the contents of the first sample beaker (the eluted charcoal) are discarded.

Analysis on the Shimadzu RF-5000U or RF-5301

The Laboratory uses two Shimadzu spectrofluorophotometers. One is a model RF-5000U, and the other is a model RF-5301. Both of these instruments are capable of synchronous scanning. The RF-5301 is the primary instrument used; the RF-5000U is primarily used as a back-up instrument except for tracing studies which were begun using this instrument. The OUL also owns a Shimadzu RF-540 spectrofluorometer which is occasionally used for special purposes.

A sample of the elutant is withdrawn from the sample container using a disposable polyethylene pipette. Approximately 3 ml of the elutant is then placed in disposable rectangular polystyrene cuvette. The cuvette has a maximum capacity of 3.5 ml. The cuvette is designed for fluorometric analysis; all four sides and the bottom are clear. The spectral range of the cuvettes is 340 to 800 nm. The pipettes and cuvettes are discarded after one use.

The cuvette is then placed in the RF-5000U or the RF-5301. Both instruments are controlled by a programmable computer. Each instrument is capable of conducting substantial data analysis.

Our instruments are operated and maintained in accordance with the manufacturer's recommendations. On-site installation of the instruments and a training session on the use of spectrofluorophotometers was provided by Delta Instrument Company.

Our typical analysis of an elutant sample where fluorescein, eosine, rhodamine WT, or sulforhodamine B dyes may be present includes synchronous scanning of excitation and emission spectra with a 17 nm separation between excitation and emission wavelengths. For these dyes, the excitation scan is from 443 to 613 nm; the emission scan is from 460 to 630 nm. The emission fluorescence from the scan is plotted on a graph. The typical scan speed setting is "very fast" on the RF-5000U; it is “fast” on the RF-5301. The typical sensitivity setting used on both instruments is "high."

Our typical analysis of an elutant sample where pyranine dye may be present includes a synchronous scanning of excitation and emission spectra with a 35 nm separation between excitation and emission wavelengths. For this dye, the excitation scan is from 360 to 600 nm; the emission scan is from 395 to 635 nm. The emission fluorescence from the scan is plotted on a graph. The typical scan speed setting is "very fast" on the RF-5000U; it is “fast” on the RF-5301. The typical sensitivity setting on both instruments is "high."

Excitation and emission slit width settings vary between the two instruments. The widths vary with the dyes for which we are sampling and for the matrix in which the dyes may be present. Excitation and emission slit width settings are summarized in Table 1.

Table 1. Excitation and emission slit width settings routinely used for dye analysis. Units are nanometers (nm)

Parameter	**RF5000U**	**RF5301**
Excitation slit for Eos, Fl, RWT, and SRB in elutant	5	3
Emission slit for Eos, Fl, RWT, and SRB in elutant	3	1.5
Excitation slit for Eos, Fl, RWT, and SRB in water	5	5
Emission slit for Eos, Fl, RWT, and SRB in water	10	3
Excitation slit for Pyranine in elutant	5	5
Emission slit for Pyranine in elutant	3	3
Excitation slit for Pyranine in pH adjusted water	5	5
Emission slit for Pyranine in pH adjusted water	3	3

Eos = Eosine. Fl = Fluorescein. RWT = Rhodamine WT. SRB = Sulforhodamine B.

The instrument produces a plot of the synchronous scan for each sample; the plot shows emission fluorescence only. The synchronous scans are subjected to computer peak picks; peaks are picked to the nearest 0.1 nm. All samples run on the RF-5000U and RF-5301 are stored on disk and printed on normal typing paper with a laser printer; sample information is printed on the chart.

All samples analyzed are recorded in a bound journal.

Quantification

We calculate the magnitude of fluorescence peaks for fluorescein, eosine, rhodamine WT, sulforhodamine B, and pyranine dyes. Dye quantities are expressed in microgram per liter (parts per billion; ppb). On the RF-5000U and RF-5301 the dye concentrations are calculated by separating fluorescence peaks due to dyes from background fluorescence on the charts, and then calculating the area within the fluorescence peak. This area is proportional to areas obtained from standard solutions.

Where there are multiple fluorescence peaks it is sometimes necessary to calculate dye concentrations based upon the height of the fluorescence peak rather that the area. The heights of the peaks are also proportional to dye concentrations.

We run dye concentration standards each day the machine is used. Ten separate standards are used; the standard or standards appropriate for the analysis work being conducted are selected. All standards are based upon the as-sold weights of the dyes. The standards are as follows:

1) 10 ppb fluorescein and 100 ppb rhodamine WT in well water from the Jefferson City-Cotter Formation
2) 10 ppb eosine in well water from the Jefferson City-Cotter Formation
3) 100 ppb sulforhodamine B in well water from the Jefferson City-Cotter Formation.
4) 10 ppb pyranine in well water from the Jefferson City-Cotter Formation. A sample of the standard is placed for at least two hours in a high ammonia atmosphere to adjust the pH to a value of 9.5 or greater.
5) 10 ppb fluorescein and 100 ppb rhodamine WT in elutant.
6) 10 ppb eosine in elutant.
7) 100 ppb sulforhodamine B in elutant.
8) 10 ppb pyranine in elutant.

Preparation of Standards

Dye standards are prepared as follows:

Step 1. A small sample of the as-sold dye is placed in a pre-weighed sample vial and the vial is again weighed to determine the weight of the dye. We attempt to use a sample weighing between 1 and 5 grams. This sample is then diluted with well water to make a 1% dye solution by weight (based upon the as-sold weight of the dye). The resulting dye solution is allowed to sit for at least four hours to insure that all dye is fully dissolved.

Step 2. One part of each dye solution from Step 1 is placed in a mixing container with 99 parts of well water. Separate mixtures are made for fluorescein, rhodamine WT, eosine, sulforhodamine B, and pyranine. The resulting solutions contain 100 mg/l dye (100 parts per million dye). The typical prepared volume of this mixture is

appropriate for the sample bottles being used; we commonly prepare about 50 ml. of the Step 2 solutions. The dye solution from Step 1 that is used in making the Step 2 solution is withdrawn with a digital Finnpipette which is capable of measuring volumes between 0.200 and 1.000 ml at intervals of 0.005 ml. The calibration certificate with this instrument indicates that the accuracy (in percent) is as follows:

At 0.200 ml, 0.90%

At 0.300 ml, 0.28%

At 1.000 ml, 0.30%

The Step 2 solution is called the long term standard. Ozark Underground Laboratory experience indicates that Step 2 solutions, if kept refrigerated, will not deteriorate appreciably over periods of less than a year. Furthermore, these Step 2 solutions may last substantially longer than one year.

Step 3. A series of intermediate-term dye solutions are made. Approximately 45 ml. of each intermediate-term dye solution is made. All volume measurements of less than 5 ml are made with a digital Finnpipette. (see description in Step 2). All other volume measurements are made with Rheinland Kohn Geprufte Sicherheit 50 ml. capacity pump dispenser which will pump within plus or minus 1% of the set value. The following solutions are made; all concentrations are based on the as-sold weight of the dyes:

1) A solution containing 1 ppm fluorescein dye and 10 ppm rhodamine WT dye.

2) A solution containing 1 ppm eosine.

3) A solution containing 10 ppm sulforhodamine B dye.

4) A solution containing 1 ppm pyranine.

Step 4. A series of eight short-term dye standards are made from solutions in Step 3. These standards were identified earlier in this section. In the experience of the Ozark Underground Laboratory these standards have a useful shelf life in excess of one week. However, in practice, they are kept under refrigeration and new standards are made weekly.

Dilution of Samples

Samples with peaks that have arbitrary fluorescence unit values of 500 or more are diluted a hundred fold to ensure accurate quantification.

Some water samples have high turbidity or color which interferes with accurate detection and measurement of dye concentrations. It is often possible to dilute these samples and then measure the dye concentration in the diluted sample.

The typical dilution is 100 fold. One part of the test sample is combined with 99 parts of water (if the test sample is water) or with 99 parts of the standard elutant (if the test sample is elutant). Typically, 0.300 ml of the test solution is combined with 29.700 ml of water (or elutant as appropriate) to yield a new test solution. All volume measurements of less than 5 ml are made with a digital Finnpipette. which is capable of

measuring volumes between 0.200 and 1.000 ml at intervals of 0.005 ml. The calibration certificate with this instrument indicates that the accuracy (in percent) is as follows:

At 0.200 ml, 0.90%

At 0.300 ml, 0.28%

At 1.000 ml, 0.30%

All other volume measurements are made with Rheinland Kohn Geprufte Sicherheit 50 ml. capacity pump dispenser which will pump within plus or minus 1% of the set value.

Quality Control

Laboratory blanks are run for every sample where the last two digits of the laboratory numbers are 00, 20, 40, 60, or 80. A charcoal packet is placed in a pumping well sampler and at least 25 gallons of unchlorinated water is passed through the sampler at a rate of about 2.5 gallons per minute. The sampler is then subjected to the same analytical protocol as all other samplers.

System functioning tests of the analytical instruments are conducted in accordance with the manufacturer's recommendations.

All materials used in sampling and analysis work are routinely analyzed for the presence of any compounds that might create fluorescence peaks in or near the acceptable wavelength ranges for any of the tracer dyes. This testing typically includes approximately 1% of materials used.

Reports

Reports are provided in accordance with the needs of the client. At a minimum we provide copies of the analysis graphs and a listing of stations and samples where dye was detected. The reports indicate dye concentrations.

Work at the Ozark Underground Laboratory is directed by Mr. Thomas Aley. Mr. Aley has 40 years of professional experience in hydrology and hydrogeology. He is certified as a Professional Hydrogeologist (Certificate #179) by the American Institute of Hydrology. Mr. Aley has 35 years of professional experience in groundwater tracing with fluorescent tracing agents.

CRITERIA FOR DETERMINATION OF POSITIVE DYE RECOVERIES

Normal Emission Ranges and Detection Limits

The OUL has established normal emission fluorescence wavelength ranges for each of the five dyes. The normal acceptable range equals mean values plus and minus two standard deviations. These values are derived from actual groundwater tracing studies conducted by the OUL.

The detection limits are based upon concentrations of dye necessary to produce emission fluorescence peaks where the signal to noise ratio is 3. The detection limits are realistic for most field studies since they are based upon results from actual field samples rather than being based upon values from spiked samples in a matrix of reagent water or the elutants from unused activated carbon samplers. In some cases detection limits may be smaller than reported if the water being sampled has very little fluorescent material in it. In some cases detection limits may be greater than reported; this most commonly occurs if the sample is turbid due to suspended material or a coloring agent such as tannic compounds. Turbid samples are typically centrifuged or, if this is not effective, diluted prior to analysis.

Table 2 provides normal emission wavelength ranges and detection limits for the five dyes when analyzed on the OUL's RF-5000U spectrofluorophotometer. Table 3 provides similar data for the OUL's RF-5301. As indicated earlier in Table 1, the analytical protocols used on the two instruments are somewhat different, especially in regard to the widths of excitation and emission slit settings.

Table 2. RF-5000U Spectrofluorophotometer. Normal emission wavelength ranges and detection limits for fluorescein, eosine, rhodamine WT, sulforhodamine B, and pyranine dyes in water and elutant samples. Detection limits are based upon the as-sold weight of the dye mixtures normally used by the OUL.

Dye and Matrix	Normal Acceptable Emission Wavelength Range (nm)	Detection Limit (ppb)
Eosine in Elutant	533.0 to 539.6	0.035
Eosine in Water	529.6 to 538.4	0.008
Fluorescein in Elutant	510.7 to 515.0	0.010
Fluorescein in Water	505.6 to 510.5	0.0005
Pyranine in Elutant	500.4 to 504.6	0.055
Pyranine in Water*	501.2 to 505.2	0.030
Rhodamine WT in Elutant	561.7 to 568.9	0.275
Rhodamine WT in Water	569.4 to 574.8	0.050
Sulforhodamine B in Elutant	567.5 to 577.5	0.150
Sulforhodamine B in Water	576.2 to 579.7	0.040

* pH adjusted water with pH of 9.5 or greater.

Note: The protocols for the analysis of pyranine dye are substantially different than those for the other dyes. As a result, there is less potential interference between pyranine and fluorescein than might otherwise be indicated by the emission wavelength values shown in the table.

Table 3. RF-5301 Spectrofluorophotometer. Normal emission wavelength ranges and detection limits for fluorescein, eosine, rhodamine WT, sulforhodamine B, and pyranine dyes in water and elutant samples. Detection limits are based upon the as-sold weight of the dye mixtures normally used by the OUL.

Dye and Matrix	Normal Acceptable Emission Wavelength Range (nm)	Detection Limit (ppb)
Eosine in Elutant	538.1 to 543.9	0.050
Eosine in Water	533.4 to 537.9	0.015
Fluorescein in Elutant	514.0 to 518.1	0.025
Fluorescein in Water	508.0 to 511.7	0.002
Pyranine in Elutant	502.1 to 508.1	0.015
Pyranine in Water*	504.1 to 510.1	0.010
Rhodamine WT in Elutant	565.4 to 572.0	0.170
Rhodamine WT in Water	572.7 to 578.0	0.015
Sulforhodamine B in Elutant	572.8 to 579.6	0.080
Sulforhodamine B in Water	580.1 to 583.7	0.008

* pH adjusted water with pH of 9.5 or greater.

Note: The protocols for the analysis of pyranine dye are substantially different than those for the other dyes. As a result, there is less potential interference between pyranine and fluorescein than might otherwise be indicated by the emission wavelength values shown in the table.

Criteria for Determining Positive Dye Recoveries

The following sections identify normal criteria used by the OUL for determining positive dye recoveries. Beginning January 1, 2001, the primary analytical instrument in use at the OUL was the RF-5301; the RF-5000U was the principal backup instrument. Studies which were in progress prior to January 1, 2001 continued to have samples analyzed on the RF-5000U.

Except for pyranine dye, the analytical protocol used for the RF-5301 provides for the use of narrower excitation and/or emission slit settings than the RF-5000U protocol. This enhances our ability to discriminate between dyes and other fluorescent compounds. The protocol which is possible with the RF-5301 (as contrasted with the RF-5000U) also provides for a better balance in the sizes of the fluorescence peaks associated with an equal concentration of all of the dyes.

Normal Criteria Used by the Ozark Underground Laboratory for Determining Positive <u>Eosine</u> Dye Recoveries <u>in Elutants</u> from Charcoal Samplers.

There is generally little or no detectable fluorescence background in the general range of eosine dye encountered in most groundwater tracing studies. The following four criteria are used to identify fluorescence peaks which are deemed to be eosine dye.

Criterion 1. There must be at least one fluorescence peak at the station in question in the range of 538.1 to 543.9 nm for samples analyzed by the RF-5301. The range must be 533.0 to 539.6 nm for samples analyzed by the RF-5000U.

Criterion 2. The dye concentration associated with the fluorescence peak must be at least 3 times the detection limit. For the RF-5301, the eosine detection limit in elutant samples is 0.050 ppb, thus this dye concentration limit equals 0.150 ppb. For the RF-5000U the eosine detection limit in elutant samples is 0.035 ppb, thus this dye concentration limit equals 0.105 ppb.

Criterion 3. The dye concentration must be at least 10 times greater than any other concentration reflective of background at the sampling station in question.

Criterion 4. The shape of the fluorescence peak must be typical of eosine. Much background fluorescence yields low, broad, and asymmetrical fluorescence peaks rather than the more narrow and symmetrical fluorescence peaks typical of eosine. In addition, there must be no other factors which suggest that the fluorescence peak may not be eosine dye from our groundwater tracing work.

Normal Criteria Used by the Ozark Underground Laboratory for Determining Positive <u>Eosine</u> Dye Recoveries <u>in Water</u> Samples.

There is generally little or no detectable fluorescence background in the general range of eosine dye encountered in most groundwater tracing studies. The following three criteria are used to identify fluorescence peaks which are deemed to be eosine dye.

Criterion 1. The associated charcoal samplers for the station should also contain eosine dye in accordance with the criteria listed above. These criteria may be waived if no charcoal sampler exists.

Criterion 2. There must be no factors which suggest that the fluorescence peak may not be eosine dye from our groundwater tracing work. For samples analyzed on the RF-5301, the fluorescence peak should generally be in the range of 533.4 to 537.9 nm. For samples analyzed on the RF-5000U, the fluorescence peak should generally be in the range of 529.6 to 538.4 nm.

Criterion 3. The dye concentration associated with the fluorescence peak must be at least three times the detection limit. Our eosine detection limit in water samples analyzed on the RF-5301 is 0.015 ppb, thus this dye concentration limit equals 0.045 ppb. For samples analyzed on the 5000U the detection limit is 0.008 ppb, thus this dye concentration limit equals 0.024 ppb.

Normal Criteria Used by the Ozark Underground Laboratory for Determining Positive Fluorescein Dye Recoveries in Elutants from Charcoal Samplers.

There is often some fluorescence background in the range of fluorescein dye present at some of the stations used in groundwater tracing studies. We routinely conduct background sampling prior to the introduction of any tracer dyes to characterize this background fluorescence and to identify the existence of any tracer dyes which may be present in the area. The fact that a fluorescence peak is identified in our analytical results is not proof that it is fluorescein dye or that it is fluorescein dye from the trace of concern. The following 4 criteria are used to identify fluorescence peaks which are deemed to be fluorescein dye recoveries from our tracing work.

Criterion 1. There must be at least one fluorescence peak at the station in question in the range of 514.0 to 518.1 nm for samples analyzed by the RF-5301. The range must be 510.7 to 515.0 for samples analyzed by the RF-5000U.

Criterion 2. The dye concentration associated with the fluorescence peak must be at least 3 times the detection limit. For the RF-5301, the fluorescein detection limit in elutant samples is 0.025 ppb, thus this dye concentration limit equals 0.075 ppb. For the RF-5000U, the fluorescein detection limit in elutant samples is 0.010 ppb, thus this dye concentration limit equals 0.030 ppb.

Criterion 3. The dye concentration must be at least 10 times greater than any other concentration reflective of background at the sampling station in question.

Criterion 4. The shape of the fluorescence peak must be typical of fluorescein. Much background fluorescence yields low, broad, and asymmetrical fluorescence peaks rather than the more narrow and symmetrical fluorescence peaks typical of fluorescein. In addition, there must be no other factors which suggest that the fluorescence peak may not be fluorescein dye from our groundwater tracing work.

Normal Criteria Used by the Ozark Underground Laboratory for Determining Positive Fluorescein Dye Recoveries in Water Samples.

There is commonly some fluorescence background in the general range of fluorescein dye at some sampling stations used in groundwater tracing studies. The following criteria are used to identify fluorescence peaks which are deemed to be fluorescein dye in water.

Criterion 1. The associated charcoal samplers for the station should also contain fluorescein dye in accordance with the criteria listed above. These criteria may be waived if no charcoal sampler exists.

Criterion 2. There must be no factors which suggest that the fluorescence peak may not be fluorescein dye from our groundwater tracing work. For samples analyzed on the RF-5301, the fluorescence peak should generally be in the range of 508.0 to 511.7 nm. For samples analyzed on the RF-5000U, the fluorescence peak should generally be in the range of 505.6 to 510.5 nm.

Criterion 3. The dye concentration associated with the fluorescence peak must be at least three times the detection limit. Our fluorescein detection limit in water samples analyzed on the RF-5301 is 0.002 ppb, thus this dye concentration limit equals 0.006 ppb. For the RF-5000U the detection limit is 0.0005 ppb, thus this dye concentration limit equals 0.0015 ppb.

Normal Criteria Used by the Ozark Underground Laboratory for Determining Positive Rhodamine WT Dye Recoveries in Elutants from Charcoal Samplers.

There is generally little or no detectable fluorescence background in the general range of Rhodamine WT dye encountered in most groundwater tracing studies. The following four criteria are used to identify fluorescence peaks which are deemed to be Rhodamine WT.

Criterion 1. For samples analyzed on the RF-5301, there must be at least one fluorescence peak at the station in question in the range of 565.4 to 572.0 nm. For samples analyzed on the RF-5000U, there must be at least one fluorescence peak at the station in question in the range of 561.7 to 568.9 nm.

Criterion 2. The dye concentration associated with the Rhodamine WT peak must be at least 3 times the detection limit. For the RF-5301, the detection limit in elutant samples is 0.170 ppb, thus this dye concentration limit equals 0.510 ppb. For the RF-5000U, the detection limit in elutant samples is 0.275 ppb, thus this dye concentration limit equals 0.825 ppb.

Criterion 3. The dye concentration must be at least 10 times greater than any other concentration reflective of background at the sampling station in question.

Criterion 4. The shape of the fluorescence peak must be typical of Rhodamine WT. In addition, there must be no other factors which suggest that the fluorescence peak may not be dye from the groundwater tracing work under investigation.

Normal Criteria Used by the Ozark Underground Laboratory for Determining Positive Rhodamine WT Dye Recoveries in Water Samples.

The following criteria are used to identify fluorescence peaks which are deemed to be Rhodamine WT dye in water.

Criterion 1. The associated charcoal samplers for the station should also contain Rhodamine WT dye in accordance with the criteria listed above. These criteria may be waived if no charcoal sampler exists.

Criterion 2. There must be no factors which suggest that the fluorescence peak may not be Rhodamine WT dye from the tracing work under investigation. For samples analyzed with the RF-5301, the fluorescence peak should generally be in the range of 572.7 to 578.0 nm. For samples analyzed with the RF-5000U, the fluorescence peak should generally be in the range of 569.4 to 574.8 nm.

Criterion 3. The dye concentration associated with the fluorescence peak must be at least three times the detection limit. Our Rhodamine WT detection limit in water samples analyzed on the RF-5301 is 0.015 ppb, thus this dye concentration limit is 0.045 ppb. For samples analyzed on the RF-5000U the detection limit is 0.050 ppb, thus this dye concentration limit equals 0.150 ppb.

Normal Criteria Used by the Ozark Underground Laboratory for Determining Positive Sulforhodamine B Dye Recoveries in Elutants from Charcoal Samplers.

There is generally little or no detectable fluorescence background in the general range of sulforhodamine B dye encountered in most groundwater tracing studies. The following four criteria are used to identify fluorescence peaks which are deemed to be sulforhodamine B.

Criterion 1. For samples analyzed on the RF-5000U, there must be at least one fluorescence peak at the station in question in the range of 567.5 to 577.5 nm. The acceptable range for samples analyzed on the RF-5301 is 572.8 to 579.6 nm.

Criterion 2. The dye concentration associated with the sulforhodamine B peak must be at least 3 times the detection limit. For the RF-5000U, the detection limit in elutant samples is 0.150 ppb, thus this dye concentration limit equals 0.450 ppb. For the RF-5301, the detection limit in elutant samples is 0.080 ppb, thus this dye concentration limit equals 0.240 ppb.

Criterion 3. The dye concentration must be at least 10 times greater than any other concentration reflective of background at the sampling station in question.

Criterion 4. The shape of the fluorescence peak must be typical of sulforhodamine B. In addition, there must be no other factors which suggest that the fluorescence peak may not be dye from the groundwater tracing work under investigation.

Normal Criteria Used by the Ozark Underground Laboratory for Determining Positive Sulforhodamine B dye Recoveries in Water Samples.

The following criteria are used to identify fluorescence peaks which are deemed to be sulforhodamine B dye in water.

Criterion 1. The associated charcoal samplers for the station should also contain sulforhodamine B dye in accordance with the criteria listed earlier. These criteria may be waived if no charcoal sampler exists.

Criterion 2. There must be no factors which suggest that the fluorescence peak may not be sulforhodamine B dye from the tracing work under investigation. For samples analyzed with the RF-5000U, the fluorescence peak should generally be in the range of 576.2 to 579.7 nm. For samples analyzed with the RF-5301, the fluorescence peak should generally be in the range of 580.1 to 583.7 nm.

Criterion 3. The dye concentration associated with the fluorescence peak must be at least three times the detection limit. For samples analyzed on the RF-5301 the detection limit in water is 0.008 ppb, thus this dye concentration limit equals 0.024 ppb. For samples analyzed on the RF-5000U the detection limit in water samples is 0.040 ppb, thus this dye concentration limit equals 0.120 ppb.

Normal Criteria Used by the Ozark Underground Laboratory for Determining Positive Pyranine Dye Recoveries in Elutants from Charcoal Samplers.

It must be remembered that the analysis protocol for pyranine dye is different than the protocol for the other four dyes discussed in this document. If the other dyes are present in a sample analyzed for pyranine dye their emission fluorescence peaks (if any) will be appreciably different than the values presented above. Because of this, there is very little analytical interference between fluorescein and pyranine dyes when both are present in a sample.

There is often some detectable fluorescence background encountered in the general range of pyranine dye in groundwater tracing studies. The following four criteria are used to identify fluorescence peaks which are deemed to be pyranine.

Criterion 1. For samples analyzed on the RF-5000U, there must be at least one fluorescence peak at the station in question in the range of 500.4 to 504.6 nm. The acceptable range for samples analyzed on the RF-5301 is 502.1 to 508.1 nm.

Criterion 2. The dye concentration associated with the pyranine dye peak must be at least 3 times the detection limit. For the RF-5000U, the detection limit in elutant samples is 0.055 ppb, thus this dye concentration limit equals 0.165 ppb. For the RF-5301, the detection limit in elutant samples is 0.015 ppb, thus this dye concentration limit equals 0.045 ppb.

Criterion 3. The dye concentration must be at least 10 times greater than any other concentration reflective of background at the sampling station in question.

Criterion 4. The shape of the fluorescence peak must be typical of pyranine dye. In addition, there must be no other factors which suggest that the fluorescence peak may not be dye from the groundwater tracing work under investigation.

Normal Criteria Used by the Ozark Underground Laboratory for Determining Positive Pyranine Dye Recoveries in Water Samples.

It must be remembered that the analysis protocol for pyranine dye is different than the protocol for the other four dyes discussed in this document. If the other dyes are present in a sample analyzed for pyranine dye their emission fluorescence peaks (if any) will be appreciably different than the values presented above. Because of this, there is very little analytical interference between fluorescein and pyranine dyes when both are present in a sample.

The fluorescence of pyranine decreases below a pH of about 9.5. Prior to analysis water samples are placed in a high ammonia atmosphere for at least two hours. A pyranine dye in water standard is placed in the same atmosphere as the samples. Prior to analysis samples are tested to insure that their pH is 9.5 or greater. If pyranine dye concentrations in a sample are so great as to require dilution for quantification of the dye concentration the diluting water used is OUL reagent water which has been pH adjusted in a high ammonia atmosphere.

The following criteria are used to identify fluorescence peaks which are deemed to be pyranine dye in water.

Criterion 1. The associated charcoal samplers for the station should also contain pyranine dye in accordance with the criteria listed earlier. These criteria may be waived if no charcoal sampler exists.

Criterion 2. There must be no factors which suggest that the fluorescence peak may not be pyranine dye from the tracing work under investigation. For samples analyzed with the RF-5000U, the fluorescence peak should generally be in the range of 501.2 to 505.2 nm. For samples analyzed with the RF-5301, the fluorescence peak should generally be in the range of 504.1 to 510.1 nm.

Criterion 3. The dye concentration associated with the fluorescence peak must be at least three times the detection limit. For samples analyzed on the RF-5301 the detection limit in water is 0.010 ppb, thus this dye concentration limit equals 0.030 ppb. For samples analyzed on the RF-5000U the detection limit in water samples is 0.030 ppb, thus this dye concentration limit equals 0.090 ppb.

Appendix D

Sampling Station Index
and
Karst Feature Index

Appendix D - Table D-2 - Sampling Station Index

Station Number	Station Name	North Latitude	West Longitude	Elevation (feet msl)
1				768
2				768
3				741
4				692
5				782
6				597
7				703
8				704
9				634
10				734
11				656
12				638
13				658
14				664
15				709
16				711
17				787
18				774
19				763
20				770
21				790
22				779
23				771
24				766
25				790
26				790
27				827
28				828
29				848
30				794
31				816
32				802
33				794
34				795
35				786
36				818
37				812
38				812
39				801
40				842
41				848
42				764
43				718
44				722
45				740
46				798
47				786
48				674
49				761
50				759

Station Number	Station Name	North Latitude	West Longitude	Elevation (feet msl)
51				738
52				712
53				711
54				680
55				665
56				698
57				702
58				738
59				747
60				816
61				832
62				773
63				733
64				812
65				838
66				832
67				646
68				602
69				662
70				734
71				732
72				744
73				654
74				667
75				704
76				713
77				unknown
78				781
79				790
80				636
81				604
82				669
83				670
84				681
85				670
86				650
87				650
88				688
89				680
90				670
91				688
92				740
93				734
94				729
95				708
96				728
97				741
98				734
99				702
100				710

Station Number	Station Name	North Latitude	West Longitude	Elevation (feet msl)
101				728
102				700
103				708
104				683
105				727
106				713
107				706
108				746
109				750
110				767
111				762
112				750
113				737
114				736
115				704
116				742
117				575
118				715
119				729
120				744
121				733
122				762
123				790
124				656
125				655
126				646
127				625
128				600
129				601
130				586
131				578
132				576
133				574
134				743
135				754
136				721
137				736
138				741
139				722
140				713
141				753
142				718
143				724
144				728
145				720
146				746
147				736
148				730
149				714
150				696
151				769
152				686

Station Number	Station Name	North Latitude	West Longitude	Elevation (feet msl)
153				636
154				629
155				634
156				671
157				665
158				695
159				686
160				611
161				612
162				672
163				683
164				
165				668
166				680
167				680
168				673
169				668
170				691
171				668
172				645
173				670
174				670
175				703
176				688
177				684
178				684
179				672
180				676
181				656
182				712
183				597
184				573
185				569
186				586
187				583
188				772
189				684
190				634
191				612
192				716
193				740
194				753
195				765
196				772
197				753
198				769
199				754
200				710
201				646
202				644
203				637

Station Number	Station Name	North Latitude	West Longitude	Elevation (feet msl)
204				688
205				663
206				716

Appendix D - Table D-2 - Karst Insurgence Feature Index

Karst Feature ID No.	Low Rim Elev, (feet MSL)	High Rim Elev. (feet MSL)	Invert Elev. (feet MSL)	Depth (feet)	Feature Type	Drain-age Area (Acres)	Karst Feature ID No.	Low Rim Elev, (feet MSL)	High Rim Elev. (feet MSL)	Invert Elev. (feet MSL)	Depth (feet)	Feature Type	Drain-age Area (Acres)
500001	663	800	663	NA	losing stream	326.79	500038	NA	NA	NA	NA	buried sink	0.77
500002	759	783	757.8	1.2	sinkhole	0.35	500039	746	764	745	1	sinkhole	0.31
500003	752	768	750	2	sinkhole	0.18	500040	NA	NA	NA	NA	buried sink	1.80
500004	766	790	763.4	2.6	sinkhole	1.69	500041	734	758	732	2	sinkhole	0.42
500005	758	788	746.5	11.5	sinkhole	2.32	500042	740	756	738	2	sinkhole	0.50
500006	730	749	728	2	sinkhole	0.30	500043	770	780	730		sinkhole	27.19
500007	728	741	726	2	sinkhole	1.41	500044	744	758	743.2	0.8	sinkhole	0.13
500008	727	731	726	1	sinkhole	0.05	500045	770	791	766	4	sinkhole	0.57
500009	738	767	736	2	sinkhole	0.46	500046	755	788	754	1	sinkhole	0.57
500010	732	748	731	1	sinkhole	0.24	500047	755	787	754	1	sinkhole	0.31
500011	729	731	728	1	sinkhole	0.02	500048	750	788	748	2	sinkhole	0.54
500012	789	793	788	1	sinkhole	0.80	500049	762	788	760	2	sinkhole	0.40
500013	741	760	740	1	sinkhole	0.30	500050	775	780	750	25	sinkhole	6.71
500014	748	761	747	1	sinkhole	0.41	500051	780	788	762.7	17.3	sinkhole	9.11
500015	755	769	754	1	sinkhole	0.32	500052	761	789	760	1	sinkhole	0.54
500016	744	758	742	2	sinkhole	0.51	500053	727	800	724	3	sinkhole	12.82
500017			outside		sinkhole	10.33	500054	780	786	778	2	sinkhole	0.59
500018	769	790	766.9	2.1	sinkhole	1.21	500055	773	788	770	3	sinkhole	0.21
500019	730	750	729	1	sinkhole	0.67	500056	772	808	726	46	sinkhole	33.01
500020	732	742	730	2	sinkhole	0.07	500057	744	786	742	2	sinkhole	3.63
500021	770	776	765.8	4.2	sinkhole	0.41	500058	768	800	766	2	sinkhole	1.47
500022	735	786	734	1	sinkhole	1.28	500059	766	772	763	3	sinkhole	0.29
500023	745	755	742	3	sinkhole	0.14	500060	767	782	766	1	sinkhole	0.66
500024	750	762	748	2	sinkhole	0.10	500061	682	686	681	1	sinkhole	74.96
500025	766	790	749.3	16.7	sinkhole	3.17	500062	767	780	764	3	sinkhole	1.21
500026	747	755	746	1	sinkhole	0.07	500063	773	780	771	2	sinkhole	0.64
500027	752	771	751	1	sinkhole	0.21	500064	754	756	752	2	sinkhole	0.05
500028	746	753	745	1	sinkhole	0.08	500065	767	776	763	4	sinkhole	0.27
500029	758	790	756	2	sinkhole	0.50	500066	770	801	766	6	sinkhole	2.28
500030	745	750	730	15	sinkhole	4.06	500067	768	808	752	16	sinkhole	15.47
500031	762	788	759	3	sinkhole	0.50	500068	762	790	751.8	10.2	sinkhole	3.79
500032	742	754	741	1	sinkhole	0.21	500069	766	768	763	3	sinkhole	0.06

Karst Feature ID No.	Low Rim Elev, (feet MSL)	High Rim Elev. (feet MSL)	Invert Elev. (feet MSL)	Depth (feet)	Feature Type	Drain-age Area (Acres)	Karst Feature ID No.	Low Rim Elev, (feet MSL)	High Rim Elev. (feet MSL)	Invert Elev. (feet MSL)	Depth (feet)	Feature Type	Drain-age Area (Acres)
500033	750	760	740	10	sinkhole	2.87	500070	786	789	783	3	sinkhole	0.19
500034	NA	NA	NA	NA	buried sink	1.00	500071	784	802	782	2	sinkhole	0.67
500035	764	784	762.4	1.6	sinkhole	0.66	500072	787	794	786	1	sinkhole	0.17
500036	766	786	765	1	sinkhole	0.25	500073	764	800	762	2	sinkhole	1.70
500037	750	794	749	1	sinkhole	1.44	500074	NA	NA	NA	NA	buried sink	0.89
500075	806	812	796	10	sinkhole	0.75	500109	813	824	802.9	10.1	sinkhole	1.23
500076	798	822	785.7	12.3	sinkhole	24.20	500110	765	768	764	1	sinkhole	0.02
500077	736	822	734	2	sinkhole	29.19	500111	825	830	810		sinkhole	8.31
500078	812	822	798	14	sinkhole	5.43	500112	772	786	768	4	sinkhole	0.22
500079	823	834	818	5	sinkhole	2.98	500113	806	822	801	5	sinkhole	5.99
500080	770	776	767.3	2.7	sinkhole	0.18	500114	763	784	762	1	sinkhole	0.27
500081	812	832	803.7	8.3	sinkhole	3.39	500115	753	766	752	1	sinkhole	0.08
500082	814	827	803.2	10.8	sinkhole	4.26	500116	752	768	751	1	sinkhole	0.22
500083	767	809	760.5	6.5	sinkhole	0.51	500117	771	776	769	2	sinkhole	0.04
500084/ 500096	810	828	807.6	2.4	sinkhole	2.18	500118	806	821	805.4	0.6	sinkhole	0.68
500085	812	822	809.5	2.5	sinkhole	3.12	500119			outside		sinkhole	0.46
500086		880	outside		sinkhole	1.12	500120	806	820	803.7	2.3	sinkhole	1.14
500087	814	834	813.8	0.2	sinkhole	3.40	500121	805	820	803	2	sinkhole	1.29
500088	803	822	801	2	sinkhole	2.29	500122		880	outside		sinkhole	0.35
500089	825	830	810	15	sinkhole	7.59	500123		880	outside		sinkhole	0.17
500090	839	850	830	9	sinkhole	2.84	500124		880	outside		sinkhole	0.09
500091	NA	NA	NA	NA	buried sink	0.89	500125	825	830	800		sinkhole	6.09
500092	810	827	800.7	9.3	sinkhole	3.75	500126	753	767	outside		sinkhole	0.31
500093	804	813	802	2	sinkhole	5.33	500127	777	799	775	1	sinkhole	0.37
500094	NA	NA	NA	NA	buried sink	8.36	500128	825	830	805	20	sinkhole	4.68
500095	845	850	830		sinkhole	2.80	500129		820	outside		sinkhole	0.00
500096/ 500084	810	828	807.6	2.4	sinkhole	2.18	500130			outside		sinkhole	0.40
500097	840	845	820		sinkhole	5.43	500131			outside		sinkhole	0.09
500098	802	814	797.3	4.7	sinkhole	3.48	500132	823	845	803	20	sinkhole	2.90
500099	NA	NA	NA	NA	buried sink	6.69	500133	830	837	818.5	11.5	sinkhole	9.07
500100	771	779	769	2	sinkhole	0.02	500134	NA	NA	NA	NA	buried sink	1.97
500101	785	798	783	2	sinkhole	0.34	500135	801	832	800	1	sinkhole	0.88
500102	790	814	784	6	sinkhole	1.65	500136		780	outside		sinkhole	0.02
500103	766	786	765	1	sinkhole	0.13	500137	NA	NA	NA	NA	buried sink	1.05
500104	770	792	768	2	sinkhole	0.27	500138	NA	NA	NA	NA	buried sink	4.85
500105	767	788	766	1	sinkhole	0.26	500139	NA	NA	NA	NA	buried sink	1.51
500106	767	786	766	1	sinkhole	0.31	500140	NA	NA	NA	NA	buried sink	3.92

Karst Feature ID No.	Low Rim Elev, (feet MSL)	High Rim Elev. (feet MSL)	Invert Elev. (feet MSL)	Depth (feet)	Feature Type	Drain-age Area (Acres)	Karst Feature ID No.	Low Rim Elev, (feet MSL)	High Rim Elev. (feet MSL)	Invert Elev. (feet MSL)	Depth (feet)	Feature Type	Drain-age Area (Acres)
500107	759	776	758	1	sinkhole	0.17	500141	NA	NA	NA	NA	buried sink	0.82
500108	762	774	761	1	sinkhole	0.12	500142	828	834	814	14	sinkhole	6.17
500143	NA	NA	NA	NA	buried sink	11.07	500175	880	905	870	10	sinkhole	8.64
500144	NA	NA	NA	NA	buried sink	0.78	500176	868	907	852.7	15.3	sinkhole	15.00
500145	NA	NA	NA	NA	buried sink	0.87	500177	868	893	858.5	9.5	sinkhole	5.42
500146	NA	NA	NA	NA	buried sink	0.67	500178	851	900	848	3	sinkhole	1.83
500147	NA	NA	NA	NA	buried sink	1.15	500179	NA	NA	NA	NA	buried sink	10.90
500148	NA	NA	NA	NA	buried sink	2.15	500180	NA	NA	NA	NA	buried sink	0.41
500149	NA	NA	NA	NA	buried sink	2.39	500181	798	804	797	1	sinkhole	0.06
500150	NA	NA	NA	NA	buried sink	3.05	500182	802	822	800	2	sinkhole	0.09
500151	840	843	839.2	0.8	sinkhole	0.40	500183	809	826	807	2	sinkhole	0.11
500152	NA	NA	NA	NA	buried sink	5.37	500184	805	823	803	2	sinkhole	0.19
500153	850	868	848	2	sinkhole	1.44	500185	805	827	803	2	sinkhole	0.28
500154	832	852	812.3	19.7	sinkhole	7.80	500186	812	834	810	2	sinkhole	0.48
500155	847	852	843	4	sinkhole	0.39	500187	700	920	700		losing stream	1475.39
500156	NA	NA	NA	NA	buried sink	4.00	500188			outside		sinkhole	0.01
500157	845	847	839	6	sinkhole	0.55	500189			outside		sinkhole	0.01
500158	834	852	828.2	5.8	sinkhole	1.05	500190			outside		sinkhole	0.01
500159	842	858	830	12	sinkhole	4.20	500191	792	796	791	1	sinkhole	0.03
500160	841	844	839	2	sinkhole	0.12	500192	796	799	795	1	sinkhole	0.02
500161	848	853	842	2	sinkhole	1.53	500193			outside		sinkhole	0.03
500162	837	846	835	2	sinkhole	0.35	500194	790	805	798	2	sinkhole	0.35
500163	832	890	828.7	3.3	losing stream	280.60	500195	803	806	801	2	sinkhole	0.03
500164	866	880	856	10	sinkhole	12.54	500196	791	804	789	2	sinkhole	0.43
500165	871	882	868	3	sinkhole	3.96	500197			outside		sinkhole	0.06
500166	878	922	876	2	sinkhole	3.22	500198	800	807	798.3	1.7	sinkhole	0.12
500167	870	920	866	4	sinkhole	8.70	500199	788	804	785.7	2.3	sinkhole	0.87
500168	868	898	864	4	sinkhole	29.06	500200	792	795	790	2	sinkhole	0.03
500169	864	889	856	8	sinkhole	2.60	500201	791	808	789	2	sinkhole	0.32
500170	879	881	877	2	sinkhole	1.40	500202	806	814	805	1	sinkhole	0.03
500171	873	910	854	19	sinkhole	19.90	500203			outside		sinkhole	0.17

Karst Feature ID No.	Low Rim Elev, (feet MSL)	High Rim Elev. (feet MSL)	Invert Elev. (feet MSL)	Depth (feet)	Feature Type	Drain-age Area (Acres)	Karst Feature ID No.	Low Rim Elev, (feet MSL)	High Rim Elev. (feet MSL)	Invert Elev. (feet MSL)	Depth (feet)	Feature Type	Drain-age Area (Acres)
500172	869	910	866.3	2.7	sinkhole	3.16	500204	808	810	807	1	sinkhole	0.01
500173	864	886	843.1	20.9	sinkhole	32.14	500205	788	792	786	2	sinkhole	0.10
500174	NA	NA	NA	NA	buried sink	1.80	500206	812	814	810	2	sinkhole	0.02
500207	794	798	792	2	sinkhole	0.14	500252	715	720	713	2	sinkhole	0.26
500208	809	810	808	1	sinkhole	0.01	500253	699	708	695	4	sinkhole	0.14
500209	732	757	733	1	sinkhole	1.67	500254	720	733	718	2	sinkhole	0.37
500210	801	803	800	1	sinkhole	0.02	500255	704	718	703.5	0.5	sinkhole	0.15
500211	799	804	798	2	sinkhole	0.04	500256	720	723	719	1	sinkhole	0.06
500212	806	811	804	2	sinkhole	0.04	500257	721	728	719	2	sinkhole	0.18
500213	802	809	800	2	sinkhole	0.06	500258	703	720	701	2	sinkhole	0.23
500214	796	806	794	2	sinkhole	0.13	500259	701	708	699	2	sinkhole	0.09
500215	754	774	756	2	sinkhole	0.56	500260	707	718	703	4	sinkhole	0.34
500216	808	809	806	2	sinkhole	0.02	500261	703	713	701	2	sinkhole	0.13
500217	800	806	799	1	sinkhole	0.05	500262	712	715	711	1	sinkhole	0.04
500218	796	802	795	1	sinkhole	0.05	500263	708	721	706	2	sinkhole	0.31
500219	796	800	795	1	sinkhole	0.04	500264	724	727	723	1	sinkhole	0.56
500220	792	795	791	1	sinkhole	0.02	500265	709	724	708	1	sinkhole	1.48
500221	793	796	792	1	sinkhole	0.04	500266	704	723	702	2	sinkhole	1.14
500222	788	791	786	2	sinkhole	0.09	500267	707	726	704	3	sinkhole	1.00
500223	788	790	786	2	sinkhole	0.06	500268	701	710	699	2	sinkhole	0.29
500224	787	800	785	2	sinkhole	0.50	500269	708	720	706	2	sinkhole	0.97
500225	784	804	782.9	1.1	sinkhole	1.21	500270	737	752	736.5	0.5	sinkhole	0.36
500226	775	789	772.5	2.5	sinkhole	0.27	500271	746	746	744	1.5	sinkhole	0.01
500227	788	808	786	2	sinkhole	0.21	500272	742	747	739.5	2.5	sinkhole	0.22
500228	789	807	786	3	sinkhole	0.34	500273	768	783	760	8	sinkhole	0.29
500229	799	802	797	2	sinkhole	0.03	500274			outside		sinkhole	0.51
500230	770	784	767	3	sinkhole	0.17	500275	770	790	760	10	sinkhole	0.79
500231	702	714	700	2	sinkhole	0.32	500276	742	748	741.5	0.5	sinkhole	0.03
500232	719	730	717	2	sinkhole	0.16	500277	740	743	738	2	sinkhole	0.11
500233	730	742	727.5	2.5	sinkhole	4.48	500278	752	768	744	8	sinkhole	0.50
500234	714	724	713.4	0.6	sinkhole	0.93	500279	763	773	762.2	0.8	sinkhole	0.47
500235	717	732	716.5	0.5	sinkhole	0.14	500280	755	776	754	1	sinkhole	1.33
500236	706	725	703	3	sinkhole	0.67	500281	758	770	748	10	sinkhole	0.24
500237	705	718	703	2	sinkhole	0.23	500282	739	759	736	3	sinkhole	0.42
500238	709	738	707	2	sinkhole	1.61	500283	780	786	778	2	sinkhole	0.56
500239	711	736	708	3	sinkhole	0.58	500284	778	784	775.1	2.9	sinkhole	1.42
500240	696	703	694	2	sinkhole	0.12	500285	745	764	743.5	1.5	sinkhole	0.30
500241	698	698	697	1	sinkhole	0.00	500286	759	760	758	0.5	sinkhole	0.23
500242	678	706	676	2	sinkhole	0.25	500287	746	752	744	2	sinkhole	0.17
500243	721	731	719	2	sinkhole	1.87	500288	755	778	754	1	sinkhole	0.42
500244	698	720	697	1	sinkhole	0.19	500289	755	756	745.5	0.5	sinkhole	0.01
500245	724	730	720.7	3.3	sinkhole	2.01	500290	755	756	745.5	0.5	sinkhole	0.01
500246	701	706	699	1	sinkhole	0.15	500291	779	786	778	1	sinkhole	0.72
500247	721	732	720	1	sinkhole	0.30	500292	780	795	777	3	sinkhole	0.23
500248	715	733	713	2	sinkhole	0.78	500293	753	754	752	1	sinkhole	0.46

Karst Feature ID No.	Low Rim Elev, (feet MSL)	High Rim Elev. (feet MSL)	Invert Elev. (feet MSL)	Depth (feet)	Feature Type	Drain-age Area (Acres)	Karst Feature ID No.	Low Rim Elev, (feet MSL)	High Rim Elev. (feet MSL)	Invert Elev. (feet MSL)	Depth (feet)	Feature Type	Drain-age Area (Acres)
500249	715	736	713	2	sinkhole	2.05	500294	789	791	788	1	sinkhole	0.01
500250	717	729	715	2	sinkhole	0.01	500295	792	795	789	2.5	sinkhole	0.04
500251	722	732	718	4	sinkhole	0.14	500296	785	795	783	2	sinkhole	0.34
500297	780	795	772	8	sinkhole	0.38	500340	754	774	753	1	sinkhole	0.42
500298	780	793	778	2	sinkhole	0.20	500341	782	795	777.3	4.7	sinkhole	3.44
500299	792	794	790	2	sinkhole	0.01	500342	762	804	760	2	sinkhole	6.29
500300	782	783	781	1	sinkhole	0.01	500343	774	778	768	6	sinkhole	1.10
500301	784	800	782	2	sinkhole	0.21	500344	770	774	768.7	1.3	sinkhole	0.05
500302	784	787	782.5	1.5	sinkhole	0.08	500345	769	774	764	5	sinkhole	0.07
500303	789	803	787	2	sinkhole	0.29	500346	783	784	781	2	sinkhole	0.00
500304	786	796	783.5	2.5	sinkhole	0.11	500347	780	786	777	3	sinkhole	0.14
500305	789	798	788	1	sinkhole	0.07	500348			outside		sinkhole	0.04
500306	790	794	788.5	1.5	sinkhole	0.04	500349	772	774	770.5	1.5	sinkhole	0.06
500307	791	804	788	3	sinkhole	0.18	500350			outside		sinkhole	0.52
500308	780	788	778	2	sinkhole	0.07	500351			outside		sinkhole	0.60
500309	781	789	779	2	sinkhole	0.05	500352			outside		sinkhole	0.53
500310	755	766	752	3	sinkhole	1.41	500353	778	780	776	2	sinkhole	0.14
500311	790	797	788	2	sinkhole	0.07	500354	770	800	757.9	12.1	sinkhole	35.35
500312	775	777	773.5	1.5	sinkhole	0.03	500355			outside		sinkhole	0.03
500313	775	778	773	2	sinkhole	0.05	500356			outside		sinkhole	0.17
500314	777	777	774	3	sinkhole	0.02	500357	768	798	763.1	4.9	sinkhole	12.99
500315	777	777	774	3	sinkhole	0.02	500358	780	796	779	1	sinkhole	3.15
500316	777	777	776	1	sinkhole	0.01	500359	778	783	775.3	2.7	sinkhole	0.36
500317	778	778	776.5	1	sinkhole	0.01	500360	770	782	766.8	3.2	sinkhole	0.97
500318	775	806	772	4	sinkhole	3.97	500361	770	771	769	1	sinkhole	0.01
500319	778	779	776	2.2	sinkhole	0.03	500362	778	780	776	2	sinkhole	0.06
500320	780	781	779	1	sinkhole	0.01	500363	782	786	780.5	1.5	sinkhole	0.02
500321	778	778	778	0.1	sinkhole	0.00	500364	779	794	776	3	sinkhole	0.58
500322	779	780	778	1	sinkhole	0.01	500365	781	790	779	2	sinkhole	0.34
500323	779	780	777	1.7	sinkhole	0.01	500366	787	794	783	4	sinkhole	0.38
500324	765	767	764	1	sinkhole	0.01	500367	802	804	800	2	sinkhole	0.04
500325	762	764	760.5	1.5	sinkhole	0.01	500368	800	804	778	2	sinkhole	0.20
500326	780	783	778	2	sinkhole	0.03	500369	786	806	780.3	5.7	sinkhole	7.83
500327	781	782	780	1	sinkhole	0.00	500370	792	800	791	1	sinkhole	0.09
500328	783	790	781	2	sinkhole	0.08	500371			outside		sinkhole	0.45
500329	758	771	755	3	sinkhole	0.10	500372	783	790	778	5	sinkhole	0.35
500330	787	799	783	4	sinkhole	0.44	500373	NA	NA	NA	NA	buried sink	1.96
500331	764	776	761	3	sinkhole	0.42	500374	790	790	789	1	sinkhole	0.19
500332	756	757	755	1	sinkhole	0.02	500375	NA	NA	NA	NA	buried sink	3.53
500333	756	757	755	1	sinkhole	0.01	500376	791	809	778	13	sinkhole	14.42
500334	756	757	755	1	sinkhole	0.01	500377	810	835	801	9	sinkhole	3.87
500335	757	757	756	1	sinkhole	0.01	500378	745	750	743	2	sinkhole	0.02
500336	756	778	755	1	sinkhole	2.08	500379	783	814	780	3	sinkhole	0.57

Karst Feature ID No.	Low Rim Elev, (feet MSL)	High Rim Elev. (feet MSL)	Invert Elev. (feet MSL)	Depth (feet)	Feature Type	Drain-age Area (Acres)	Karst Feature ID No.	Low Rim Elev, (feet MSL)	High Rim Elev. (feet MSL)	Invert Elev. (feet MSL)	Depth (feet)	Feature Type	Drain-age Area (Acres)
500337	762	774	761.3	0.7	sinkhole	0.46	500380	761	763	760.5	0.5	sinkhole	0.00
500338	753	755	752	1	sinkhole	0.04	500381			outside		sinkhole	0.06
500339	762	774	760.4	1.6	sinkhole	0.50	500382			outside		sinkhole	0.07
500383			outside		sinkhole	0.16	500392	880	896	878	2	sinkhole	3.58
500384			outside		sinkhole	0.10	500393	857	895	848	9	sinkhole	10.06
500385			outside		sinkhole	0.14	500394	760	764	759	1	sinkhole	0.06
500395	735	740	734	1	sinkhole	0.02	500395	735	740	734	1	sinkhole	0.02
500396	730	737	728	2	sinkhole	0.02	500401	754	773	752	2	sinkhole	0.47
500397	725	731	724	1	sinkhole	0.05	500402	750	758	748	2	sinkhole	0.50
500398	720	732	718	2	sinkhole	0.10	500403	742	750	741	1	sinkhole	0.29
500399	718	722	717	1	sinkhole	0.03	500404	707	748	705	2	sinkhole	1.31
500400	758	773	756	2	sinkhole	0.26	500405	703	707	702	1	sinkhole	0.11
500386			outside		sinkhole	0.19	500406	816	839	813	3	sinkhole	0.20
500387			outside		sinkhole	0.16	500407	822	846	815	7	sinkhole	0.29
500388	867	884	850	17	sinkhole	6.02	500408	819	843	817	2	sinkhole	0.09
500389	848	922	840	8	sinkhole	13.07	500409	827	831	826	1	sinkhole	0.05
500390	863	922	850	13	sinkhole	11.81	500410	799	867	798	1	losing stream	7.88
500391	847	896	838	9	sinkhole	7.72	500411	754	816	752	2	losing stream	10.57

Appendix E

Karst Photographs
Redacted for confidential reasons related to karst.

Appendix F

Individual Dye Trace Reports

Introduction to Appendix F

The purpose of Appendix F is to summarize data on the 41 groundwater traces conducted in the Section 5 area. Dyes for the first group of 28 traces (Trace Numbers 04-01 through 05-28) were introduced in 2004-2005. Dyes for the second group of 13 traces were introduced in 2008-2009.

Each of the dye traces is discussed separately. The discussions include a description of where and how each dye introduction was made and identify the type and quantity of tracer dye used. Where potable water was used with the dye introduction the quantity is identified. A rationale for conducting each of the dye traces is also included.

A total of 205 sampling stations were established and numbered in consecutive order. There was no Station 164. The station numbers where dye derived from a particular trace was detected in one or more activated carbon samplers and in one or more grab samples of water is identified.

The focus of the tracing work was to identify springs that received recharge water from the individual dye introductions. Streams in the area were routinely sampled to ensure that no spring discharge points were missed. As a result of the stream sampling a number of previously undocumented springs were identified.

A figure has been prepared for each trace made during the main investigation showing the dye introduction point and the diagrammatic groundwater flow path followed by the dye to the spring or springs from which the dye discharged. The diagrammatic flow is shown as a straight line; the actual flow route is unknown but is certainly not a straight line. A single figure showing all of the relevant traces used to delineate the includes the last 13 traces.

Primary sampling reliance in the groundwater tracing study was placed on activated carbon samplers and secondary reliance was on grab samples of water. The activated carbon samplers are continuous samplers that accumulate passing tracer dyes by adsorption rather than filtration. The amount of dye detected when a carbon sampler is analyzed in the laboratory is a function of the concentration of dye in the passing water. The velocity of the passing water has a negligible effect on the amount of dye collected in the activated carbon sampler.

Tables are routinely provided showing a few of the earlier dye detections in activated carbon samplers from the spring sampling stations where dye from the particular trace was detected. All results are reported in Appendix B Other sampling stations that had dye detection associated with a given trace and derived their dye detections from the station or stations shown in the tables, are listed in geographic order.

One can sum dye concentrations at a spring to estimate the time at which a particular percent of the total dye detected at the spring discharged from the spring. Estimates of 50% and 90% of total dye discharge are commonly useful. Such estimation requires that the flow rates of the spring be estimated for the period during which dye discharged from the spring. These estimates can be useful in dealing with spills or discharges of materials potentially harmful to groundwater quality that occur at or near the feature traced to the spring.

The estimated number of days after dye introduction that dye from a particular trace was detectable in activated carbon samplers at receiving springs is potentially a very useful value for assessing contamination issues involving contaminants with transport characteristics similar to the tracer dyes. The following assumptions have been used in calculating these values:

- The values use the last date that an activated carbon sampler positive for the dye was in place at the sampling station. This applies even if there are intervening samples where dye was not detected.
- If the last sample collected does not fully meet the criteria for a positive dye detection professional judgment is used to determine the last date for dye detection. It is not uncommon for dye

deterioration to result in samples collected near the end of a dye trace not fully meeting positive detection criteria.

- If the last sampler collected from a sampling station was positive for the tracer dye then the number of days shown is prefaced by the symbol for greater than (>).

The discussions of the individual traces include explanatory information as necessary and summarize important findings from the particular traces.

Table F-1
Individual Dye Trace Summary Table

Trace No.	Trace Name	Figure No.	Karst Area	Input Feature No.	Dye Input Date/Time	Input Elevation (feet MSL)	Dye Type	Dye Quantity (lbs)	Water Used (gallons or gpm)	Precipitation/ Conditions	First Detection Station No./Name	Additional Dye Detection Stations No./Name	Time of Travel (1st detection)	Dye Detection Duration	Dye Trace Length (feet)	1st . Detection Station Elevation	Trace Elevation Loss (feet)	Mean Gradient (feet/mile)	Minimim Mean Velocity (feet per day)	Comments
04-01		F-1	Bloom. Karst	178	6-15-04 @ 0807	810	eosine	1	15,000	Rain after input			<1 day	>216 days	535	790	20	197	5,718	Detected dye at Station 19; dye was later detected at Station 78 once it was established. Velocity derived from Station 54 detection.
04-02		F-2	Bloom. Karst	91	6-15-04 @ 0938	800	rhodamine WT	2	13,000	Rain after input			8 hours	<33 days	2,616	712	88	178	8,710	Velocity derived from Station 12 detection.
04-03		F-3	Bloom. Karst	190	6-30-04	852	eosine	2	dry set	dry			1 day	>255 days	1,617	794	58	189	2,097	Veleocity derived from Station 4 detection and runoff-producing rain on 7/4/04.
04-04	Trace	F-4	Bloom. Karst	102	7/26/04 @ 0757	802	eosine	2	0.5 gpm storm runoff, & 2,000	Rain			<1 day	>176 days	2,940	712	90	162	10,462	Velocity derived from Station 68 detection.
04-05	Trace	F-5	Bloom. Karst	174	7-26-04 @ 0848	814	rhodamine WT	1	7,000				11 hours	>176 days	802	774	40	263	1,813	Veleocity derived from Station 16 detection.
04-06	Trace	F-6	Bloom. Karst	ss3	8-30-04 @ 1215	840	rhodamine WT	1	20 gpm from pond			Rd.	<1 day	<98 days	1,631	781	59	191	9,910	
04-07		F-7	Bloom. Karst	64	9-10-04 @ 1132	786	fluorescein	.33	6,000				11 days	>210 days	1,604	681	105	346	147	
													2 days	<68 days	1,911	712	74	204	783	Velocity based on Stations 12 and 85 detections.
													18 days	>210 days	2,155	670	116	284	120	
04-08		F-8	Bloom. Karst	99	9-10-04 @ 1203	750	rhodamine WT	1	2,000	drought			27 days	>210 days	2,128	667	83	206	78	Velocity derived from Station 67 detection.
04-09	Trace	F-9	Bloom. North Karst	ss5	9-30-04 @ 1838	715	rhodamine WT	2	15 gpm creek flow	drought			6 days	<189 days	5,325	650	65	64	949	Figure 21 does not show Station 4 as a detection point; however, dye was detected there once surface flows had resumed. Velocity based on Station 87 detection.
04-10	Trace	F-10	Bloom. Karst	192	12-1-04 @ 1425	853	eosine	4	1 gpm storm runoff	storm response			2 days	<90 days	2,968	816	37	66	1,475	
04-11	Trace	F-11	Bloom. Karst	ss1	12-7-04 @ 1226	765	eosine	3	10 gpm storm runoff				13 days	>122 days	2,760	674	91	174	214	This was a losing stream dye trace.
													14 days	>122 days	5,971	654	111	98	425	
05-12		F-12	Bloom. Karst	52	1-5-05 @ 1736	766	sulforhodamine B	3	8 gpm storm runoff				<5 days	<51 days	4,075	674	92	119	833	
05-13		F-13	Bloom. Karst	446	1-13-05 @ 1522	810	fluorescein	0.5	3 gpm storm runoff				<5 days	>43 days	3,210	711	99	163	660	
05-14	Trace	F14	Bloom. North Karst	272	1-13-05 @ 1540	728	fluorescein	0.67	4 gpm storm runoff				<1 day	>92 days	693	688	40	305	2,371	Velocity base on Station 87 dectection.
05-15	Trace	F-15	Simpson Chapel Karst	433	2-3-05 @ 1710	760	fluorescein	1	4,000				<6 hours	<68 days	1,094	736	24	116	5,276	Velocity base on Station 128 water sample detection.
05-16		F-16	Simpson Chapel Karst	423	2-4-05 @ 0842	770	rhodamine WT	1	2 gpm				<1 day	>74 days	792	729	41	273	1,483	Figure 28 does not show Station 132 because it is too far west to appear at the figure's scale. Velocity based on Station 132 detection.
05-17		F-17	Bloom. Karst	67	2-28-05 @ 1137	766	rhodamine WT	0.5	2,000				1 day	>39 days	927	674	92	524	893	
05-18		F-18	Bloom. Karst	38	2-28-05 @ 1322	765	eosine	0.5	dry set & 2,000				<1 day	>39 days	770	713	52	357	3,073	Dye was introduced as a dry set. Some, but not all, dye seems to have entered the groundwater system during a storm on 3-22-05. The remainder was mobilized by water introduced on 4-5-05.
05-19		F-19	Simpson Chapel Karst	400	2-28-05	756	eosine	0.5	dry set & 2,000				1 day	>29 days	809	700	56	365	980	Dye was introduced as a dry set. Some, but not all, dye seems to have entered the groundwater system during a storm on 3-22-05. The remainder was mobilized by water introduced on 4-5-05. Figure 31 does not show Station 131 because it is too far west to appear at the figure's scale. Velocity based on Station 131 detection.
05-20		F-20	Simpson Chapel Karst	ditch failure	3-23-05 @ 1313	758	rhodamine WT	0.5	5 gpm storm runoff				6 days	>28 days	804	730	28	184	132	
05-21	Trace	F-21	Bloom. North	316	4-2-05 @ 1128	707	eosine	0.25	1,800				<20 min.	>18 days	243	683	24	521	13,997	Velocity based on visible dye observation.
													<18 days	>18 days	365	680	27	391	20	

Notes: MSL - Mean Sea Level, lbs - pounds, gpm - gallons per minute, min. - minute, Bloom. - Bloomington, Rd. - Road,

Table F-1 (continued)
Individual Dye Trace Summary Table

Trace No.	Trace Name	Figure No.	Karst Area	Input Feature No.	Dye Input Date/Time	Input Elevation (feet MSL)	Dye Type	Dye Quantity (lbs)	Water Used (gallons or gpm)	Precipitation/ Conditions	First Detection Station No./Name	Additional Dye Detection Stations No./Name	Time of Travel (1st detection)	Dye Detection Duration	Dye Trace Length (feet)	1st . Detection Station Elevation	Trace Elevation Loss (feet)	Mean Gradient (feet/mile)	Minimim Mean Velocity (feet per day)	Comments
05-22	Trace	F-22	Simpson Chapel Karst	ditch failure	4-2-05 @ 1238	781	eosine	0.25	1,000				6 hours	>17 days	689	754	27	207	2,869	Figure 34 does not show Station 128 because it is covered by the title block in the figure; however, Station 34 does appear on Figure 12. Velocity based on Station 128 detection.
05-23		F-23	Simpson Chapel Karst	405	4-2-05 @ 1258	756	rhodamine WT	0.5	800				<6 hours	>18 days	758	700	56	390	3,087	Figure 35 does not show Station 131 because it is too far west to appear at the figure's scale. Velocity based on Station 131 detection.
05-24	Trace	F-24	Bloom. North Karst	226	4-2-05 @ 1405	790	eosine	1	1,800				1.5 days	>18 days	5,052	650	140	146	3,770	Figure 36 does not show Station 185 because it is too far north to appear at the figure's scale. Velocity based on Station 185 detection.
05-25		F-25	Bloom. North Karst	318	4-4-05 @ 1635	699	fluorescein	1 oz	1,000				<3 days	>16 days	314	668	31	521	107	The Station 190 detection is somewhat questionable: no background sample, no confirmatory water sample, and the possibility of roadway contamination in the road ditch.
05-26	Trace	F-26	Bloom. North Karst	315	4-4-05 @ 1650	719	sulforhodamine B	0.25	1,000				<10 days	>16 days	687	680	39	300	71	
05-27		F-27	Simpson Chapel Karst	442	4-4-05 @ 1735	789	rhodamine WT	0.5	1,000				<2 days	>15 days	478	769	20	221	293	
05-28		F-28	Bloom. North	322	4-4-05 @ 1836	700	rhodamine WT	0.25	1,500				8 min.	>16 days	268	670	30	591	48,240	Velocity based on visible dye observation.
													<10 days	>10 days	1,195	645	55	243	125	
08-01		F-29	Bloom. Karst	66	11-19-08 @ 1628	778	fluorescein	0.25	2,200				<6 days	>166 days	1,605	670	108	355	297	Velocity based on Station 83 detection.
													<1.5	>166 days	1,306	681	97	392	1,037	Velocity based on Station 12 detection and higher dye concentrations at Treefall Branch.
08-02		F-30	Bloom. Karst	49	11-19-08 @ 1648	768	rhodamine WT	0.75	4,600				<51 days	<51 days	2,561	665	103	212	50	
08-03		F-31	Bloom. Karst	103	11-19-08 @ 1722	750	eosine	1	0.25 gpm				3 days	>336 days	5,041	665	85	89	1,688	Velocity based on Station 80 detection.
09-04		F-32	Bloom. Karst	ss1	2-1-09 @ 1630	736	eosine	1	1.5 gpm				<16 days	>170 days	4,137	667	69	88	262	
													5 days	no data	5,014	654	82	86	1,002	Velocity based on Station 68 detection.
09-05		F-33	Bloom. Karst	55	2-2-09 @1142	745	fluorescein	0.25	4,200				<1.5 days	<106 days	1,210	696	49	214	1,076	
													8 days	<78 days	7,098	646	99	74	883	
													8 days	<15 days	6,574	644	101	81	817	
09-06		F-34	Bloom. Karst	154	2-3-09 @1516	738	sulforhodamine B	0.75	dry set				<1 day	<77 days	1,280	688	50	206	9,711	Velocity based on lack of rain until 2/10/09 to mobilize the dye and the detection of dye at Station 67.
09-07	Trace	F-35	Bloom. Karst	ditch	4-27-09 @ 1830	769	eosine	3	4,200				77-85 days	>177 days	869	720	49	298	10	
													<7 days	>97 days	6,653	646	123	98	996	
													<7 days	<85 days	6,376	637	132	109	954	
09-08		F-36	Bloom. Karst	109	4-27-09 @ 1935	764	fluorescein	0.5	dry set followed by 4,200 gallons on 4/28/09				<4 days	no data	3,904	674	90	122	1,186	Velocity based on Station 12 detection.
09-09		F-37	Bloom. Karst	40	4-28-09 @ 1037	765	rhodamine WT	1	4,200				<6 days	<6 days	1,093	696	69	333	181	
													<6 days	<84 days	6,504	646	119	97	1,082	
													<6 days	<21 days	6,195	637	128	109	1,030	
09-10		F-38	Bloom. Karst	ss1	7-7-09 @ 0616	750	eosine	2.5	4,200				<6 days	<106 days	2,806	674	76	143	475	Velocity based on Station 12 detection.
													<13 days	>14 days	5,300	654	96	96	409	Velocity based on Station 67 detection.
09-11		F-39	Bloom. Karst	karst window	7-7-09 @ 0835	720	sulforhodamine B	0.25	no noticeable flow				<1.5 days	>106 days	341	704	16	248	301	Velocity based on Station 67 detection.
09-12		F-40	Bloom. Karst	50	7-7-09 @ 1059	776	fluorescein	1	4,200				<7 days	>106 days	3,764	674	102	143	551	Velocity based on Station 12 detection.
09-13		F-41	Bloom. Karst	72	7-7-09 @ 1203	736	rhodamine WT	0.5	4,200				<14 days	>14 days	2,771	638	98	187	200	

Notes: MSL - Mean Sea Level, lbs - pounds, gpm - gallons per minute, min. - minute, Bloom. - Bloomington, Rd. - Road,

Trace 04-01: **Trace**

Potable water was discharged into a sinkhole (GIS insurgence feature No.178) located at approximately at an elevation of approximately 810 feet above mean sea level (msl). The water was from a nearby fire hydrant and flow began at 0807 hours on June 15, 2004. One pound of eosine dye mixture containing approximately 75% dye and 25% diluent was introduced at the bottom of the sinkhole at 0857 hours. Water was discharged continuously until 0907 hours on June 15, 2004. A total of 15,000 gallons of water was used to introduce the dye into the groundwater system. There was a runoff-producing storm later that afternoon.

The dye introduction point was selected because it is within the corridor for I-69 and currently receives runoff from SR37. Eosine dye was selected to reduce the possibility that dye would be visible if it were discharged into

The dye from this trace discharged from (Station 78). However, Station 78 was not established until after the trace was begun. Thus, dye was first detected at Station 19 (, which was established below the confluence of its two outlets A and B.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-1. Stations 54 and 13 do not appear on the figure because they are too far south to appear at the figure's scale.

The following table shows groundwater flow route detections of dye in activated carbon samplers from Trace 04-01.

Trace 04-01 Detections at Station 19.

Sampling Period	Peak Emission Wavelength (nm)	Eosine Dye Concentration (ppb)
5/26 to 6/3/04	ND	ND
6/3/ to6/17/04	540.1	986
6/17 to 6/23/04	539.5	75.4*
6/23 to 6/29/04	539.5	55.4
6/29 to 7/8/04	539.4	26.8*
7/8 to 7/18/04	539.2	3.56
7/18 to 7/28/04	538.8	5.80
7/28 to 8/4/04	538.8	5.60
8/4 to 8/13/04	536.2	6.20
8/13 to 8/30/04	536.2	4.80

* Value is the mean of two samples.

When the sampling station was established at dye from Trace 04-01 was still being discharged and demonstrated that the detectable eosine dye from this trace was being discharged from (Station 78) and no dye was being discharged from (Station 79). Dye from this trace continued to be detectable on the activated carbon samplers through the sampling period December 6, 2004 to January 17, 2005, therefore, detectable dye was present for >216 days after dye introduction.

The first dye arrival and the peak dye concentration at (Station 78) were less than one day after dye introduction. This is based on the first detection of dye at (Station 19). The straight-line groundwater flow path distance was approximately 535 feet. The elevation loss is approximately 20 feet. The mean gradient along this flow path is approximately 197 feet per mile.

The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 5,718 feet per day based on the first detection of dye at Station 54.

Dye from this trace was detected at the following sampling stations from upstream to downstream from dye discharged from

Trace 04-01 linked a sinkhole that currently receives runoff from SR37 to which is also within the Section 5 corridor. No previous traces are known to have been detected at has not been identified as having special significance to the project.

Trace 04-02: Trace

Potable water was discharged into a sinkhole (GIS insurgence feature No.91)located at approximately at an elevation of approximately 800 feet msl. The water was from a nearby fire hydrant and flow was begun at 0938 hours on June 15, 2004. Two pounds of rhodamine WT dye mixture containing approximately 20% dye and 80% diluent was introduced at the bottom of the sinkhole at 0950 hours. Water was discharged continuously until 1013 hours on June 15, 2004. A total of 13,000 gallons of water was used to introduce the dye into the groundwater system. There was a runoff-producing storm later that afternoon. The dye introduction point was selected because it is within the corridor for I-69 and it had a fire hydrant making for efficient water introduction.

The dye from this trace discharged from (Station 52).

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-2. Station 68 does not appear on the figure because it is too far south to appear at the figure's scale.

The following table shows the groundwater flow routedetections of dye in activated carbon samplers from Trace 04-02.

Trace 04-02

Sampling Period	Peak Emission Wavelength (nm)	Rhodamine WT Dye Concentration (ppb)
6/9 to 6/11/04	ND	ND
6/11 to 6/16/04	569.3	458
6/16 to 6/23/04	568.8	366
6/23 to 6/29/04	568.2	265
6/29 to 7/8/04	568.7	102
7/8 to 7/18/04	568.5	56.3

Based on dye detection at the downstream sampling station (Station 12, Unnamed Tributary in Section 25), the first dye arrival at (Station 52) was about eight hours after dye introduction. The straight-line groundwater flow path distance was approximately 2,616 feet. The elevation loss is approximately 88 feet. The mean gradient along this flow path is approximately 178 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 8,710 feet per day. The dye was detectable at Station 52 in activated carbon samplers for approximately 33 days after dye introduction.

Dye from this trace was detected at the following sampling stations from upstream to downstream from dye discharged from

-

Trace 04-02 hydrologically connected a sinkhole in the Section 5 corridor with a relatively large discharge spring approximately 2,600 feet from the SR37 centerline. It is clear that springsappreciably outside the corridor have the potential to be impacted from activities in the corridor. Also, the trace showed that the tested insurgence feature transfers water across the subwatershed boundary from

Trace 04-03: Trace

Two pounds of eosine dye mixture containing approximately 75% dye and 25% diluent was placed as a dry set in a culvert draining into a sinkhole (GIS insurgence feature No.190) on June 30, 2004 at 1600 hours. The dye introduction point is a sinkhole that has been covered by SR37 but has a culvert directing road runoff into it. The culvert is located at approximately
W at an elevation of approximately 852 feet msl. Eosine dye was used because of high background concentrations of fluorescein and rhodamine WT dyes at a potential detection point.

The dye almost certainly was not mobilized until a storm event on July 4, 2004, which produced 1.60 inches of rainfall and produced a more than eight-fold increase in discharge from
Appendix G).

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-3. Station 4 does not appear on the figure because it is too far north to appear at the figure's scale.

The following table shows the groundwater flow route detections of dye in activated carbon samplers from Trace 04-03.

Trace 04-03

Sampling Period	Peak Emission Wavelength (nm)	Eosine Dye Concentration (ppb)
6/24 to 6/30/04	ND	ND
6/30 to 7/9/04	540.2	27,000
7/9 to 7/18/04	539.6	204
7/18 to 7/28/04	540.1	1,910
7/28 to 8/5/04	539.7	548
8/5 to 8/13/04	539.7	548

Note: There are additional eosine detections from Trace 04-03 at this sampling station; the data are found in Appendix B.

Dye from this trace was detected at the following sampling stations from upstream to downstream from dye discharged from

The first dye arrival and the peak dye concentration at (Station 30) occurred about one day after dye introduction. This is based on dye detection at the downstream sampling station, (Station 43). The straight-line groundwater flow path distance is approximately 1,615 feet. The elevation loss is approximately 58 feet. The mean gradient along this flow path is approximately 178 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 2,097 feet per day based on the first detection at the more distant Station 4. Based upon activated carbon samplers the dye was detectable at Station 30 for approximately about 255 days after dye introduction. Dye was still detectable in the last sampler analyzed.

This trace revises the recharge area. Fitch (1994) included the catchment area for this dye introduction point within the recharge area). Trace 04-03 demonstrated that it is not and that road activity within the catchment area for the dye introduction point

would not impact the quantity or quality of water discharged from and its associated springs.

Water discharged from is treated before public exposure since it is contaminated with polychlorinated biphenyls (PCBs). Impervious surfaces, such as roadways, increase the quantity of runoff. If this part of SR37 or the proposed I-69 were in the recharge area it would increase the amount of water flowing to that would need to be treated.

Trace 04-04: Failure Trace

Two pounds of eosine dye mixture containing approximately 75% dye and 25% diluent was introduced into a road ditch that is failing downwards (GIS insurgence feature No.102). The dye was introduced at 0757 hours on July 26, 2004. Approximately 0.5 gpm of storm runoff was entering the groundwater system at this location at the time of dye introduction. From 0912 to 0922 hours on July 26, 2004, 2,000 gallons of potable water was introduced at the to enhance the introduction of the dye into the groundwater system.

The dye introduction point is located at approximately at an approximate elevation of 802 feet msl. The purpose of the trace was to help identify which groundwater system isreceiving highway runoff from this part of the highway.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-4. Station 68 does not appear on Figure F-4 because it is too far south to appear at the figure's scale.

The following table shows the groundwater flow path detections of dye in activated carbon samplers from Trace 04-04.

Trace 04-04 Ditch Failure Trace Dye Detections at Station 52.

Sampling Period	Peak Emission Wavelength (nm)	Eosine Dye Concentration (ppb)
7/8 to 7/18/04	ND	ND
7/18 to 7/27/04	540.2	7,240
7/27 to 8/4/04	540.1	7,130
8/4 to 8/13/04	540.3	1,150
8/13 to 8/31/04	540.1	764
8/31 to 9/9/04	539.9	186

Note: There are additional eosine detections from Trace 04-04 at this sampling station; the data are found in Appendix B.

Dye from this trace was detected at the following sampling stations from upstream to downstream from dye discharged from

The first dye arrival and the peak dye concentration at (Station 52) occurred about one day after dye introduction. The straight-line groundwater flow path distance is approximately 2,940 feet. The elevation loss is approximately 90 feet. The mean gradient along this flow path is approximately 162 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 10,462 feet per day based on the dye detections at Stations 12 and 85. At the dye was detectable from activated carbon samplers for approximately175days after dye introduction. Dye was still detectable in the last sampler analyzed.

Trace 04-04 was the second trace to be detected at and the third (including a pre-Tier 2 trace) to demonstrate water transfer across the subwatershed boundary tc . This trace was from a point that currently receives runoff from SR37 through a soil pipe or possibly a reopening sinkhole). However, we have no other evidence of a buried sinkhole at this location. If there was an initial sinkhole it may have beenfilled during construction of the adjacent lanes of SR37. The reopening point is at the downstream end of the concrete ditch liner. This point couldreadily transmit

contaminants from the roadway to has not been identified as having special significance for this project.

Trace 04-05: Trace

One pound of rhodamine WT dye mixture containing approximately 20% dye and 80% diluent was introduced into a sinkhole at this location (GIS insurgence feature No.174). Water for the trace was from a nearby fire hydrant. Water flow was begun at 0840 hours on July 26, 2004. The dye was introduced at 0848 hours and water flow ceased at 0855 hours on July 26, 2004. A total of 7,000 gallons of water was used to introduce the dye into the groundwater system.

The dye introduction point is located at approximately at an elevation of approximately 814 feet msl. The purpose of the trace was to identify which groundwater system receives runoff from this part of the highway corridor.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-5. Station 13 does not appear on the figure because it is too far south to appear at the figure's scale.

The following table shows the groundwater flow path detections of dye in activated carbon samplers from Trace 04-05.

Trace 04-05

Sampling Period	Peak Emission Wavelength (nm)	Rhodamine WT Dye Concentration (ppb)
7/8 to 7/18/04	ND	ND
7/18 to 7/28/04	567.7	29,200
7/28 to 8/4/04	567.7	25,700
8/4 to 8/13/04	567.9	5,170
8/13 to 8/31/04	569.0	1,300
8/31 to 9/9/04	568.6	309

Note: There are additional rhodamine WT detections from Trace 04-05 at this sampling station; the data are found in Appendix B.

Dye from this trace was detected at the following sampling stations from upstream to downstream from dye discharged from

A nearby quarry occasionally pumps water from an impoundment in immediately upstream of (just upstream of Station 54) and discharges the excess down This was the apparent source of dye detected at Station 53 ( ).

The first dye arrival at Station 18) was about 11 hours after dye introduction. This estimate is based on dye detections at the downstream sampling station, at (Station 16). The straight-line groundwater flow path distance was approximately 802 feet. The elevation loss is approximately 40 feet. The mean gradient along this flow path is approximately 263 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 1,813 feet per day based on the dye detection at the downstream Station 16. At the dye was detectable from activated carbon samplers for approximately 174 days after dye introduction. Dye was still detectable in the last sampler analyzed.

Trace 04-05 hydrologically linked a sinkhole in the corridor with a spring in the Section 5 corridor that was undocumented prior to this investigation. is a relatively small spring that discharges into has not been determined to have special significance to the project.

Trace 04-06:

One pound of rhodamine WT dye mixture containing approximately 20% dye and 80% diluent was introduced into the outflow from a retention pond built in a sinking stream basin (GIS insurgence feature No. ss3). The dye was introduced at 1215 hours on August 30, 2004. There was an estimated 20 gpm flowing out of the pond at the time of dye introduction.

The dye introduction point is located at approximately at an elevation of approximately 840 feet msl. The purpose of the trace was to identify which groundwater system receives runoff from this part of the highway corridor.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-6. Stations 15, 54, 13, and 80 do not appear on Figure F-6 because they are too far south to appear at the figure's scale.

The following table shows the groundwater flow path detections of dye in activated carbon samplers from Trace 04-06.

Trace 04-06

Sampling Period	Peak Emission Wavelength (nm)	Rhodamine WT Dye Concentration (ppb)
8/24 to 8/30/04	ND	ND
8/30 to 9/2/04	567.1	17,900
9/2 to 9/9/04	568.5	240
9/9 to 9/21/04	567.9	102
9/21 to 9/29/04	568.3	50.4
9/29 to 10/5/04	568.6	21.2

Note: There are additional rhodamine WT detections from Trace 04-06 at this sampling station; the data are found in Appendix B.

Rhodamine WT dye from this trace was discharged from (Station 79). No dye was detected at (Station 78). The first dye arrival and the peak dye concentration at (Station 79) were less than one day after dye introduction based on observations of visible concentrations of dye. The flow path from the dye introduction point to the east side of SR37 is almost all through culverts. The straight-line groundwater flow path distance is approximately 1,631 feet. The elevation loss is approximately 59 feet. The mean gradient along this flow path is approximately 191 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 9,910 feet per day. Dye was detectable at for 98 days following the dye introduction.

Dye that discharged from (Station 79) was detected at the following sampling stations from upstream to downstream:

-

Dye was not detected at Station 19 because this station was not being sampled at the time of this trace. More direct data were being acquired from Stations 78 and 79. Dye certainly passed though the stream reach sampled by Station 19.

Trace 04-06 demonstrated a flow path that had been presumed by local karst experts. This trace hydrologically linked a sinking stream basin that is almost entirely within the highway corridor to a spring that is also in the Section 5 corridor. No previous traces are known to have been detected at has not been determined to have special significance to the project.

The water discharged from often does not thermally equilibrate with the bedrock environment. It felt relatively warm during high flow events during the summer sampling events. This is almost certainly due to its short residence time in the subsurface and the relatively high residence time in the retention pond upstream of the dye introduction point.

Trace 04-07:

On September 10, 2004, potable water was discharged into a sinkhole (GIS insurgence feature No.64) located at approximately at an elevation of approximately 786 feet msl. The actual dye introduction point is outside of the corridor, but the sinkhole captures road runoff from SR37 . Two thousand gallons of water was introduced from 1104 to 1110 hours. The water was introduced on the east side of the sinkhole and ponded. Another 2,000 gallons of water was introduced on the west side of the sinkhole from 1130 to 1134 hours. At 1132, approximately one-third pound of fluorescein dye mixture containing approximately 75% dye and 25% diluent was introduced into the sinkhole. From 1234 to 1238 hours, a third load of 2,000 gallons of water was introduced to flush the dye mixture into the groundwater system. A total of 6,000 gallons of potable water was introduced for this trace.

Dye from this trace discharged from The two former stations were established when dye from this trace was not detected in the first sampling event after dye introduction. All of these springs are in the same topographic basin. Dye from this trace was detected at the following sampling stations:

Station 85: Upstream of Station 83

Station 86:

The dye introduction point and diagrammatic flow paths of the groundwater trace are shown on Figure F-7.

The following table shows groundwater flow path dye detections in activated carbon samplers from Trace 04-07.

Trace 04-07 Dye Detections

Sampling Period	**Station 52 Fluorescein Dye Concentration (ppb)**	**Station 84 Fluorescein Dye Concentration (ppb)**	**Station 83 Fluorescein Dye Concentration (ppb)**
8/31 to 9/9/04	ND	NS	NS
9/9 to 9/21/04	7.48	NS	NS
9/21 to 9/28/04	8.24	NS	NS
9/28 to 10/5/04	10.9	319	10.2
10/5 to 10/12/04	3.74	156	26.6
10/12 to 10/25/04	ND	192	48.9
10/25 to 11/8/04	2,080*	56.0	13.7
11/8 to 11/17/04	2.87	47.9	12.3
11/17 to 12/6/04	ND	32.7	11.9
12/6 to 12/20/04		21.1	9.62
12/6 to 12/21/04	ND		

* Value is the mean of two samples.

Note: There are additional fluorescein detections from Trace 04-07 at these sampling stations; the data are found in Appendix B.

is not truly a spring; it is sampling a stream below a gaining stream reach. There are two springs at its headwaters (Stations 49 and 50), but neither spring received detectable dye from this

trace. The dye concentrations measured at (Station 83) were consistently lower than those measured at which is a similar distance from the dye introduction point and has more flow. These data suggest that may be recharged partly by losses in the spring branch above the Treefall Branch sampling station. It is not uncommon in karst areas for the same short stretch of stream to have both gains and losses in flow.

had a dye detection that was an order of magnitude higher than any detections at The peak concentration arrived almost two months after the dye introduction, however, the period of detection was much shorter at than at This suggests that there is considerable complexity in the groundwater system in this area that has not been resolved by this investigation. The complexity should be viewed as an example of karst hydrology in the region and not as a deficiency in the investigation. The complexity in the groundwater system should have no effect on road design, construction, operation, or maintenance.

The first dye arrival at was about 2 days after dye introduction. The straight-line groundwater flow path distance was approximately 1,911 feet. The elevation loss is approximately 74 feet. The mean gradient along this flow path is approximately 204 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 783 feet per day based on dye detections at Stations 85 and 12. Dye was detectable for 68 days at The peak dye concentration was during the October 25 to November 8, 2004 sampling period when the weather had been very dry. On October 12, 2004, a series of storms started moving through the area and through November 2, 2004 a total of approximately 5.8 inches of rain had fallen (including almost 2.5 inches on October 18, 2004). It is these series of storms that presumably provided the unusual pattern of dye detections at

The first dye arrival at (Station 84) was from three to eleven days after dye introduction, depending on the source of dye detected at Station 85.. The straight-line groundwater flow path distance was approximately 1,604 feet. The elevation loss is approximately 105 feet. The mean gradient along this flow path is approximately 346 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 147 feet per day. Dye was detectable in for about 199 days after dye introduction when sampling was halted.

The first dye arrival at (Station 83) was from two to eighteen days after dye introduction, depending on the source of dye at Station 12. The straight-line groundwater flow path distance was approximately 2,155 feet. The elevation loss is approximately 116 feet. The mean gradient along this flow path is approximately 284 feet per mile. Dye was discharged from for about 199 days after dye introduction when sampling was halted.

Since the flow path to is a shorter, steeper pathway than the path to East, but had lower concentrations of dye, it is probable that the pathway has formed in the recent geologic past and does not yet have sufficient size to accommodate all the available water. Excess flows (essentially overflow) appear to discharge at Sexton Spring, while base flow is discharged at Branch. Over time, should capture most or all of the flow, unless its water, in turn, is being pirated to Spring.

None of these springs have been demonstrated to have special importance to this project. Neither were documented before this investigation.

Trace 04-08:

On September 10, 2004 a dye introduction was made into a sinkhole (GIS insurgence feature No.99)located at approximately at an elevation of approximately 750 feet msl. Two thousand gallons of potable water was introduced from 1202 to 1209 hours. One pound of rhodamine WT dye mixture containing approximately 20% dye and 80% diluent was introduced into the sinkhole at 1203 hours. There was no ponding of water in the sinkhole.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-8. The following table shows the groundwater flow path detections of dye in activated carbon samplers from Trace 04-08.

Trace 04-08 Dye Detections at Station 74.

Sampling Period	Peak Emission Wavelength (nm)	Rhodamine WT Dye Concentration (ppb)
8/31 to 9/21/04	ND	ND
9/21 to 10/25/04	567.4	139
10/25 to 11/8/04	569.1	44.5
11/8 to 11/17/04	568.6	17.6
11/17 to 12/6/04	569.7	25.1
12/6 to 12/21/04	568.8	35.0

Note: There are additional rhodamine WT detections from Trace 04-08 at this sampling station; the data are found in Appendix B.

Dye from this trace was also detected at the Unnamed tributary at (Station 67), downstream from

The first dye arrival at (Station 74) was about 27 days after dye introduction, almost certainly due to the drought conditions under which the trace was conducted. The straight-line groundwater flow path distance was approximately 2,128 feet. The elevation loss is approximately 83 feet. The mean gradient along this flow path is approximately 206 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 76 feet per day based on the dye detection at the downstream Station 67. Dye was detectable at for >210 days after dye introduction; sampling halted at this time. has not been demonstrated to have special significance for this project. was not documented before this investigation.

Trace 04-09: **Trace**

On September 30, 2004 at 1838 hours, two pounds of rhodamine WT dye mixture containing approximately 20% dye and 80% diluent was introduced into (GIS insurgence feature No.ss5)located at approximately at an elevation of approximately 715 feet msl. Flow in at the time and place of dye introduction was estimated at 15 gpm. The trace was started under drought conditions to determine whether or not was losing some or all of its flow around (old). The topographic basin includes an appreciable portion of the Section 5 corridor and receives runoff from SR37 .

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-9.

The following table shows the groundwater flow path detections of dye in activated carbon samplers from Trace 04-09.

Trace 04-09

Sampling Period	**Station 87** **Rhodamine WT Dye Concentration (ppb)**	**Station 89** **Rhodamine WT Dye Concentration (ppb)**
9/29 to 10/6/04	20,500	NS
10/6 to 10/14/04	1,210	520
10/14 to 10/27/04	341	134
10/27 to 11/8/04	37.5	7.74
11/8 to 11/17/04	17.8	6.94

Note: There are additional rhodamine WT detections from Trace 04-09 at this sampling station; the data are found in Appendix B.

The dye was detected at (Station 89) and in higher concentrations at (Station 87). Dye was detectable at Station 89 for 209 days after dye introduction. No dye was detected at Station 4) until flow had resumed in the October 14 through October 27, 2004 sampling period. This trace demonstrated that under the drought conditions tested, loses all of its flow into the groundwater system. That water then resurges at (Station 89) and other points in between Station 89 and Station 87. Figure F-9 does not Station 4 as a detection point, although dye was detected there. However, the dye was not detected at Station 4 until surface flows had resumed. The detections at Station 4 were about two weeks after the detections in the downstream Station 87.

The first dye arrival at (Station 87) was less than six days after dye introduction. The travel time demonstrated is almost certainly slower under the drought conditions tested than under normal flow conditions. The straight-line groundwater flow path distance was approximately 5,325 feet. The elevation loss is approximately 65 feet. The mean gradient along this flow path is approximately 64 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 949 feet per day. After introduction, dye was detectable for 180 days at

Trace 04-09 is an important trace because it demonstrates that the tested reach of sinks under very low flow conditions and almost certainly loses water under base and higher flow conditions. The sinking/losing reach receives runoff from and is located downstream of

, which is a Superfund site. Neither nor the gaining reach downstream of it were documented as groundwater discharge points before this investigation.

Trace 04-10: **Trace**

On December 1, 2004 at 1425 hours, four pounds of eosine dye mixture containing approximately 75% dye and 25% diluent was introduced into a sinkhole (GIS insurgence feature No.192) west of the The dye introduction point is located at approximately 39.17309° N and 86.56304 W at an elevation of approximately 853 feet msl. Eosine dye was used because of high background concentrations of fluorescein and rhodamine WT dyes at the nearby Illinois Central Spring. There was approximately one gpm of storm runoff entering the groundwater system at the time of dye introduction.

The majority of the dye was detected at (Station 31). Smaller concentrations were detected at (Stations 25 and 26, respectively). The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-10. The following tables show the groundwater flow path detections of dye in activated carbon samplers from Trace 04-10.

Trace 04-10

Sampling Period	Peak Emission Wavelength (nm)	Eosine Dye Concentration (ppb)
11/8 to 11/17/04	ND	ND
11/17 to 12/3/04	541.5	1,150
12/3 to 12/7/04	541.0*	139*
12/7 to 12/21/04	541.8	4,140
12/21 to 1/11/05	541.6	415

* Values are the mean of two samples.

Note: There are additional eosine detections from Trace 04-10 at this sampling station; the data are found in Appendix B.

Trace 04-10

Sampling Period	Peak Emission Wavelength (nm)	Eosine Dye Concentration (ppb)
11/17 to 12/3/04	ND	
12/3 to 12/21/04	541.5*	22.7*
12/21/04 to 1/11/05	541.5	36.3
1/11 to 1/18/05	541.0	10.9
1/18 to 2/24/05	541.3	3.53
2/24 to 3/16/05	ND	

* Values are the mean of two samples.

Trace 04-10

Sampling Period	Peak Emission Wavelength (nm)	Eosine Dye Concentration (ppb)
11/17 to 12/3/04	539.0*	1.42
12/3 to 12/21/04	541.5	6.37
12/21/04 to 1/11/05	541.4	41.1
1/11 to 1/18/05	541.3	11.6
1/18 to 2/24/05	540.4*	0.772

* A fluorescence peak is present that does not meet all criteria for a positive dye result but has been calculated as though it were dye for background purposes.

Dye from this trace was detected at the following sampling station downstream of and the associated

-

The first dye arrival at (Station 31) was about two days after dye introduction, during a recession from storm response. However, the peak dye concentration appears to have arrived on December 7, 2004 and appears to have been in response to a second storm on December 7, 2004 (Appendix G). The straight-line groundwater flow path distance was approximately 2,968 feet. The elevation loss is approximately 37 feet. The mean gradient along this flow path is approximately 66 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 1,475 feet per day. After introduction, dye from this trace was detectable for >105 days at Dye was detectable for 85 days after dye introduction at Station 25 (.

receives some recharge water from the which is a Superfund site contaminated with PCBs. is very important to the design of I-69 since its contaminated discharge is treated before continuing downstream. Additional impervious surfaces, such as I-69 if it were built in the recharge area, could increase the amount of water requiring treatment. Trace 04-10 confirmed that the sinkhole in which the dye introduction was made lies within the recharge area of The trace also demonstrated interbasin transfer for water from the topographic basin to the

Trace 04-11:

On December 7, 2004 at 1226 hours, three pounds of eosine dye mixture containing approximately 75% dye and 25% diluent was introduced into a road ditch to determine whether or not the road ditch recharges the groundwater system (GIS insurgence feature No. ss1). The dye introduction point is located at approximately at an elevation of approximately 765 feet msl.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-11.

The following tables show detections of dye in activated carbon samplers from Trace 04-11 at May, Spring.

Trace 04-11

Sampling Period	Peak Emission Wavelength (nm)	Eosine Dye Concentration (ppb)
11/17 to 12/6/04	ND	ND
12/6 to 12/20/04	541.2	9.82
12/20/04 to 1/5/05	541.2	89.6
1/5 to 1/10/05	541.6	12.6
1/10 to 1/18/05	541.3	12.6

Note: There are additional eosine detections from Trace 04-11 at this sampling station; the data are found in Appendix B.

Dye from this trace was detected at the following sampling stations:

Eosine dye was detected at .This trace demonstrates that the road ditch or the creek of which it is the headwaters, contributes water to two groundwater systems. The two groundwater systems are those of
The appreciably lower concentrations of dye at compared with the concentrations at suggest that the losses from the channel are occurring in separate reaches of the stream channel.

Trace 04-11 is important for four reasons:

1) The dye introduction point recharges

2) The trace demonstrates that

3) The trace demonstrates that the stream branch is a losing stream.

4) The trace demonstrates complexity in the distribution of recharge in the study area.

The first dye arrival and the peak concentration of dye at (Station 48) were about 13 days after dye introduction. The straight-line flow path distance was approximately 2,760 feet. The elevation loss is approximately 91 feet. The mean gradient along this flow path is approximately 174 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 214 feet per day. After introduction, dye from this trace was detectable for >132 days at when sampling was halted.

The first dye arrival and the peak concentration of dye at (Station 73) were less than 14 days after dye introduction. The straight-line flow path distance was approximately 5,971 feet. The elevation loss is approximately 111 feet. The mean gradient along this flow path is approximately 98 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 425 feet per day. After introduction, dye from this trace was detectable for 106 days at The decreasing concentrations of dye from Station 76 to Station 75 to Station 90 to Station 73 (is recharged by channel losses downstream from Station 90. The channel was generally dry near station 73 while there was flowing water near Station 74. was not documented before this investigation and has not been determined to have any special significance.

Trace 05-12:

On January 5, 2005 at 1736 hours, three pounds of sulforhodamine B dye mixture containing approximately 75% dye and 25% diluent was introduced into a sinkhole (GIS insurgence feature No.52) located at approximately at an elevation of approximately 766 feet msl. Approximately eight gpm of storm water runoff was entering the groundwater system at the time of dye introduction. The purpose of this dye introduction was to identify the groundwater system that might be impacted by road construction and use in this part of the highway corridor.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-12. The following table shows the groundwater flow path detections of dye in activated carbon samplers from Trace 05-12.

Trace 05-12

Sampling Period	Peak Emission Wavelength (nm)	Sulforhodamine B Dye Concentration (ppb)
12/20/04 to 1/5/05	ND	ND
1/5 to 1/10/05	579.5	662
1/10 to 1/18/05	578.8	14.1
1/18 to 2/11/05	578.0	12.5

Note: There are additional eosine detections from Trace 04-11 at this sampling station; the data are found in Appendix B.

The first dye arrival and the peak concentration of dye at (Station 48) were less than five days after dye introduction. The straight-line flow path distance was approximately 4,075 feet. The elevation loss is approximately 92 feet. The mean gradient along this flow path is approximately 119 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 833 feet per day. After introduction, dye from this trace was detectable for 51 days at

This trace demonstrates that recharge area crosses the entire SR37 corridor and at least one-half mile of the corridor axis is within the area. is a biologically significant cave.

Trace 05-12 also demonstrates groundwater flow a karst flowpathcrossing under SR37. This flow also crosses the subwatershed boundary and transfers water from the topographic basin to the

Trace 05-13:

On January 13, 2005 at 1522 hours, one-half pound of fluorescein dye mixture containing approximately 75% dye and 25% diluent was introduced into a sinkhole (GIS insurgence feature No.446) that had formed in a ditch along SR37 just north of The dye introduction location is located at approximately at an elevation of approximately 810 feet msl. The purpose of the trace was to identify which groundwater system receives runoff from this part of the highway corridor.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-13.

The following table shows the groundwater flow path detections of dye from Trace 05-13.

Trace 05-13

Sampling Period	Peak Emission Wavelength (nm)	Fluorescein Dye Concentration (ppb)
10/26/04 to 1/10/05	514.8**	1,57*
1/10 to 1/18/05	516.0	43.4
1/18 to 2/1/05	515.9	16.5
2/1 to 2/9/05	514.0 **	1.00
2/9 to 2/25/05	514.6 **	1.19

* mean of two values ** A fluorescence peak is present which does not meet all the criteria for a positive dye result, but is has been calculated as though it were dye for background purposes.

The first dye arrival and the peak concentration of dye at (Station 16) were less than five days after dye introduction. The straight-line flow path distance was approximately 3,210 feet. The elevation loss is approximately 99 feet. The mean gradient along this flow path is approximately 163 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 660 feet per day. After introduction, dye from this trace was detectable for 43 days at

Fluorescein dye from was discharged between and Station 16. No dye from this trace was discharged from Station 2) or the culvert adjacent to it (Station 1). Similarly, no dye was discharged from (Station 18). The dye may have been discharged from (Station 122), but the sampling station was not established early enough in the trace to be definitive. Additionally, the samplers at Station 63 had been removed and this station was unavailable to narrow the location of the spring from which Trace 05-13 was discharged. However, this trace demonstrates a karst flowpathflow beneath the SR37 alignment. There are no known groundwater systems associated with this stream reach known to have any special project significance.

Trace 05-14:

On January 13, 2005 at 1540 hours, two-thirds of a pound of fluorescein dye mixture containing approximately 75% dye and 25% diluent was introduced into a sinkhole (GIS insurgence feature No.272) that had formed in the median of SR37 just south of The dye introduction is located at approximately at an elevation of approximately 728 feet msl. The purpose of the trace was to identify which groundwater system receives runoff from this part of the highway corridor.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-14.

The following table shows the groundwater flow route detections of dye in activated carbon samplers from Trace 05-14.

Trace 05-14

Sampling Period	Peak Emission Wavelength (nm)	Fluorescein Dye Concentration (ppb)
1/5 to 1/10/05	512.6*	1.05
1/10 to 1/14/05	516.7	536
1/14 to 1/21/05	516.8	397
1/21 to 2/11/05	515.7	52.1
2/11 to 3/16/05	515.7	66.3

* A fluorescence peak is present which does not meet all the criteria for a positive dye result, but is has been calculated as though it were dye for background purposes.
Note: There are additional fluorescein detections from Trace 05-14 at this sampling station; the data are found in Appendix B.

Dye from this trace was detected at the following sampling stations (listed from upstream to downstream):

-

Based on the detection at Station 87, the first dye arrival at (Station 88) was less than one day after dye introduction. The straight-line flow path distance was approximately 693 feet. The elevation loss is approximately 40 feet. The mean gradient along this flow path is approximately 305 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 2,371 feet per day. After introduction, dye from this trace was detectable for about92 days at when sampling was halted.

Fluorescein dye from At lower concentrations, it was also detected at the station in the stream channel upstream of When the sampling station at was established there was no flow in the channel uphill from the spring. This indicates that there is an overflow or intermittent spring above The trace also demonstrates which groundwater system could be impacted from the section of road tested by this trace. has not been demonstrated to have any special significance to this project. Neither nor the overflow or intermittent spring upstream of it were documented before this investigation. Both the dye introduction point and are in the Section 5 corridor.

Trace 05-15:

One pound of fluorescein dye mixture containing approximately 75% dye and 25% diluent was introduced into a sinkhole (GIS insurgence feature No.433) located at approximately at an elevation of approximately 760 feet msl. The trace was started using potable water hauled to the sinkhole on February 3, 2005. The first load of water was discharged into the sinkhole from 1707 hours to 1718 hours. At 1710 hours, one pound of fluorescein dye mixture containing approximately 75% dye and 25% diluent was introduced. A second load of water was discharged from 1748 hours to 1757 hours. A total of 4,000 gallons of hauled water was used for this trace. The purpose of the trace was to identify which groundwater system receives runoff from this part of the highway corridor.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-15.

The following table shows the groundwater flow route detections in activated carbon samplers of dye from Trace 05-15.

Trace 05-15

Sampling Period	Peak Emission Wavelength (nm)	Fluorescein Dye Concentration (ppb)
2/4 to 2/10/05	516.5	169,000
2/10 to 3/17/05	517.1	2,710
3/17 to 3/24/05	517.2	499
3/24 to 4/5/05	516.5	235
4/5 to 4/12/05	515.9	238
4/12 to 4/20/05	ND	

Dye from this trace was detected at the following sampling stations downstream of

Fluorescein dye was visually observed discharging from Station 137 Spring) early on the morning of February 4, 2005. Colored water extended for about one mile downstream of This resulted in calls by local residents to the Monroe County Health Department and the Washington Township Water District. Both of these organizations were aware of our dye-tracing program and were able to address the callers' concerns. However the spring had not been discovered and samplers placed until the reports of dye discharge were made. Therefore no background fluorescence values are available. Despite the lack of background data, this was an unambiguous detection.

OUL has found that in most karst settings, one pound of dye is the minimum quantity to be used to ensure a credible dye detection. In some settings, we learn that the systems are more open and smaller quantities could be used to produce credible results. Trace 05-15 was the first trace known to us conducted in the The quantity of dye chosen was based on our experience in the Bloomington Karst and other karst studies. However based on our experience with this trace, appreciably smaller quantities of dye were used in subsequent Simpson Chapel Karst traces.

Appendix B shows detections of fluorescence in the range of fluorescein at (Station 109) and Doug (Station 108) near the date of the dye introduction for Trace 05-15. However, the detection at precedes the dye introduction and is consistent with regional background values. Considering the very high concentrations of dye detected at it is highly unlikely that the small values at are anything but background fluorescence.

Based on the visual observation of dye in near Station 126, the first dye arrival at (Station 137) was less than six hours after dye introduction. The straight-line flow path distance was approximately 1,094 feet. The elevation loss is approximately 24 feet. The mean gradient along this flow path is approximately 116 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 5,276 feet per day. After introduction, dye from this trace was detectable for 68 days at It is noteworthy that none of the adjacent springs had detectable fluorescein resulting from this trace. was undocumented before this investigation.

Trace 05-15 hydrologically linked a sinkhole in the Section 5 corridor with a previously undocumented spring that is also in the corridor. The linked sinkhole's boundaries extend beyond the subwatershed boundary, so this trace demonstrates some interbasin transfer from to the has not been demonstrated to have special significance for this project. Trace 05-15 demonstrated the presence of a karst flowpath that crosses under SR37.

Trace 05-16:

On February 4, 2005 at 0842 hours, one pound of rhodamine WT dye mixture containing approximately 20% dye and 80% diluent was introduced into a karst window (GIS insurgence feature No.423) located at approximately at an elevation of approximately 770 feet msl. Approximately two gpm were flowing through the karst window at the time of dye introduction. The purpose of the trace was to identify which groundwater system receives runoff from this part of the highway corridor.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-16.

The following table shows the groundwater flow route detections of dye in activated carbon samplers from Trace 05-16.

Trace 05-16.

Sampling Period	Peak Emission Wavelength (nm)	Rhodamine WT Dye Concentration (ppb)
1/19 to 2/4/05	ND	ND
2/4 to 2/9/05	568.6	417,000
2/9 to 2/25/05	568.9	4,940
2/25 to 3/22/05	570.0	1,400
3/22 to 4/5/05	569.1	316
4/5 to 4/13/05	569.4	323

Note: There is an additional fluorescein detection from Trace 05-16 at this sampling station; the data are found in Appendix B.

Dye from Trace 05-16 was also detected at the downstream sampling station, . The figure does not show Station 132 because it is too far west to appear at the figure's scale.

Based on the detection at (Station 132), the first dye arrival at Station 94) was about 13 hours after dye introduction. The straight-line flow path distance was approximately 792 feet. The elevation loss is approximately 41 feet. The mean gradient along this flow path is approximately 273 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 1,483 feet per day based on the (Station 132) detection. After introduction, dye from this trace was detectable for about74 days at when sampling was halted. It is noteworthy that none of the adjacent springs had detectable rhodamine WT resulting from this trace. was undocumented before this investigation and is not known to have any special project significance.

The sinkhole linked by this trace has boundaries that extend across the subwatershed boundaries. The trace demonstrates interbasin transfer from the

Trace 05-17:

On February 28, 2005, the was begun using potable water hauled to the introduction point. Water was discharged from 1135 hours until 1145 hours. A total of 2,000 gallons of water was introduced at the dye introduction point. One-half pound of rhodamine WT dye mixture containing approximately 20% dye and 80% diluent was introduced into the sinkhole (GIS insurgence feature No.67) at 1137 hours. The location of the dye introduction point is approximately at an elevation of approximately 766 feet msl. The purpose of this trace was two-fold: to help characterize the patterns of corridor runoff through the subsurface and to evaluate the hydrologic relationship of this insurgence feature with the groundwater system. While the dye introduction point is located outside the corridor, its watershed extends to SR37 .

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-17.

The following table shows the groundwater flow route detection of dye in activated carbon samplers from Trace 05-17.

Trace 05-17

Sampling Period	Peak Emission Wavelength (nm)	Rhodamine WT Dye Concentration (ppb)
2/11 to 2/25/05	ND	ND
2/25 to 3/1/05	569.6	799
3/1 to 3/16/05	570.0	412
3/16 to 3/23/05	570.0	13.5

Note: There are additional rhodamine WT detections from Trace 05-17 at this sampling station; the data are found in Appendix B.

The first dye arrival and the peak dye concentration at (Station 48) were approximately one day after dye introduction. The straight-line flow path distance was approximately 927 feet. The elevation loss is approximately 92 feet. The mean gradient along this flow path is approximately 524 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 893 feet per day. After introduction, dye from this trace was detectable for about39 days at sampling was halted.

This trace demonstrated that the recharge area extends farther north than shown by previous traces. Surface runoff from portions of SR37 tributary to the dye introduction point for 05-17 contribute to the flow of the biologically significant

Trace 05-18:

On February 28, 2005 at 1322 hours, one-half pound of eosine dye mixture containing approximately 75% dye and 25% diluent was placed in a sinkhole (GIS insurgence feature No.38) as a dry set. The dry set was designed to allow the dye to be transported into the groundwater system during a runoff-producing storm. The dye introduction location is approximately
at an elevation of approximately 765 feet msl. The purpose of the trace was to characterize groundwater flow patterns in this portion of the corridor.

On April 5, 2005, 2,000 gallons of potable water was pumped into the sinkhole to ensure that the dye entered the groundwater system. The water was introduced from 0920 to 0940 hours.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-18. The following tables show the groundwater flow route detections of dye from Trace 05-18 at Station 76 (Upstream of

Trace 05-18

Sampling Period	Peak Emission Wavelength (nm)	Eosine Dye Concentration (ppb)	Source of Dye (Trace Number)
1/17 to 2/25/05	541.0	27.4	04-11
2/25 to 3/16/05	540.1	10.7	04-11
3/16 to 3/23/05	540.7	57.9	05-18
3/23 to 3/31/05	540.9	101	05-18
3/31 to 4/8/05	540.8	225	05-18

The increase in dye concentration is not as dramatic as it would have been if all the dye had been mobilized in a single event. However, there is more than an order of magnitude increase in dye concentration between the pre-trace concentrations and the dye concentrations in the last sampling period. Some, but not all, of the dye seems to have entered the groundwater system during a storm on March 22, 2005. The remainder was mobilized by water introduced on April 5, 2005. The velocity of the dye front was calculated based on the interpretation that some of the dye was mobilized on March 22, 2005.

Dye from this trace was detected at the following sampling stations downstream of Station 76 (

Based on the detection at the downstream Station 90, the first dye arrival and the peak dye concentration at were about six hours after the March 22, 2005 storm event. The straight-line flow path distance was approximately 770 feet. The elevation loss is approximately 41 feet. The mean gradient along this flow path is approximately 357 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 3,073 feet per day, based on the detection at Station 90. After introduction, dye from this trace was detectable for >39 days at Upstream of when sampling was halted. This previously undocumented spring has not been demonstrated to have special significance for this project. Dye discharged from the spring at Station 76 was probably the source for the dye detected at Station 75, which samples both surface water in the channel as well as groundwater discharge.

Trace 05-19:

On February 28, 2005, one-half pound of eosine dye mixture containing approximately 75% dye and 25% diluent was placed in a sinkhole (GIS insurgence feature No.400) as a dry set. The dry set was designed to allow the dye to be transported into the groundwater system during a runoff-producing storm. The dye introduction location is approximately at at an elevation of approximately 756 feet msl. The purpose of the trace was to characterize groundwater flow patterns in this portion of the corridor.

On April 5, 2005, 2,000 gallons of potable water was pumped into the sinkhole to ensure that the dye entered the groundwater system. The water was introduced from 1036 to 1057 hours.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-19. Dye from this trace was also detected at the downstream sampling station, (Station 131). The figure does not show Station 131 because it is too far west to appear at the figure's scale.

The following table shows the groundwater flow route detections of dye in activated carbon samplers from Trace 05-19 at

Sampling Period	Peak Emission Wavelength (nm)	Eosine Dye Concentration (ppb)
1/19 to 2/9/05	ND	ND
2/9 to 3/29/05	541.3	3,230
3/29 to 4/4/05	540.2	1,270
4/4/ to 4/13/05	541.1	3,320
4/13 to 4/20/05	540.8	254

Some, but not all, of the dye entered the groundwater system during a storm on March 22, 2005. The remainder was mobilized by water introduced on April 5, 2005. The velocity of the dye front was calculated based on this interpretation.

Based on the detection at the downstream Station 131, the first dye arrival and the peak dye concentration at (Station 102) were about one day after the March 22, 2005 storm event. The straight-line flow path distance was approximately 809 feet. The elevation loss is approximately 56 feet. The mean gradient along this flow path is approximately 365 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 980 feet per day, based on the detection at Station 131. After introduction, dye from this trace was detectable for about >51 days at Headwall Spring when sampling was halted.

Trace 05-19 hydrologically linked a large sinkhole in the corridor to a previously undocumented spring also located in the Section 5 corridor. has not been demonstrated to have special significance for this project.

Trace 05-20:

On March 23, 2005 at 1313 hours, one-half pound of rhodamine WT dye mixture containing approximately 20% dye and 80% diluent was introduced into a ditch failure in the median of SR 37). There were approximately five gpm of stormwater runoff entering the groundwater system at the time of dye introduction. The dye introduction location is approximately at at an elevation of approximately 758 feet msl. The purpose of the trace was to characterize groundwater flow patterns in this portion of the corridor.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-20.

The following table shows the groundwater flow route detections of dye in activated carbon samplers from Trace 05-20.

Trace 05-20

Sampling Period	Peak Emission Wavelength (nm)	Rhodamine WT Dye Concentration (ppb)
2/25 to 3/22/05	ND	ND
3/22 to 3/29/05	568.9*	455*
3/29 to 4/5/05	567.8	6,140
4/5 to 4/13/05	568.5	2,350
4/13 to 4/20/05	569.2	1,120

* Values are the mean of two samples.

The first dye arrival at (Station 148) was about six days after the dye introduction. The straight-line flow path distance was approximately 804 feet. The elevation loss is approximately 28 feet. The mean gradient along this flow path is approximately 154 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 132 feet per day. After introduction, dye from this trace was detectable for about28 days at . Dye was still detectable when sampling was halted.

Trace 05-20 hydrologically linked a sinkhole in the median of SR37 with a previously undocumented spring that is also located in the Section 5 corridor. has not been demonstrated to have any special significance for the project.

Trace 05-21:

On April 2, 2005 at 1127 hours, potable water was introduced into a sinkhole (GIS insurgence feature No.316) that was reopening in the road ditch along SR 37. At 1128 hours, 0.25 pound of eosine dye mixture containing approximately 75% dye and 25% diluent was introduced into the groundwater system. Water introduction ended at 1147 hours. Approximately 1,800 gallons of water was introduced to start Trace 05-21. The dye introduction point is located approximately at at an elevation of approximately 707 feet msl. The purpose of the trace was to help characterize groundwater flow patterns around this section of the corridor.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-21.

The following table shows the groundwater flow route detections in activated carbon samplers of dye from Trace 05-21 at

Sampling Period	Peak Emission Wavelength (nm)	Eosine Dye Concentration (ppb)
3/23 to 3/30/05	ND	ND
3/30 to 4/7/05	541.3	1,160
4/7 to 4/14/05	541.0*	296*
4/14 to 4/20/05	541.1	76.9

* Values are the mean of two samples.

Eosine dye from Trace 05-21 was observed discharging from (Station 163) at 1153 hours on April 2, 2005. The minimum velocity of the dye front is based on this observation.

Eosine dye was also detected at

Sampling Period	Peak Emission Wavelength (nm)	Eosine Dye Concentration (ppb)
4/7 to 4/14/05	ND	ND
4/14 to 4/20/05	541.0	2.83

The flow path to seems to be minor leakage from the main flow path that discharges at

The first dye arrival at (Station 163) was in less than 20 minutes after the dye introduction. The straight-line flow path distance was approximately 243 feet. The elevation loss is approximately 24 feet. The mean gradient along this flow path is approximately 521 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 13,997 feet per day. After introduction, dye from this trace was detectable for about 18 days at at which time sampling was halted.

The first dye arrival at (Station 166) was between 12 and 18 days after the dye introduction. The straight-line flow path distance was approximately 365 feet. The elevation loss is approximately 27 feet. The mean gradient along this flow path is approximately 391 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 20 feet per day. Dye from this trace was not detected at Station 166 until the last sampling event. After introduction, dye from this trace was detectable at for >18 days at which time sampling was halted.

The dye introduction point receives runoff from SR37. The springs to which the dye introduction point has been connected are also in the Section 5 corridor. Neither of these springs was documented prior to this investigation. The groundwater system identified by Trace 05-21 has not been demonstrated to have special significance for this project.

Trace 05-22:

On April 2, 2005 at 1233 hours, potable water was introduced into a sinkhole that was reopening in the road ditch along SR 37. At 1238 hours, 0.25 pound of eosine dye mixture containing approximately 75% dye and 25% diluent was introduced into the groundwater system. Water introduction ended at 1248 hours. Approximately 1,000 gallons of water was introduced to start Trace 05-22. There was some ponding of water during water introduction. The dye introduction point is located approximately at at an elevation of approximately 781 feet msl. The purpose of the trace was to help characterize groundwater flow patterns around this section of the corridor.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-22. The figure does not show Station 128 because it is covered by the title block.

The following table shows groundwater flow route detections of dye in activated carbon samplers from Trace 05-22 at

Sampling Period	Peak Emission Wavelength (nm)	Eosine Dye Concentration (ppb)
2/10 to 3/24/05	ND	ND
3/24 to 4/5/05	541.3	3,740
4/5 to 4/12/05	541.2	685
4/12 to 4/19/05	540.7	167

Dye from this trace was detected at the following sampling stations downstream of

Based on the detection at (Station 128), the first dye arrival at (Station 135) was about six hours after the dye introduction. The straight-line flow path distance was approximately 689 feet. The elevation loss is approximately 27 feet. The mean gradient along this flow path is approximately 207 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 2,869 feet per day, based on the detection at After introduction, dye from this trace was detectable for about 17 days at Van Spring at which time sampling was halted.

Trace 05-22 linked a reopening sinkhole that receives runoff from SR37 with a previously undocumented spring located in the Section 5 corridor. This groundwater system has not been demonstrated to have special significance for this project. Trace 05-22 demonstrated the presence of a karst flowpath that crosses under SR37.

Trace 05-23:

On April 2, 2005 at 1256 hours, potable water was introduced into a sinkhole (GIS insurgence feature No.405) that was reopening in the road ditch along SR 37. At 1258 hours, 0.5 pound of rhodamine WT dye mixture containing approximately 20% dye and 80% diluent was introduced into the groundwater system. Water introduction ended at 1300 hours. Approximately 800 gallons of water was introduced to start Trace 05-23. The dye introduction point is located approximately at at an elevation of approximately 756 feet msl. The purpose of the trace was to help characterize groundwater flow patterns around this section of the corridor.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-23.

The following table shows groundwater flow routedetections of dye in activated carbon samplers from Trace 05-23.

Trace 05-23

Sampling Period	Peak Emission Wavelength (nm)	Rhodamine WT Dye Concentration (ppb)
2/9 to 3/29/05	ND	ND
3/29 to 4/4/05	567.8	14,700
4/4 to 4/13/05	571.4	378*
4/13 to 4/20/05	571.6	56.5*

* Due to a large concentration of eosine in the sample, the rhodamine WT concentration cannot be accurately calculated.

Dye from this trace was also detected at the downstream sampling station, (Station 131). The figure does not show Station 131 because it is too far west to appear at the figure's scale.

Based on the detection at the downstream Station 131, the first dye arrival and the peak dye concentration at (Station 102) were less than six hours after dye introduction. The straight-line flow path distance was approximately 758 feet. The elevation loss is approximately 56 feet. The mean gradient along this flow path is approximately 390 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 3,087 feet per day, based on the detection at Station 131. Dye from this trace was detectable for about18 days at at which time sampling was halted.

Trace 05-23 hydrologically linked one sinkhole in a cluster of sinkholes that are located in the corridor to a spring also located in the Section 5 corridor. This was the second trace to has not been demonstrated to have special significance for this project. The trace demonstrated the presence of a karst flowpath crossing SR37.

Trace 05-24:

On April 2, 2005 at 1405 hours, potable water was introduced into a sinkhole (GIS insurgence feature No.226) north of . At 1410 hours, one pound of eosine dye mixture containing approximately 75% dye and 25% diluent was introduced into the groundwater system. Water introduction ended at 1430 hours. Approximately 1,800 gallons of water was introduced to start Trace 05-24. The dye introduction point is located approximately at at an elevation of approximately 790 feet msl. The purpose of the trace was to help characterize groundwater flow patterns around this section of the corridor.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-24. The figure does not show Station 185, since it is too far north to appear at the figure's scale.

The following tables show the groundwater flow routedetection of dye in activated carbon samplers from Trace 05-24 at

Trace 05-24

Sampling Period	Peak Emission Wavelength (nm)	Eosine Dye Concentration (ppb)
11/17 to 12/3/04	ND	
12/3/04 to 4/7/05	540.7	11.0
4/7 to 4/15/05	540.5	8.50
4/15 to 4/20/05	541.1*	14.20*

* Based on the mean of two samplers each analyzed twice.

Trace 05-24

Sampling Period	Peak Emission Wavelength (nm)	Eosine Dye Concentration (ppb)
3/16 to 3/29/05	ND	ND
3/29 to 4/7/05	540.9	96.9
4/7 to 4/14/05	540.7	12.6
4/14 to 4/20/05	540.5	4.82

The dye was detected at and in higher concentrations at indicating that most of the dye was discharged downstream of It was also detected at the following downstream sampling stations:

Based on the detection at Station 185, the first dye arrival at (Station 87) was about 1.5 days after dye introduction. The straight-line groundwater flow path distance was approximately 5,052 feet. The elevation loss is approximately 140 feet. The mean gradient along this flow path is approximately 146 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 3,770 feet per day, based on the detection at Station 185. After introduction, dye was detectable for about18 days at at which time sampling was halted. After introduction dye was detectable for >18 days at Station 89 (

.

Trace 05-24 was the second trace to flow to previously undocumented springs. The springs in have not been demonstrated to have special significance for the project.

Trace 05-25:

On April 4, 2005 beginning at 1634 hours, potable water was introduced into a sinkhole (GIS insurgence feature No.318) that is north of . At 1635 hours, one ounce of fluorescein dye mixture containing approximately 75% dye and 25% diluent was introduced into the groundwater system. Water introduction ended at 1639 hours. Approximately 1,000 gallons of water was introduced to start Trace 05-25. The dye introduction point is located approximately at
W at an elevation of approximately 699 feet msl. The purpose of the trace was to help characterize groundwater flow patterns around this section of the corridor.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-25.

The following table shows groundwater flow routedetections of dye in activated carbon samplers from Trace 05-25.

Trace 05-25

Sampling Period	Peak Emission Wavelength (nm)	Fluorescein Dye Concentration (ppb)
3/23 to 3/30/05	ND	ND
3/30 to 4/7/05	517.0	18,700
4/7 to 4/14/05	516.9	833
4/14 to 4/20/05	516.9	579

Dye was also detected at Station 190, which is located in the SR37 ditch. There is only wet-weather flow at Station 190. Given the hydrogeologic setting it is likely that the fluorescein detected at Station 190 flowed through the epikarstic zone from the dye introduction point. The dye concentration from the positive activated carbon sampler was 64.8 ppb. This is much larger than fluorescein detections commonly derived from parking lots and highways, so highway runoff is an unlikely source for the dye detected at Station 190. Under the conditions tested water movement to Station 190 represents a minor flow path. Figure 37 shows flow paths to both Stations 169 and 190.

The first dye arrival and peak dye concentration at were less than three days after dye introduction. The straight-line groundwater flow path distance was approximately 314 feet. The elevation loss is approximately 31 feet. The mean gradient along this flow path is approximately 521 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 107 feet per day. After introduction dye was detectable for >16 days at before sampling was halted.

Trace 05-25 hydrologically linked a sinkhole in the Section 5 corridor to a previously undocumented spring that is also in the corridor. has not been demonstrated to have special significance for the project.

Trace 05-26:

On April 4, 2005 at 1647 hours, potable water was pumped into a sinkhole (GIS insurgence feature No.315) that was reopening in a slope above the southwest corner of At 1650 hours, one-quarter of a pound of sulforhodamine B dye mixture containing approximately 75% dye and 25% diluent was introduced into the groundwater system. Water introduction ended at 1657 hours. Approximately 1,000 gallons of water was introduced to start Trace 05-26. The dye introduction point is located approximately at at an elevation of approximately 719 feet msl. The purpose of the trace was to help characterize groundwater flow patterns around this section of the corridor.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-26.

The following table shows the groundwater flow route detections of dye in activated carbon samplers from Trace 05-26.

Trace 05-26

Sampling Period	Peak Emission Wavelength (nm)	Sulforhodamine B Dye Concentration (ppb)
3/30 to 4/7/05	ND	ND
4/7 to 4/14/05	577.4	4.11
4/14 to 4/20/05	577.0	4.86

The first dye arrival at Station 166) was less than ten days after dye introduction. The straight-line groundwater flow path distance was approximately 687 feet. The elevation loss is approximately 39 feet. The mean gradient along this flow path is approximately 300 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 71 feet per day. After introduction, dye was detectable for about 16 days at before sampling was halted.

Trace 05-26 demonstrates ha karst flowpath The trace links a reopening sinkhole that abuts SR37 with a previously undocumented spring that is in the Section 5 corridor. ing has not been demonstrated to have special significance for the project.

Trace 05-27:

On April 4, 2005 at 1734 hours, potable water was introduced into a sinkhole (GIS insurgence feature No.442) that was reopening in the road ditch along SR 37. At 1735 hours, 0.5 pound of rhodamine WT dye mixture containing approximately 20% dye and 80% diluent was introduced into the groundwater system. The water introduction ended at 1738 hours. Approximately 1,000 gallons of water was introduced to start Trace 05-27. The dye introduction point is located approximately at at an elevation of approximately 789 feet msl. The purpose of the trace was to help characterize groundwater flow patterns around this section of the corridor.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-27.

The following table shows groundwater flow route detections of dye in activated carbon samplers from Trace 05-27.

Trace 05-27

Sampling Period	Peak Emission Wavelength (nm)	Rhodamine WT Dye Concentration (ppb)
4/3/05 (water)	ND	ND
4/3 to 4/6/05	568.6	5.37
4/6 to 4/13/05	569.4	333
4/13 to 4/19/05	568.4	278

The first dye arrival at (Station 198) was less than two days after dye introduction. The peak concentration of dye arrived between two and nine days after dye introduction. The straight-line groundwater flow path distance was approximately 478 feet. The elevation loss is approximately 20 feet. The mean gradient along this flow path is approximately 221 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 293 feet per day. After introduction, dye was detectable for about15 days at before sampling was halted.

Trace 05-27 demonstrates a karst flowpath The trace links a reopening sinkhole that abuts SR37 with a previously undocumented spring in the Section 5 corridor. Thorn Spring has not been demonstrated to have special significance for the project.

Trace 05-28:

On April 4, 2005 at 1834 hours, potable water was introduced into a sinkhole (GIS insurgence feature No.322) that was reopening in the road ditch along SR 37. At 1836 hours, 0.25 pound of rhodamine WT dye mixture containing approximately 20% dye and 80% diluent was introduced into the groundwater system. The water introduction ended at 1742 hours. Approximately 1,500 gallons of water was introduced to start Trace 05-28. The dye introduction point is located approximately at at an elevation of approximately 700 feet msl. The purpose of the trace was to help characterize groundwater flow patterns along an alignment of a possible new terrain interchange associated with Kinser Pike.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-28.

The following table shows dye detections in activated carbon samplers from Trace 05-28 at

Sampling Period	Peak Emission Wavelength (nm)	Rhodamine WT Dye Concentration (ppb)
3/23 to 3/30/05	ND	ND
3/30 to 4/7/05	568.1	4,110
4/7 to 4/14/05	569.9	696
4/14 to 4/20/05	568.8	218

Rhodamine WT dye was observed discharging from (Station 173) at 1844 hours on April 4, 2005. The minimum velocity of the dye front was calculated from this observation. The first dye arrival at (Station 173) was approximately eight minutes after dye introduction. The straight-line groundwater flow path distance was approximately 268 feet. The elevation loss is approximately 30 feet. The mean gradient along this flow path is approximately 591 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 48,240 feet per day. After introduction, dye was detectable for about 16 days at before sampling was halted.

Dye from Trace 05-28 was also detected at (Station 172). The following table shows dye detections in activated carbon samplers from Trace 05-28 at

Trace 05-28

Sampling Period	Peak Emission Wavelength (nm)	Rhodamine WT Dye Concentration (ppb)
3/23 to 3/30/05	ND	ND
3/30 to 4/14/05	569.1	14.0

The first dye arrival at (Station 172) was less than ten days after dye introduction. The straight-line groundwater flow path distance was approximately 1,195 feet. The elevation loss is approximately 55 feet. The mean gradient along this flow path is approximately 243 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 125 feet per day. This flow path is relatively minor under these flow conditions compared with the flow pathway to After introduction, dye was detected at for about 10 days before sampling was halted.

Neither of the springs that received water from Trace 05-28 were documented prior to this investigation. This groundwater system and these two springs have not been demonstrated to have special significance for this project.

Trace 08-01:

At 1628 hours on November 19, 2008, the introduction of potable water into a sinkhole began (GIS insurgence feature No.66(GIS Feature Number 66. The dye introduction point is located at approximately at an elevation of approximately 778 feet msl. The water was hauled to the location by truck. At 1630 hours, 0.25 pound of fluorescein dye mixture containing approximately 75% dye and 25% diluent was introduced into the flowing water. Water was continuously discharged into the sinkhole until 1637 hours. A total of 2,200 gallons was used to start this trace. The purpose of this trace was to help delineate the recharge area of

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-29.

The following table shows the groundwater flow path detection of dye in activated carbon samplers from Trace 08-01.

Trace 08-01:

Sampling Period	Station 83 Fluorescein Dye Concentration (ppb)	Station 84 Fluorescein Dye Concentration (ppb)
10/16 to 11/19/08	ND	1.85*
11/19 to 11/25/08	279	17,500
11/25 to 12/3/08	135	968
12/3 to 12/10/08	48.1	281
12/10 to 12/20/08	13.4	83.4
12/20/08 to 1/8/09	10.3	44.2
1/8 to 1/23/09	3.09	27.9
1/23 to 4/21/09	3.40	17.2
4/21 to 4/27/09	1.22	3.83
4/27 to 5/4/09	1.55	2.53

* background value

Dye from this trace was detected at the following sampling stations downstream of

The dye first arrived at in less than 1.5 days. The straight-line distance of this flowpath is approximately 1,306 feet. The elevation loss is approximately 97 feet. The mean gradient along this flow path is approximately 392 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 1,037 feet per day based on the Station 12 dye detection. After introduction, dye was detectable for about 166 days at before sampling was halted.

It is not clear if groundwater flow to had a faster or slower velocity than flow to . However, it is likely that the travel rate to May B Spring was slower than to had lower concentrations of dye both in this trace and in Trace 04-07 (Trace). These concentrations support the concept that contributes water to The straight-line groundwater flow path distance is approximately 1,605 feet. The elevation

loss is approximately 108 feet. The mean gradient along this flow path is approximately 355 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 297 feet per day. After introduction, dye was detectable for about 166 days at before sampling was halted.

This trace demonstrates that the sinkhole traced does not contribute water to and lies outside its recharge area. This groundwater system has limited biological significance; see the discussion for Trace 09-07.

Trace 08-02:

At 1648 hours on November 19, 2008, the introduction of potable water into a sinkhole began (GIS insurgence feature No.49). The dye introduction point is at approximately at an elevation of approximately 768 feet msl. Water was conveyed into the sinkhole via a garden hose. The hose was discharging approximately 4.8 gpm. At 1702 hours, 0.75 pound of rhodamine WT dye mixture containing approximately 20% dye and 80% diluent was introduced. At 0850 hours on November 20, 2008, water introduction was halted. Approximately 4,600 gallons of water was used to start this trace. The purpose of this trace was to help delineate the recharge area of

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-30.

The following table shows the groundwater flow path detections of dye in activated carbon samplers from Trace 08-02.

Trace 08-02

Sampling Period	Peak Emission Wavelength (nm)	Rhodamine WT Dye Concentration (ppb)
11/25 to 12/3/08	ND	ND
12/3 to 12/10/08	(1)	
12/10 to 12/20/08	(1)	
12/20/08 to 1/9/09	568.0	24.0
1/9 to 1/23/09	ND	

(1) = A small amount of rhodamine WT may be present in this sample, but it cannot be accurately calculated due to the presence of another dye.

Dye was only detected at between 31 and 51 days after dye introduction. The straight-line groundwater flow path distance was approximately 2,561 feet. The elevation loss is approximately 103 feet. The mean gradient along this flow path is approximately 212 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 50 feet per day, although the first arrival of rhodamine WT may have been obscured by another dye. After introduction, dye was detectable for about 51 days at

The trace demonstrates that the sinkhole into which dye was introduced does not contribute water to and lies outside of the recharge area. Trace 08-02 was the second trace detected at Trace 08-03, while introduced a few minutes later than Trace 08-02, was detected earlier. is a large spring in the study area, but has no other known project significance.

Trace 08-03:

At 1722 hours on November 19, 2008, one pound of eosine dye mixture containing approximately 75% dye and 25% diluent was introduced into the discharge from a small spring in a losing stream reach within a large sinkhole (GIS insurgence feature No.103). Flow was estimated to be approximately 0.25 gpm and all re-entered the groundwater system within about 30 feet of the dye introduction point. On November 20, 2008 at 0925 hours, almost all dye had moved into the groundwater system. Nevertheless, a fire hydrant about 800 feet upstream of the dye introduction point was opened and discharged through a water meter. Approximately 17,500 gallons of water was discharged between 0931 and 1030 hours. This water increased the velocity of dyed water flowing through the groundwater system. If this much water had been used at the time of dye introduction it would have moved some of the dye down the valley instead of allowing almost all of it to enter the groundwater system.

The dye introduction point is located at approximately at an elevation of approximately 750 feet msl. The purpose of this trace was to help delineate the recharge area of

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-31. The following table shows the groundwater flow route detections of dye in activated carbon samplers from Trace 08-03 at

Trace 08-03

Sampling Period	Peak Emission Wavelength (nm)	Eosine Dye Concentration (ppb)
10/16 to 11/19/08	ND	ND
11/19 to 11/25/08	541.3	600
11/25 to 12/3/08	541.6	1,110
12/3 to 12/10/08	541.2	340
12/10 to 12/20/08	541.2	215
12/20/08 to 1/9/09	541.1	59.7
1/9 to 1/23/09	541.0	50.0

Note: There are additional eosine detections from Trace 08-03 at this sampling station; the data are found in Appendix B.

Dye from this trace was detected at the following sampling stations:

-

Based on the Station 80 dye detection, dye first arrived at about three days after dye introduction. The straight-line groundwater flow path distance is approximately 5,041 feet. The elevation loss is approximately 85 feet. The mean gradient along this flow path is approximately 89 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 1,688 feet per day. After introduction, dye was detectable for about 336 days at before sampling was halted.

This is one of two traces detected at The groundwater trace crossed the subwatershed boundary and thus demonstrates interbasin transfer of water from the basin to the basin. The trace also demonstrates that the dye introduction feature does not contribute water to and therefore lies outside its recharge area. While is a relatively large spring for this study area, it has no other known project significance.

Trace 09-04:

At 1630 hours on February 1, 2009, one pound of eosine dye mixture containing approximately 75% dye and 25% diluent was introduced into snow melt running down the tributary stream (GIS insurgence feature No. ss1) in which is located. Flow was estimated to be approximately 1.5 gpm. The dye introduction point is located at approximately at an elevation of approximately 736 feet msl.

A dye introduction (Trace 04-11) at the headwaters of this stream demonstrated that a portion of this tributary loses water to The purpose of Trace 09-04 was to help define what portion of the tributary loses water to

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-32.

The following table shows the groundwater flow path detections of dye in activated carbon samplers from Trace 09-04 that discharged from springs.

Trace 09-04:

Sampling Period	**Station 74 Eosine Dye Concentration (ppb)**	**Station 73 Eosine Dye Concentration (ppb)**	
1/23 to 2/3/09	ND	ND	
2/3 to 2/10/09	ND	7.44	
2/10 to 2/17/09	0.842*	6.21	
2/17 to 2/26/09	0.487*	7.06	
2/26 to 3/6/09	1.20	12.9	

* mean of two samples ** Background not from Trace 09-04.
Note: There are additional eosine detections from Trace 09-04 at Stations 73 and 74; the data are found in Appendix B.

Dye from this trace was also detected at the following sampling stations but derived their dye from surface flowpaths or dye discharged from the springs above.

-

Even though is farther downstream in the system than it had an order of magnitude higher dye concentration than and had an earlier dye detection. That indicates that receives more of its recharge from the dyed tributary than does is merely sampling passing surface water in this trace.

This trace demonstrates that the dye introduction point is downstream of the reach that loses water into the groundwater system and is thus not part of the recharge area.

Dye first arrived at between 9 and 16 days after dye introduction. The straight-line groundwater flowpath distance was approximately 4,137 feet. The elevation loss is approximately 69 feet. The mean gradient along this flow path is approximately 88 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 262 feet

per day. After introduction, dye was detectable for >170 days at before sampling was halted.

Dye first arrived at about five days after dye introduction. The straight-line groundwater flowpath distance was approximately 5,014 feet. The elevation loss is approximately 82 feet. The mean gradient along this flow path is approximately 86 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 1,002 feet per day based on the Station 68 dye detection. Dye from this trace was overridden by dye from Trace 09-10, so the persistence of the dye from Trace 09-04 is unknown. However, it was >85 days. The same duration applies to

Trace 09-05:

At 1142 hours on February 2, 2009, potable water was introduced into a sinkhole (GIS insurgence feature No.55) in preparation for dye introduction. The water was hauled to the dye introduction point by truck. At 1144 hours, 0.25 pound of fluorescein dye mixture containing approximately 75% dye equivalent and 25% diluent was introduced into the water flow. At 1151 hours, the first load of water, amounting to 2,100 gallons, had been discharged to the ground. A second load of water was discharged at the same location from 1232 to 1241 hours. A total of 4, 200 gallons of water was used to start this trace. The purpose of this trace was to help delineate the recharge area of

The location of the dye introduction point is approximately at an elevation of approximately 745 feet msl.

The dye introduction point and diagrammatic flow paths of the groundwater trace are shown on Figure F-33.

The following table shows the groundwater flow path detections of dye in activated carbon samplers from Trace 09-05.

Trace 09-05:

Sampling Period	Station 150 Fluorescein Dye Concentration (ppb)	Station Fluorescein Dye Concentration (ppb)	Station Fluorescein Dye Concentration (ppb)
1/9 to 1/23/09	ND	0.724**	NS
1/23 to 2/3/09	314		
1/23 to 2/10/09		288	58.5
2/3 to 2/10/09	668		
2/10 to 2/17/09	87.7	9.79	0.935
2/17 to 2/26/09	12.1	6.64	ND
2/26 to 3/6/09	11.6	6.20	ND
3/6 to 3/17/09	4.69*	4.89	ND
3/17 to 3/23/09	4.20	2.16	ND
3/23 to 3/31/09	4.72	2.92	ND
3/31 to 4/15/09	7.81	1.50	ND

* mean of three samples ** background value NS = No sample

Dye from Trace 09-05 was detected at the following additional sampling station:

- Station 202: (this station only had flow for one sampling period during this trace)

The table above is truncated; the complete results are provided in Appendix B. Dye first arrived at Station 150 (in less than 1.5 day after dye introduction. The straight-line groundwater flowpath distance was approximately 1,210 feet. The elevation loss is approximately 49 feet. The mean gradient along this flow path is approximately 214 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 1,076 feet per day. After introduction, dye was detectable for 96 days at Station 150 (S

Dye first arrived at Station 201 (within eight days after dye introduction. The straight-line groundwater flowpath distance was approximately 7,098 feet. The elevation loss is approximately 99 feet. The mean gradient along this flow path is approximately 74 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 883 feet per day. After introduction, dye was detectable for 78 days at

Dye first arrived at Station 202 (and its associated downstream sampling station within eight days after dye introduction. The straight-line groundwater flowpath distance was approximately 6,574 feet. The elevation loss is approximately 101 feet. The mean gradient along this flow path is approximately 81 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 817 feet per day. After introduction, dye was detectable for 8 days at Station 202) and for 15 days at Station 203 (Downstream of). The dye concentration was substantially greater at Station 203 than at Station 202.

Trace 09-05 demonstrates complexity in the groundwater distribution pattern in the southern part of the Section 5 corridor. The most extremely separated springs, and had similar dye concentrations and duration of dye discharge, while the spring between them had much lower concentrations and a much briefer period of dye discharge.

This groundwater system has limited biological significance; see the discussion for Trace 09-07. The sinkhole used for this dye introduction did not contribute water to and therefore lies outside of the recharge area.

Trace 09-06:

At 1516 hours on February 3, 2009, 0.75 pound of sulforhodamine B dye mixture containing approximately 75% dye and 25% diluent was placed as a dry set in a snow-covered sinkhole (GIS insurgence feature No.154). The location of the dye introduction point is approximately at an elevation of approximately 738 feet msl. The purpose of the trace was to help delineate the recharge area.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-34. Dye was not detected at any spring, however sulforhodamine Bdye was detected at several locations in the unnamed tributary containing Trough Spring, including a sampling station established after the dye introduction. This station was called Downstream of (Station 204). Downstream of was the most upstream of the stations sampled with a positive dye detection from this trace.

Dye from Trace 09-06 was detected at the following sampling stations located downstream from Station 204:

-

Since Station 204 (Downstream of) is not a spring, there is either a spring we failed to locate, or more likely, simply a gaining stream reach between (Station 75) and Station 204 that received water from the

The temperature stayed below freezing until February 5, when the daytime highs reached the mid-50s. There was probably not enough snow to create runoff to mobilize the dye, but it did create good antecedent conditions. The rainfall event on February 10, 2009 on wet soil probably moved the dye into the groundwater system and the calculations of first arrival and velocity are based on that assumption.

Based on the dye detection at Station 67 and the estimate that the dye did not move into the groundwater system until February 10, dye first arrived at Station 204 (Downstream of about half a day after dye introduction. The straight-line groundwater flowpath distance was approximately 1,280 feet. The elevation loss is approximately 50 feet. The mean gradient along this flow path is approximately 206 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 9,711 feet per day. After introduction, dye was detectable for 77 days at Station 204.

The sinkhole used for this dye introduction does not contribute water to and lies outside their recharge areas.

Trace 09-07:

At 1830 hours on April 27, 2009, potable water began to be discharged to a roadside ditch. At 1832, three pounds of eosine dye mixture containing approximately 75% dye and 25% diluent was introduced into the potable water discharge. At 1840 hours, the first load of approximately 2,100 gallons of water had been discharged to the ditch. A second load of potable water was discharged at the same point from 1902 to 1911 hours. A total of approximately 4,200 gallons of water was used to start Trace 09-07. The location of the dye introduction point is approximately at an elevation of approximately 769 feet msl. The purpose of the trace was to help delineate the recharge area and to test for recharge from areas that have no visible sinkhole development.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-35.

The following table shows the groundwater flow path detections of dye in activated carbon samplers from Trace 09-07.

Trace 09-07: SR 37

Sampling Period	Station 75 Eosine Dye Concentration (ppb)	Station 145 Eosine Dye Concentration (ppb)	Station 201 Eosine Dye Concentration (ppb)	Station 203 osine Dye Concentration (ppb)
4/21 to 4/27/09	14.8**	ND	ND	ND
4/27 to 5/4/09	37.0	ND	780	8.65
5/4 to 5/12/09	42.8	ND	159*	8.52
5/12 to 5/19/09	27.1	ND	0.521***	14.6
5/19 to 5/26/09	12.6			
5/26 to 6/2/09	18.5			
5/19 to 5/27/09		ND	27.8*	0.461***
5/27 to 6/2/09		ND	25.3	2.43
6/2 to 6/10/09	14.0	1.95	52.1	4.33*
6/10 to 6/16/09	33.0	4.34	84.4	11.9
6/16 to 6/24/09	32.4	3.42	31.2	5.74
6/24 to 7/6/09	12.2	1.23	14.7	0.705*

* mean of two samples ** residual dye from Trace 09-04 This sample did not meet all criteria for a positive detection but has been calculated as though it were the tracer dye.
Note: There are additional eosine detections from Trace 09-07 at all four sampling stations; the data are found in Appendix B.

Dye from this trace was detected at the following sampling station downstream of

detections are not at least an order of magnitude greater than the background sample. However, grab samples of water were also collected when the carbon samplers were replaced and the water samples went to non-detect between the traces.

Dye first arrived at Station 75) less than seven days after dye introduction. The straight-line groundwater flowpath distance was approximately 1,196 feet. The elevation loss is approximately 65 feet. The mean gradient along this flow path is approximately 287 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 178 feet per day. After introduction, dye was detectable for at least 70 days at Trough Spring before it was overridden by dye from a subsequent trace.

Dye first arrived at (Station 145) between 77 and 85 days after dye introduction. The straight-line groundwater flowpath distance was approximately 869 feet. The elevation loss is approximately 49 feet. The mean gradient along this flow path is approximately 298 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 10 feet per day. After introduction,dye was detectable for about 177 days until sampling was halted.

Dye first arrived at less than seven days after dye introduction. The straight-line groundwater flowpath distance was approximately 6,653 feet. The elevation loss is approximately 123 feet. The mean gradient along this flow path is approximately 98 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 996 feet per day. After introduction, dye was detectable for about 97 days at before sampling was halted.

Dye first arrived at Downstream of less than seven days after dye introduction. The straight-line groundwater flowpath distance was approximately 6,376 feet. The elevation loss is approximately 132 feet. The mean gradient along this flow path is approximately 109 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 954 feet per day. After introduction, dye was detectable for less than 85 days at Station 203 (Downstream of).

The dye introduction point is essentially on the HUC14 subwatershed boundary with no evidence of a karst feature or a buried karst feature. Not only was there recharge, but there was both fast and complex recharge with water going to both the basins and specifically to four different discharge points. This dye introduction point was less than 10 feet from the current SR37 shoulder. This has important implications for water and spills running off pavement even in areas without mapped karst features.

This trace links and from linkage through 09-05 and 09-09, These spring systems may share a faunal assemblage with based on the hydrologic linkage.

This trace demonstrates that the area traced does not contribute water to and therefore lies outside its recharge area.

Trace 09-08:

At 1935 hours on April 27, 2009, one-half pound of fluorescein dye mixture containing approximately 75% dye and 25% diluent was placed in the r sinkhole (GIS insurgence feature No.109) as a dry set to be introduced into the groundwater system by a series of storms predicted over the following 24 hours. However, little of the dye had been mobilized overnight and potable water was hauled to the location to expedite the dye introduction. From 1214 hours to 1231 hours on April 28, approximately 2,100 gallons of potable water was introduced into the A second load was introduced from 1704 hours to 1719 hours. A total of approximately 4,200 gallons were used to start Trace 09-08. The location of the dye introduction point is approximately at an elevation of approximately 764 feet msl. The purpose of the trace was to help delineate the recharge area.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-36.

The following table shows the groundwater flow path detections of dye in activated carbon samplers from Trace 09-08.

Trace 09-08

Sampling Period	Peak Emission Wavelength (nm)	Fluorescein Dye Concentration (ppb)
4/21 to 4/27/09		ND
4/27 to 5/4/09	516.3	5,810
5/4 to 5/12/09	515.5	62.8
5/12 to 5/19/09	515.7	15.3
5/19 to 5/26/09	515.8	11.6
5/26 to 6/2/09	515.5	10.9
6/2 to 6/10/09	515.9	4.97
6/10 to 6/16/09	515.6	4.74
6/16 to 6/24/09	515.5	4.46
6/24 to 7/6/09	515.9	4.71

Dye from Trace 09-08 was detected at the following sampling stations downstream of

Dye first arrived at less than seven days after dye introductionbased on the Station 12 dye detection. The straight-line groundwater flowpath distance was approximately 3,903feet. The elevation loss is approximately 90 feet. The mean gradient along this flow path is approximately 122 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 1,186 feet per day. After introduction, dye was detectable for 70 days at before the dye was overridden by a subsequent trace.

The trace demonstrated that the sinkhole contributes water to and therefore lies within the recharge area. The trace also crossed the entire highway corridor as well as the subwatershed boundary and transferred water from the

Trace 09-09:

At 1037 hours on April 28, 2009, potable water began to be pumped to the Crowder sinkhole (GIS insurgence feature No.40). The location of the dye introduction point is approximately at an elevation of approximately 765 feet msl. At 1041 hours, one pound of rhodamine WT dye mixture containing approximately 20% dye and 80% diluent was introduced into the discharge. The first load of water was completely discharged at 1102 hours. A second load was introduced from 1117 to 1142 hours on April 28, 2009. A total of approximately 4,200 gallons of water were used to start Trace 09-09. The purpose of the trace was to help delineate the recharge area.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-37.

The following table shows the detections of dye in activated carbon samplers from Trace 09-09.

Trace 09-09:

Sampling Period	**Station 150** **Road Rhodamine WT Dye Concentration (ppb)**	**Station 201** **Rhodamine WT Dye Concentration (ppb)**	**Station 203** **Rhodamine WT Dye Concentration (ppb)**
4/21 to 4/27/09		ND	ND
4/21 to 4/28/09	ND		
4/27 to 5/4/09		3,120	38.3
4/28 to 5/4/09	12.8		
5/4 to 5/12/09	ND	126.5*	9.61
5/12 to 5/19/09	ND	0.521**	30.3
5/19 to 5/27/09	ND	57.8*	ND
5/27 to 6/2/09	ND	22.4	ND
6/2 to 6/10/09	ND	25.6	ND
6/10 to 6/16/09	ND	ND	ND
6/16 to 6/24/09	ND	15.3**	ND
6/24 to 7/6/09	ND	18.2**	ND

* mean of two samples ** A fluorescence peak is present that does not meet all the criteria for a positive dye result. However, it has been calcuclated as though it were the tracer dye

Dye first arrived at Station 150 (within six days after dye introduction. The straight-line groundwater flowpath distance was approximately 1,093 feet. The elevation loss is approximately 69 feet. The mean gradient along this flow path is approximately 333 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 181 feet per day. Dye was detectable for six days or less at , so the groundwater velocity was higher than the minimum stated above.

Dye first arrived at Station 201 ( ) within six days after dye introduction. The straight-line groundwater flowpath distance was approximately 6,504 feet. The elevation loss is approximately 119 feet. The mean gradient along this flow path is approximately 97 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 1,082 feet per day. After introduction, dye was detectable for 84 days at .

Dye first arrived at Station 203 (Downstream of within six days after dye introduction. The straight-line groundwater flowpath distance was approximately 6,195 feet. The elevation loss is approximately 128 feet. The mean gradient along this flow path is approximately 109 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 1,030 feet per day. After introduction, dye was detectable for 21 days at Downstream of

This is the third trace to demonstrate that this suite of springs share recharge areas; the other traces were Trace 09-05 and 09-07. These spring systems may share a faunal assemblage with based on the hydrologic linkage demonstrated by Trace 09-07. is biologically noteworthy (see Section 6.5 of the report), but with lesser significance than

This trace demonstrates that the area traced does not contribute water to and lies outside its recharge area.

At 0616 hours on July 7, 2009, potable water was introduced at the downstream end of a culvert under SR 37(GIS insurgence feature No.ss1). The location of the dye introduction point is approximately at an elevation of approximately 750 feet msl. Two and one-half pounds of eosine dye mixture containing approximately 75% dye and 25% diluent was introduced into the discharged water at 0623, at which time the first load of water had been fully discharged. A second load of water was discharged from 0641 hours to 0649 hours on July 7, 2009. Each load was approximately 2,100 gallons, resulting in a total of 4,200 gallons of water being introduced into this ephemeral stream.

Trace 04-11 demonstrated that some portion of the stream channel recharges while Trace 09-04 (initiated about 1,000 feet south of the point at which Trace 04-11 was started) showed that its dye introduction point was downstream of the stream reach that recharges The purpose of Trace 09-10 was to better define the stream reach that recharges

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-38.

The following table shows the groundwater flow path detections of dye in activated carbon samplers at from Trace 09-10.

Trace 09-10

Sampling Period	Peak Emission Wavelength (nm)	Eosine Dye Concentration (ppb)
6/24 to 7/6/09		ND
7/6 to 7/21/09	540.4	2,800
7/21 to 8/2/09	540.4	36.9
8/2 to 10/21/09	541.6	23.0

Trace 09-10

Sampling Period	Peak Emission Wavelength (nm)	Eosine Dye Concentration (ppb)
6/24 to 7/6/09	541.4	3.34*
7/6 to 7/21/09	541.1	182

* This is residual dye from Trace 09-07

Earlier traces demonstrated that the more downstream reaches of this stream lose water that recharge and this trace did not reveal anything new about those flowpaths.

Dye from this trace was detected at the following additional sampling stations:

-

•

Based on the Station 12 dye detection, dye first arrived at within 13 days after dye introduction. The straight-line groundwater flowpath distance was approximately 5,300 feet. The elevation loss is approximately 96 feet. The mean gradient along this flow path is approximately 96 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 409 feet per day. After introduction, dye was detectable for >106 days at before sampling was halted. Dye was detected at Station 73 ( ) and at Station 75 (Trough Spring) for > 14 days before sampling was halted.

The trace demonstrated that the dye introduction point is within the stream reach that loses water into the groundwater system and is therefore within the recharge area.

Trace 09-11:

From 0835 to 0845 hours on July 7, 2009, 0.25 pound of sulforhodamine B dye mixture containing approximately 75% dye and 25% diluent was introduced into a well. The location of the dye introduction point is approximately The dye had been previously dissolved in approximately 0.5 gallon of potable water in a disposable container and was poured into a disposable funnel that was connected to a disposable hose that reached standing water. The dye mixture was then flushed from the hose using five gallons of potable water. The elevation of the pooled water where the dye was introduced was approximately 720 feet msl. The purpose of the trace was to determine which spring(s) receive water passing through the dye introduction point and to help understand the hydrologic and biologic relationship among spring systems near

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-39.

The following table shows the groundwater flow path detections of dye in activated carbon samplers from Trace 09-11 at Station 75 (Trough Spring).

Trace 09-11

Sampling Period	Peak Emission Wavelength (nm)	Sulforhodamine B Dye Concentration (ppb)
6/24 to 7/6/09		ND
7/6 to 7/21/09	577.2	6,850

Dye from Trace 09-11 was detected at the following additional sampling stations:

-

The additional detection points are located downstream of Station 73 is fed by a karst groundwater flowpath from stream losses downstream of Station 145 detected residual dye suggesting continuing low flow through the dye introduction point. There was detectable dye present in the water samples at Station 145 for a month after the dye introduction.

Based on the Station 67 dye detection, dye first arrived at about 1.5 days after dye introduction. The straight-line groundwater flowpath distance was approximately 341 feet. The elevation loss is approximately 16 feet. The mean gradient along this flow path is approximately 248 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 301 feet per day. There was no sampling after the sampling period in which the initial detection was made so there are no data on the persistence of the dye.

The mean velocity calculated above consists mostly of a surface channel where flow may be faster than throughthe groundwater path.

At 1059 hours on July 7, 2009, potable water was introduced into a sinkhole (GIS insurgence feature No. 50). The location of the dye introduction point is approximately at an elevation of approximately 776 feet msl. At 1103 hours, one pound of fluorescein dye mixture containing approximately 75% dye and 25% diluent was introduced into the discharge. The first load of water was completely discharged at 1106 hours. A second load of water was discharged at the same location from 1128 to 1135 hours on July 7, 2009. Each load was approximately 2,100 gallons, resulting in a total of 4,200 gallons of water being introduced for this trace. The purpose of this trace was to help delineate the recharge area.

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-40.

The following table shows the groundwater flow path detections of dye in activated carbon samplers from Trace 09-13.

Trace 09-12

Sampling Period	**Peak Emission Wavelength (nm)**	**Fluorescein Dye Concentration (ppb)**
6/24 to 7/6/09	515.9	4.71*
7/6 to 7/21/09	516.4	16,200
7/21 to 8/2/09	516.5	154
8/2 to 10/21/09	516.3	92.8

* residual dye from Trace 09-08

Dye from this trace was detected at the following sampling stations downstream of

Based on Station 12 dye detections, dye first arrived at within seven days after dye introduction. The straight-line groundwater flowpath distance was approximately 3,764 feet. The elevation loss is approximately 102 feet. The mean gradient along this flow path is approximately 143 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 551 feet per day. After introduction, dye was detectable for >106 days at before sampling was halted.

Trace 09-12 hydrologically links a sinkhole in the corridor to and demonstrates a karst groundwater flowpath across SR37. It alsodemonstrates interbasin transfer across a subwatershed boundary between the The trace also demonstrates that the sinkhole contributes water to the groundwater system and therefore lies within the recharge area.

Trace 09-13:

At 1203 hours on July 7, 2009, potable water was introduced into a sinkhole (GIS insurgence feature No. 72). The location of the dye introduction point is approximately
W at an elevation of approximately 736 feet msl. At 1205 hours, 0.5 pound of rhodamine WT dye mixture containing approximately 20% dye and 80% diluent was introduced into the discharge. The first load of water was completely discharged at 1215 hours. A second load was introduced between 1238 and 1248 hours on July 7, 2009. Each load was approximately 2,100 gallons, resulting in a total of 4,200 gallons of water being introduced for this trace. The purpose of this trace was to help delineate the recharge area. The dye introduction point is outside the study corridor. but was necessary to complete the recharge area delineation

The dye introduction point and diagrammatic flow path of the groundwater trace are shown on Figure F-41.

The following table shows the groundwater flow path detection of dye in activated carbon samplers from Trace 09-13 at Station 12 (Unnamed Tributary in Section 25).

Trace 09-13

Sampling Period	**Peak Emission Wavelength (nm)**	**Rhodamine WT Dye Concentration (ppb)**
6/24 to 7/6/09		ND
7/6 to 7/21/09	567.1	74.9

Dye first arrived at Station 12 within14 days after introduction. The straight-line groundwater flowpath distance was approximately 2,771 feet. The elevation loss is approximately 98 feet. The mean gradient along this flow path is approximately 187 feet per mile. The minimum mean groundwater flow velocity along this flow path under these flow conditions was approximately 200 feet per day. There was no repeat sampling after the initial dye detection at this sampling location, so the persistence of dye is unknown.

This trace demonstrates that the sinkhole traced does not contribute water to
and lies outside their recharge areas. The groundwater system associated with this trace does not have any identified special significance for this project.

Appendix G

Sample Results Graphs
Redacted for confidential reasons related to karst.

Appendix H

ICS Data
Redacted for confidential reasons related to karst.

Appendix I

Confidential Data
Redacted for confidential reasons related to karst.

Appendix J

Cave Fauna Report

Interstate 69 Evansville to Indianapolis
Tier 2 Studies: Section 5 Cave Fauna

Final Report

Julian J. Lewis, Ph.D.
Lewis & Associates LLC
Cave, Karst & Groundwater
Biological Consulting
17903 State Road 60
Borden, IN 47106-8608

lewisbioconsult@aol.com

August 2005

Introduction

The following biological survey was conducted in support of the I-69 Tier 2, Section 5 Environmental Impact Statement (EIS) and applicable portions of the 1993 Memorandum of Understanding (MOU) as entered into by the Indiana Department of Transportation (INDOT), the Indiana Department of Natural Resources (IDNR), the Indiana Department of Environmental Management (IDEM), and the U.S. Fish and Wildlife Service (USFWS) to delineate guidelines for construction of transportation projects in karst regions of the state.

The study was prepared by Lewis and Associates, LLC (Dr. Julian J. Lewis), of Borden, Indiana under contract with Ozark Underground Laboratory (OUL) of Protem, Missouri, under the prime contractor Michael Baker, Jr. Inc. (Baker), of Crown Point, Indiana.

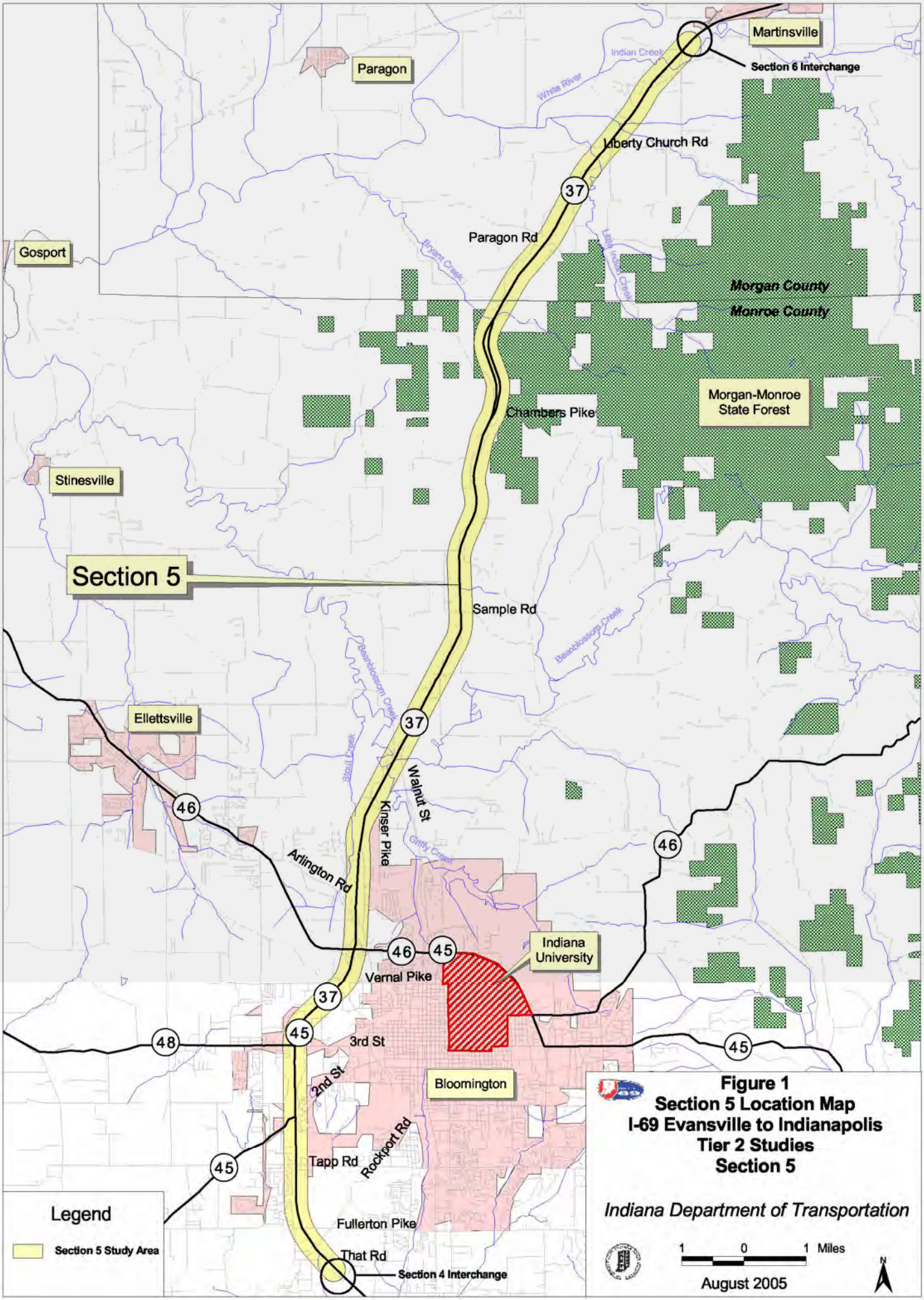
Section 5 EIS studies were centered in an approximately 2,000-foot wide corridor along State Route 37 (SR 37) from just south of Bloomington in Monroe County, Indiana to just south of Martinsville in Morgan County, Indiana (see Figure 1). As part of these studies, biological surveys were conducted of accessible caves that were linked to the corridor either hydrologically or by logical inference. The Section 5 accessible caves included:

- – cave passages have been mapped that extend under SR 37 (Roy and Wells 1959), and four dye traces from the Section 5 corridor were detected at its spring. A state-listed crayfish was observed in May Cave during the reconnaissance survey.

- - is a tributary to and receives runoff from the Section 5 corridor.

- - has been linked by logical inference to the Section 5 corridor due to its location immediately adjacent to the corridor and because the direction of observed flow indicates that its recharge area is located within the corridor. is a submerged cave accessible via a karst window.

The preliminary extent of minimum and maximum recharge areas for the system are shown on Figure 2. The system and cave entrance locations are classified as Confidential and are not shown on mapping for this report.


Martinsville
Section 6 Interchange
Paragon
Indian Creek
White River
Liberty Church Rd
37
Paragon Rd
Gosport
Bryant Creek
Little Indian Creek
Morgan County
Monroe County
Morgan-Monroe State Forest
Chambers Pike
Stinesville
Section 5
Sample Rd
Beanblossom Creek
Ellettsville
Stout Creek
Walnut St
Kinser Pike
Gulfy Creek
46
Arlington Rd
Indiana University
45
Vernal Pike
48
3rd St
2nd St
Bloomington
Rockport Rd
Tapp Rd
Fullerton Pike
That Rd
Section 4 Interchange
Legend
Section 5 Study Area
Figure 1
Section 5 Location Map
I-69 Evansville to Indianapolis
Tier 2 Studies
Section 5
Indiana Department of Transportation
1 0 1 Miles
August 2005
N

Methodology

General Sampling Methodology

Sample method type, timing, and location selection were based upon the conditions encountered in the caves, methods developed during sampling of numerous similar caves, and the professional judgment of the cave biologist, Dr. Lewis. All of the samples collected as part of this study were maintained in the custody of the sampler (Dr. Lewis) during collection, transport, preparation and examination.

The investigation included:

- Manual collection,
- Pitfall traps,
- Leaf litter collection and Berlese extraction,
- Shrimp-baited jars,
- Karaman-Chappuis extraction of interstitial aquatic fauna, and
- Taxa identification.

Manual Collection

Manual collection was conducted by Dr. Lewis throughout the sampled portions of all three caves including:

- Observation of cave passage surfaces;
- Overturning of rocks and gravels within the passages;
- Temporary capture, identification, measurement, taxa and sex determination, documentation, and release of selected cave fauna (e.g., crayfish); and
- Hand sampling of surfaces with a water color brush and transfer of specimens to a four-dram vial with 70% isopropyl alcohol for later identification.

Shrimp-baited jars and Karaman-Chappuis extraction samples were placed in a cooler and transported to the laboratory where samples were placed in petri dishes and examined for living fauna under a dissecting microscope.

Pitfall Traps

Five pitfall traps were placed throughout the accessible portion of Cave and two rounds of pitfall trapping were conducted in Cave passages during the sampling events. The first was comprised of 12 pitfalls, 6 in each of the two passages. The second round of pitfalls consisted of a line of 10 traps placed in the southern stream passage. The pitfall traps were distributed to provide representative coverage of the passages and were placed at locations conducive to the capture of obligate subterranean species.

Upon selection of a sampling location, a small excavation was made with a garden trowel in the mudbank. A four-ounce glass specimen jar was placed in the excavation and the annular space was filled to grade. The jar contained 70% isopropyl alcohol, for use as a preservative, and was prepared prior to entry into the cave. The edge of the jar was

baited with limburger cheese spread and the jar was usually loosely covered with a local flat stone.

Pitfall traps were left in place for five to ten days before collection. Collection consisted of:

- Observation of the cave surfaces around the jar by Dr. Lewis,
- Hand sampling of surfaces with a small brush and transfer to a four-dram vial with 70% isopropyl alcohol for later identification,
- Documentation of the jar condition and observations,
- Placement of sample identification in the jar and sealing of the jar lid,
- Transfer of the jar to a bag for retrieval from the cave, and
- Transport of the samples to the laboratory under custody of the sampler (Dr. Lewis).

Collection of Leaf Litter

Leaf litter taken from the three caves were placed in a Berlese funnel (with overhead light/heat) for extraction of the invertebrates into a vial of 70% isopropyl alcohol as follows:

- Transfer of the leaf litter to a bag for retrieval from the cave,
- Upon return to the surface, placement of the samples into a cooler on ice, and
- Transport of the samples to the laboratory under custody of the sampler (Dr. Lewis).

Shrimp-Baited Jars

Either a jar or larger bait bucket were baited with two uncooked shrimp and lowered to the bottom of the Cave karst window. The baited jar/buckets were retrieved 8 to 12 hours following placement as follows:

- Placement of sample identification in the jar and sealing of the jar lid,
- Transfer of the jar to a bag for retrieval from the cave,
- Upon return to the surface, placement of the samples into a cooler on ice, and
- Transport of the samples to the laboratory under custody of the sampler (Dr. Lewis).

Extraction of Interstitial Aquatic Fauna

An appropriate location for the extraction of interstitial aquatic fauna from the underground stream channel in both the north and south passages were selected by Dr. Lewis. The extraction of interstitial aquatic fauna was conducted via the Karaman-Chappuis method as follows:

- Excavation of stream sediments with a garden trowel and transfer to a pre-rinsed bucket,
- Washing of Detritus in the bucket with water from the stream,

- Pouring of water from the bucket through a plankton net,
- Transfer of residual material in the net to a four-ounce glass specimen jar,
- Placement of identification on the sample jar and sealing of the jar lid,
- Transfer of the jar to a bag for retrieval from the cave,
- Upon return to the surface, placement of the samples into a cooler on ice, and
- Transport of the samples to the laboratory under custody of the sampler (Dr. Lewis).

Taxa Identification

The contents of the sample jars and vials were placed in a cooler and transported to the laboratory where samples were placed in petri dishes and examined for living fauna under a dissecting microscope by Dr. Lewis. Specimens of each taxon were placed in 3 or 4 dram vials of 40% isopropyl alcohol and labeled per cave of origin, state, county, distance to nearest town, date and collector, as described above.

Some taxa required the use of outside taxonomists for specific identification. These taxonomists were part of the Lewis project team (see Appendix H for affiliations). The identification of specimens was performed by appropriate taxonomists with expertise with the taxa to be identified:

- Dr. Thomas C. Barr, Jr. (carabid beetles), professor emeritus, University of Kentucky;
- Dr. J. P. Battigelli (collembolans), consultant, Earthworks Research Group;
- Dr. Lynn Ferguson (diplurans), professor, Longwood University;
- Dr. Robert Hershler (aquatic snails), curator, Department of Invertebrate Zoology, Smithsonian Institution;
- Dr. John R. Holsinger (amphipods),professor, Department of Biological Sciences, Old Dominion University;
- Dr. Pierre Paquin (spiders), post-doctoral fellow, Department of Biological Sciences, San Diego State University; and
- Dr. Janet Reid (copepods), research associate, Virginia Museum of Natural History.

Samples were prepared as appropriate for taxa specific identification and shipped in accordance with the requirements of the recipient facility and state, federal, and international regulations.

Cave Specific Sampling Methodology and Narrative

consisted of a small karst window covered by a limestone well house where about 13 steps lead down to a water-filled hole (approximately one meter in diameter). The actual cave is a conduit completely filled with water. On May 23, 2005 specimens of the Packard's groundwater amphipod (*Crangonyx packardi*) and Northern cave isopod (*Caecidotea stygia*) were found on rocks on a ledge at the water's edge. Two pitfalls

baited with limburger cheese were placed in mudbanks next to the water. A jar baited with two uncooked shrimp was lowered to the bottom of the water. Water clarity at that time was about one meter. The pitfalls and baited jar were retrieved on May 26, 2005. One cyclopoid copepod was taken from the jar. The pitfalls produced several cave dung flies **(***Spelobia tenebrarum*) and one springtail (Entomobryid Collembolan). Around the periphery of the top of the karst window were two crayfish (*Cambarus tenebrosus*) (approximately 45 and 80mm) and two cave crayfish (*Orconectes inermis testii*) (approximately 35 and 40mm).

The cave was revisited on June 3, 2005. A jar baited with shrimp was placed within a larger bait bucket, weighted and lowered to the bottom of the karst window. It was retrieved about eight hours later. One cave crayfish (approximately 35 mm) was noted on the wall of the passage. Water clarity was less than one meter. Several Indiana cave amphipods (*Crangonyx indianensis*) were found in the shrimp-baited jar.

The water from the karst window emerges at approximately 1-2 gpm from a pipe about 210 feet downslope from the entrance to the karst window. Soil from the hillside has slumped over the pipe and the spring habitat is primarily mud with a little limestone gravel. On May 23 and 24, 2005 no fauna was appreciated in the spring.

This cave was reported in the Indiana Cave Survey as having 300 feet of walking-height passage. On May 23, 2005 the cave was entered and about 30 feet of passage was found. The cave ended in mud fill with a bank of detritus. A small stream comprised of gray water with a distinct sewage odor was flowing into the cave. The stream sank about 15 feet inside the entrance. No fauna was found in the stream.

The most common animals noted in the cave were psychodid flies, which are frequently associated with contaminated water. Six cave salamanders (*Eurycea lucifuga*) were noted. Six pitfalls baited with limburger cheese were placed in the cave. It seemed apparent that this cave would flood with any rain, so the pitfalls were retrieved on May 26, 2005. The pitfalls were mostly populated with cave dung flies and cave hump-backed flies (*Megaselia cavernicola*), although a few entomobryid springtails, one terrestrial isopod (Rathke's pillbug [*Trachelipus rathkei*]) - a wolf spider (*Meta ovalis*), a staphylinid beetle (probably *Aleochara*) and a braconid wasp (*undetermined species*) were also taken.

Berlese extraction of the leaf litter demonstrated entomobryid springtails, psychodid flies, one pseudoscorpion (*Kleptochthonius*), the staphylinid beetle (*Lesteva pallipes*), a spider (*Scotinella fratrella*) and a fragile dipluran (*Campodea fragilis*).

The overall picture of the fauna occurring at this site is primarily that of a disturbed area with a contaminated stream. The only troglobite noted was the ubiquitous cave dung fly.

The stream flowing into the cave was inspected on July 22, 2005 after a rainfall of 0.34 inches recorded the previous evening in Bloomington. The water at that time had a discernible sewage odor, but was clearer in appearance.

Reported in the literature from this cave were the northern cave isopod (*Caecidotea stygia*) (Fleming 1973); Indiana cave amphipods, Packard's groundwater amphipods, and crayfish (Eberly 1955, Hobbs & Barr 1972, Hobbs et al., 1977); and Barr's cave crayfish ostracod (*Sagittocythere barri*), and the Mayfield Cave ground beetle (*Pseudanophthalmus shilohensis mayfieldensis*) (Barr 1960).

was first sampled for this project on May 23, 2005. At that time 10 pitfall traps baited with limburger cheese were placed: five in the south passage and five in the north. About 100 feet inside the entrance a ladder was required to scale a waterfall about eight feet in height. Beyond the waterfall the cave branched into two passages, each containing a shallow stream. Heading upstream the passage to the right (south passage) appeared to be the more heavily traveled, with graffiti on the walls and refuse in and along the stream. Northern cave isopods, Indiana cave amphipods and Packard's groundwater amphipods were found in the stream. No stygobitic crayfish were noted between the origin of the passage and the signature room, a high ceiling room with walls covered with spray paint and much refuse scattered about. About 600 feet of the south passage was examined for fauna. One Mayfield cave ground beetle was found in gravels adjacent to the stream. Other troglobites noted were the cave dung fly, Bollman's cave milliped (*Conotyla bollmani*) and the subterranean sheet-web spider (*Phanetta subterranean*).

In the north passage all crayfish from the passage origin to the point where the passage lowered to a height of about three feet (approximately 900 feet into the cave) were captured, identified, sexed, measured and released. Eight crayfish were found: *Cambarus tenebrosus* 42mm ♀, 63mm ♂, and *Orconectes inermis testii* 47mm ♂, 45mm ♂, 39mm ♀, 52mm ♂, 42mm ♀, 47mm ♂. Northern cave Isopods also were common under stones in this stream. Also present were the Indiana cave and Packard's groundwater amphipods.

The cave was visited again on June 3, 2005. At that time the pitfalls were retrieved. All five from the south passage were intact and four were intact from the north passage (the fifth trap was found in the stream, presumably dislodged by a raccoon). Although pitfalls are not quantitative sampling devices, an inference of the relative abundance can be made. In the five pitfalls from the south passage the predominant species present was the cave dung fly, followed by the cave hump-backed fly. In addition, one greenhouse millipede (*Oxidus gracilis*) and two Bollman's cave millipeds (*Conotyla bollmani*) were taken. A few entomobryid springtails were also collected. In general, the fauna sampled was sparse, consistent with the pitfall placement in the dark zone of a typical nutrient poor cave environment.

The fauna taken in the four pitfalls in the north passage also was sparse, consisting of a few cave dung flies and springtails.

Many stones were turned in the stream in the south passage to search for crayfish. None were appreciated. A shallow trough was dug in a gravel bar to conduct Karaman Chappuis faunal extraction of interstitial species. This yielded Packard's groundwater amphipod. In the adjacent riffle area gravel and sand were dug from the stream substrate, placed in a bucket, washed with stream water and the supernatant poured through plankton net. This produced two hydrobiid snails (hidden spring snail [*Fontigens cryptica]*), northern cave isopods, a slender spring flatworm (*Phagocata gracilis)*, and Packard's groundwater and Indiana cave amphipods.

In the north passage a riffle area was also sampled for interstitial fauna using the same technique. This produced northern cave isopods, and Packard's groundwater and Indiana cave amphipods.

A census of surficial crayfish present in the north passage was conducted and the following were noted: *Cambarus tenebrosus* 89mm ♂, *Orconectes inermis testii* 46mm ♂, 45mm ♂, 50mm ♀, 45mm ♂.

The cave was visited again on July 22, 2005 primarily for the purpose of placing pitfall traps to further evaluate the terrestrial fauna. Ten pitfalls were placed in riparian mudbanks the south passage of the cave. The pitfalls were all put in the dark zone of the cave, the first upstream of the junction of the two stream passages and the last where the passage lowers to about one foot above the cave stream.

At that time, examination of about 20 stones in the same riffle that had previously produced the hidden spring snails revealed the presence of one adult snail on the underside of a rock. Further upstream, approximately 50 more rocks were turned and one juvenile hidden spring snail about 1mm in length was noted on the underside of a stone. Only one crayfish was found, a *Cambarus tenebrosus* – no *Orconectes* were found in the south passage stream.

was visited on July 29, 2005 for the purpose of pulling the pitfalls, all of which were recovered intact. The traps were more populated than the previous May 23 and June 3, 2005 series of pitfalls. The predominant animal in these pitfalls was the cave dung fly, of which a total of 227 individuals were taken. Other flies in the pitfalls were six cave hump-backed flies, four mycetophils and four psychodids.

The next most common animals in the pitfalls were collembolans. Six specimens of a lightly pigmented entomobryid springtail were present in the first trap, which was placed in a short side passage upstream of the main waterfall. Two *Sinella* were taken in trap eight and one *Arrhopalites* in trap 10. The only other fauna appreciated were three ground beetles (*Platynus*), one each in the first three traps, and a total of four Bollman's cave millipedes.

Sampling Results

None of the species found in caves in I-69 Section 5 were listed on the Federal List of Threatened/Endangered Species.

The results of the survey identifications are defined, detailed and summarized in the following four tables:

- Table 1 defines the ecological classification system or cave species,
- Table 2 defines the state or federal global rank of rarity,
- Table 3 details the species identified during the survey by its: taxonomy, scientific name, original author of the species, ecological classification, descriptive common name, cave name in which it was found, the state/global rank, and a narrative about the species.
- Table 4 summarizes the obligate subterranean species in the caves by common and scientific names, global rarity rank, listing and ecological status, and cave name.

Table 1 Ecological Classification System or Cave Species

Classification	Abbreviation	Definition
Troglobite	TB	terrestrial, morphologically adapted and restricted to caves, must feed and reproduce in the cave environment
Troglophile	TP	terrestrial, +/- morphologically adapted to caves, not restricted to caves, but can feed and reproduce in the cave environment
Trogloxene	TX	terrestrial, not usually morphologically adapted to caves, usually leaves the cave to either feed or reproduce
Stygobite	SB	aquatic, morphologically adapted and restricted to caves, must feed and reproduce in the cave environment
Stygophile	SP	aquatic, +/- morphologically adapted to caves, not restricted to caves, but can feed and reproduce in the cave environment
Stygoxene	SX	aquatic, not usually morphologically adapted to caves, usually leaves the cave to either feed or reproduce
Accidental	AC	fall or wash into the caves with no demonstrable affiliation, with the habitat
Parasite/commensal	PS	lives on or parasitizes a host animal

Table 2 – Definition of State and Global Ranks of Rarity

State/Global Rank	Number of sites in state/globally	Characterization
G1	1-5	critically imperiled
G2	6-20	imperiled
G3	21-100	vulnerable
G4	100+	apparently secure
G5		secure
SE		exotic species

References to state listed species come from the Indiana Department of Natural Resources (IDNR), Division of Nature Preserves, Natural Heritage Program of endangered, threatened, rare and extirpated vertebrates and invertebrates of Indiana dated January 18, 2002 available at: http://www.in.gov/dnr/naturepr/pdf/vertinve.pdf.

The IDNR Division of Fish & Wildlife maintains a list of species of concern, threatened or endangered available at: http://www.in.gov/dnr/fishwild/endangered/rare.pdf. Vertebrates, mollusks and crustaceans that are listed as endangered in Indiana are protected from taking pursuant to the Nongame and Endangered Species Act of 1973 (IC 14-22-34) and Fish and Wildlife Administrative Rules (312 IAC).

Table 3 - Species Identified

PHYLUM	CLASS	ORDER	FAMILY	Species	Source	Ecological Classification	Common Name	Cave	State/ Global Rank	Narrative
PLATYHELMINTHES	TURBELLARIA	TRICLADIDA	PLANARIIDAE	*Phagocata gracilis*	Haldeman	SP	Slender spring flatworm		S4/G4	This flatworm is ubiquitous in springs and caves of the eastern U.S. (Kenk 1972). It is also common in cave streams and in some populations the worms are depigmented and nearly white in color, as is the case in May Cave. Hyman (1937) described the unpigmentedPhagocata in Donaldson's Cave, Lawrence Co., Indiana as Phagocata subterranea which Kenk (1970) synonymized with Phagocata gracilis.
MOLLUSCA	GASTROPODA	MESOGASTROPODA	HYDROBIIDAE	*Fontigens cryptica*	Hubricht	SB	Hidden spring snail		S1/G1	Two of these snails were initially taken from the interstices of gravel in a stream riffle in May Cave by Karaman Chappuis extraction. On a subsequent trip one snail was found on the underside of a stone in the same riffle and a juvenile was found under a stone in a different riffle. The snails are completely unpigmented and the shell is white/translucent. This is the only known species of the genus in Indiana. Fontigens cryptica was first found in a small spring in Clark County, Indiana (Hubricht 1963). This locality and the vicinity has been searched by Dr. Robert Hershler (Smithsonian Institution) and me repeatedly without finding the snail. An equivocal site was represented by a dead shell brought up from a depth of one meter by a Bou-Rouch sampling pumpwell placed in a gravel bar on the Blue River (Lewis 1999). A sight record also exists for aFontigens from another Harrison Cave Spring in Harrison County (Lewis 1999). Fontigens cryptica is listed as a State Endangered Species. The only known extant population of this species is in May Cave.
		SIGMURETHRA	DISCIDAE	*Anguispira alternata*	Say	TX	Alternate terrestrial snail		S3/G4	This species is reported to have a wide habitat tolerance ranging from woodlands, rocky areas, weedy road and railroad sides and urban areas in vacant lots and gardens (Hubricht, 1985). This species is a common threshhold trogloxene in Indiana caves (Lewis, Burns and Rafail 2003).
ARTHROPODA	CRUSTACEA	EUCOPEPODA	CYCLOPIDAE	*Macrocyclops albidus*	Jurine	SX	copepod		S4/G4	The copepods were attracted to shrimp-baited jars lowered into the karst window.
				Megacyclops latipes	Lowndes	SX	Copepod		S4/G4	The specimens were sampled from the interstices of gravel in stream riffles.
			CANTHOCAMPTIDAE	*Attheyella illinoisensis*	Forbes	SP	Copepod		S4/G4	This is a widespread species that occurs in many habitats (Reid, in litt. 2005).
		OSTRACODA	ENTOCYTHERIDAE	*Sagittocythere barri*	Hart & Hobbs	SB/PS	Barr's cave crayfish ostracod		S3/G4	Hart & Hobbs (1961) reported this species from May Cave. It is commensal on cave crayfish
		ISOPODA	ASELLIDAE	*Caecidotea stygia*	Packard	SB	Northern cave isopod		S4/G5	This isopod is common in May Cave and occurs under stones around the mouth of the karst window in Well Cave. Fleming (1972) reported the species from May Cave, but erroneously reported the cave to be in Washington County. Caecidotea jordani is a subterranean species also known from Monroe County, but it is known only from two sites, both of which consist of groundwater in the interstices of unconsolidated deposits. It has never been found in caves (Lewis 1998). It is one of the most wide ranging subterranean members of the genus, recorded from southwestern Ohio, most of Kentucky, southern Illinois and a small area of eastern Missouri (Lewis & Bowman, 1981).
				Lirceus fontinalis	Rafinesque	SX	Bluegrass spring isopod		S4/G4	This species occurred in the entrance area of May Cave. Hubricht and Mackin (1949) reported this species from about 45 localities in southern Indiana, Kentucky, southwestern Ohio and northern Tennessee. The isopod is a threshold trogloxene, primarily occurring in springs.
			ARMADILLIDIIDAE	*Armadillidium vulgare*	Latreille	TX	Common pillbug		SE	This terrestrial isopod typically occurs under boards and stones around houses or other structures. In Well Cave they were common under the stone roof of the well house.
			PORCELLIONIDAE	*Trachelipus rathkei*	Brandt	TX	Rathke's pillbug		SE	Native to Europe, this species has become widespread in North America where it is a characteristic component of deciduous forests (Harding & Sutton, 1985
			TRICHONISCIDAE	*Haplophthalmus danicus*	Budde-Lund	TP	Danish pillbug		SE	This terrestrial isopod was common in debris in a room containing trash and vandalism in May Cave. This species is native to Europe, but is widespread in several continents now (Harding & Sutton 1985). It commonly occurs in caves.
				Hyloniscus riparius	Koch	TX	Riparian pillbug		SE	This species is native to Europe, but has been widely established in the eastern U.S. As the name implies, it typically occurs along streams with much leaf litter or detritus (Schultz 1965).
		AMPHIPODA	CRANGONYCTIDAE	*Crangonyx barri*	Zhang & Holsinger	SB	Barr's cave amphipod		S3/G3	This species was taken from the undersides of stones at the mouth of the karst window. Crangonyx barri occurs from central Kentucky north into southern Indiana, where its range was previously thought to terminate in the counties of the Blue River area. The occurrence in Monroe County is a range extension of some zoogeographic interest. Crangonyx barri is recorded as Crangonyx sp. 1 (undescribed cave amphipod) and classified as a rare species on the state list of endangered, threatened, rare and extirpated vertebrates and invertebrates of Indiana. Since the state list was last updated the description of the species was published by Zhang and Holsinger (2003) and continued sampling has indicated that it is somewhat more abundant than the state list classification as S2/G2.
				Crangonyx indianensis	Zhang & Holsinger	SB/SP	Indiana cave amphipod		S3/G3	This species was taken from gravels in May Cave. In Well Cave it was found roaming the surfaces of stones as well as coming to shrimp-baited jars placed on the bottom of the karst window. This amphipod is endemic to the karst of Indiana, where it is reported only from caves and spring orifices. With one exception (in the southeastern Indiana karst), all of the known localities are in the southcentral karst area. Zhang & Holsinger (2003) reported it from May Cave.
				Crangonyx packardi	Smith	SB	Packard's groundwater amphipod		S3/G4	This amphipod was taken from the interstices of gravel as well as from under stones in both of the main passages in May Cave. This species, first described from a well in Orleans, Orange Co., Indiana, is now known to occur from Indiana west to Kansas (Zhang & Holsinger 2003). Crangonyx packardi is typically found deeper in the interstices of stream gravels whileCrangonyx indianensis occurs on the surface of the substrate. Crangonyx packardi also occurs in drip pools and ephemeral cave streams. Lewis (1998) found it a meter deep in gravel interstices of the Blue River. Zhang & Holsinger (2003) reported it from May Cave. Crangonyx packardi is listed as a State Rare Species and is categorized as S2/G3. Lewis (2002a) classified this species as S3/G3 for the USDA Forest Service Region 9 conservation assessment of the species.
		DECAPODA	CAMBARIDAE	*Orconectes inermis testii*	Hay	SB	Cave crayfish		S2/G3	This crayfish has long been known from May Cave (Eberly 1955, Hobbs & Barr 1972, Hobbs et al. 1977). This crayfish subspecies was reported from 21 caves by Hobbs et al. 1977. It occurs deep in the dark zone of the left stream passage in May Cave. In Well Cave it comes to the periphery of shrimp bait and is seen at the top of the karst window on rocks and the walls of the passage. Orconectes inermis testii is listed as a State Threatened Species and is categorized as S2/G3.
				Cambarus tenebrosus		SP	Crayfish		S4/G4	This species is common in Indiana caves. In May Cave it has been found from the entrance passage far into the dark zone in the left stream passage. It has been observed in Well Cave at the top of the karst window on rocks and the walls of the passage.

Table 3 - Species Identified

PHYLUM	CLASS	ORDER	FAMILY	Species	Source	Ecological Classification	Common Name	Cave	State/ Global Rank	Narrative
ARTHROPODA	DIPLOPODA	CHORDEUMATIDA	CONOTYLIDAE	*Conotyla bollmani*	McNeill	TB/TP	Bollman's cave milliped		S3/G3	Described as Trichopetalum bollmani by McNeill (1887) from Mayfield's Cave, Monroe Co., Indiana. Bollman (1889) redescribed it as Scotherpes wyandotte from "near Wyandotte Cave". Lewis (1998) reported sampling almost 200 caves in the Blue River basin containing Wyandotte Cave and never found Conotyla. Shear (1971) reported the "near Wyandotte Cave" record as a surface localities along with one other site to the north, but failed to specify where or the habitat. I have examined the single depauperate type specimen of Scotherpes wyandotte now in the collection of the Smithsonian Institution and put little stock in the validity of the record, since it fails to specify *how near* the specimen was taken from Wyandotte Cave – it could have come from 20 miles away. Regardless of its ecological classification, it certainly occupies the niche of troglobitic milliped in the caves where it occurs. Hoffman and Lewis (1997) and Lewis (2003) summarized the range of this Indiana endemic, which occurs in caves in southcentral Indiana in the East Fork of White River drainage (Orange, Lawrence, Monroe, Martin, Owen counties). Conotyla bollmani is listed as a State Rare Species and is categorized as S2/G3. Lev
		JULIDA	JULIDAE	*Ophyiulus pilosus*	Newport	TP	Milliped		SE	This species is an exotic, probably native to Italy, that is widespread in the northeastern U.S. (Hoffman 1999). It has been reported from caves in Clark, Harrison, Lawrence and Orange counties (Lewis 1983, 1994, 1996, 1998, 2003) and is particularly common in the caves of the Tincher Special Karst Area in Lawrence County.
		POLYDESMIDA	PARADOXOSOMATIDAE	*Oxidus gracilis*	Koch	TX	Greenhouse milliped		SE	This species probably originated in Japan, but has spread nearly worldwide in temperate counties and at higher elevations in the tropics. It is found across North America and is present in astronomical numbers in many parts of the eastern U.S. (Hoffman 1999). It is frequently present in noxious numbers in caves.
	ARACHNIDA	PSEUDOSCORPIONIDA	CHTHONIIDAE	*Kleptochthonius*	sp.	TX	Pseudoscorpion			One specimen of a 4-eyed (i.e., epigean) pseudoscorpion was taken from leaf litter with Berlese extraction. There remain many undescribed species in this genus; this specimen does not match any of the species reported from Indiana caves (K. packardi, K. lewisorum, K. griseomanus, Muchmore 2000).
		ARANEAE	AMAUROBIIDAE	*Coras*	sp.		Spider			
			LINYPHIIDAE	*Centromerus cornupalpis*	O.P.-Cambridge	TX	Sheet-web spider		S4/G4	This species was reported by Lewis (1994, 1995, 1998; Lewis et al 2004) from caves in Harrison, Jennings and Orange counties, where it was usually a threshold trogloxene.
				Phanetta subterranea	Emerton	TB	Subterranean sheet-web spider		S4/G5	This tiny spider is ubiquitous in Indiana caves, where it has been found in Clark, Crawford, Decatur, Dubois, Jefferson, Jennings, Lawrence, Monroe, Orange, Ripley, Monroe, Orange and Washington counties (Lewis 1983, 1994, 1995, 1996, 1998; Lewis and Rafail 2002; Lewis, Burns and Rafail 2002). Originally described from Wyandotte Cave, Crawford Co., the species was redescribed by Millidge (1984) and reported from a range between Alamama and Pennsylvania, west to Indiana. Peck & Lewis (1978) reported this species from Illinois and Missouri.
				Bathyphantes	sp.		Sheet-web spider			
			LIOCRANIDAE	*Scotinella fratrella*	Gertsch	AC	Spider		S5/G5	This species is frequently found in old fields or disturbed areas (Young & Edwards 1990; Haskins & Shaddy 1986), and is indicative of the suburban environment in which this cave entrance occurs.
			LYCOSIDAE	*Meta ovalis*	sp.	TX	Wolf spider			Wolf spiders are common around cave entrances where they frequently occur around wet detritus near streams.
			TETRAGNATHIDAE		Gertsch	TP	American cave orb weaver		S4/G5	This species is ubiquitous in caves of the eastern U.S. (Marusik and Koponen,1992). It has been recorded from essentially every county in Indiana that has caves (Blatchley 1897; Banta 1907; Lewis 1983, 1994; 1995; 1996; 1998; 2001; Lewis & Rafail 2002; Lewis, Burns & Rafail 2003).
			PISAURIDAE	*Dolomedes scriptus*	Hentz	TX	Fishing spider		S4/G5	This spider was found on the wall of the Well Cave well house. These spiders typically occur around streams where they usually occur on rocks or boulders (Carico 1973).
		COLLEMBOLA	ENTOMOBRYIDAE	*Pseudosinella collina*	Wray	TP	Hilly springtail		S2-G3/4	This species was is known primarily from caves, where in Indiana it has been recorded from Martin, Monroe, Orange and Washington counties (Lewis, 1998, Lewis et al. 2004; Christiansen & Bellinger, 1998c). In May Cave this species was taken in the dark zone of the cave on mudbanks in the main stream passage. Many of the other collection sites in Indiana were in cave entrance leaf litter in sheltered sinkhole floor or twilight zone habitat.
				Pseudosinella	sp.	TP	Springtail			A single specimen of this springtail was taken from a pitfall trap placed in Well Cave.
				Sinella alata	Christiansen	TP/TX	Indiana cave springtail		S3/G3	These springtails were found under stones and debris in the dark zone of the cave. This species is endemic to Indiana, where it has been found in caves in Clark, Crawford, Harrison, Jennings, Lawrence, Monroe, Orange and Washington counties (Lewis, 1983; 1994; 1995; 1998; 2002; Lewis et al. 2004). Sinella alata is classified as a state endangered species. This classification is an administrative artifact from its placement on the list at a time when the species had not yet been found in the numerous localities cited above – steps are being taken to de-list.
			HYPOGASTRURIDAE	*Ceratophysella*	sp.		Springtail			The taxonomy of this group is too confused at present to allow specific identification.
			ISOTOMIDAE	*Isotoma viridis*	Bourlet	TX	Springtail		S5/G5	This ubiquitous species is occasionally found in leaf litter or detritus in cave entrances, where it was found in Booby Trap Cave.
			SMINTHURIDAE	*Arrhopalites*	sp.	TP	Springtail			A single specimen was taken in a pitfall trap in the dark zone of the cave.
	INSECTA	DIPLURA	CAMPODEIDAE	*Campodea fragilis*	Meinert	TX	Fragile dipluran		S5/G5	This is a cosmopolitan species that occurs across North American, Europe, South Africa and Australia. It occurs occasionally in caves (Ferguson email 2005).
		ORTHOPTERA	GRYLLACRIDIDAE	*Ceuthophilus brevipes*		TX	Cave cricket		S4/G4	This species replaces C. stygius in the northern part of the Indiana karst and occurs sporadically in other Indiana caves. Hubbell (1936) reported it from seven localities in Indiana, including Mayfield's Cave, Monroe Co., as well as 20 states in the eastern U.S and Canada.
		COLEOPTERA	CARABIDAE	*Pseudanophthalmus shilohensis mayfieldensis*			Mayfield Cave ground beetle		S1/G1	This species occurs from northern Lawrence County through Monroe County into Owen County, but the subspecies P. s. mayfieldensis has been reported from four caves in Monroe County including May Cave (Barr 1960, Lewis & Rafail 2003). In May Cave the beetle was found on moist riparian stream gravel. Pseudanophthalmus shilohensis mayfieldensis is classified as a state endangered species.
				Bembidion	sp.	TX	Ground beetle			This is probably Bembidion texanum, a widespread and common beetle in eastern U.S. caves. A male specimen would be necessary for specific identification.
				Platynus	sp.	TX	Ground beetle			This is probably Platynus tenuicollis, a widespread and common beetle in eastern U.S. caves.
			STAPHYLINIDAE	*Lesteva pallipes*		TX	Rove beetle		S4/G4	This species frequents caves where it is frequently found in abundance under rocks along streams.
				Quedius erythrogaster		TX	Rove beetle		S5/G5	This species commonly occurs in caves.
				Aleochara	sp.	TX	Rove beetle			This beetle is probably the troglophile Aleochara lucifuga, which occurs in caves and animal burrows in the eastern U.S. (Klimaszewski and Peck 1986).

Table 3 - Species Identified

PHYLUM	CLASS	ORDER	FAMILY	Species	Source	Ecological Classification	Common Name	Cave	State/ Global Rank	Narrative
ARTHROPODA		DIPTERA	HELEOMYZIDAE	*Aecothea specus*		TX	Heleomyzid fly		S4/G4	This species occurs on the walls and ceilings of caves. The ecology of heleomyzid flies in an Indiana cave was discussed in some detail by Busacca (1975).
			PHORIDAE	*Megaselia cavernicola*	Brues	TP	Cave hump-backed fly		S5/G5	This species is ubiquitous in caves of the eastern U.S. and has also been reported from surface collections (Borgmeier 1965). It probably occurs in nearly every cave in Indiana that is of any length (Lewis 1994; 1995; 1996; 1998; 2001; Lewis & Rafail 2002; Lewis, Burns & Rafail 2003) and comes to baited pitfalls in abundance.
			SPHAEROCERIDAE	*Spelobia tenebrarum*	Aldrich	TB	Cave dung fly		S5/G5	This fly is ubiquitous in Indiana caves and comes readily to pitfall traps (Blatchley 1897; Banta 1907; Lewis 1994; 1995; 1996; 1998; 2001; Lewis & Rafail 2002; Lewis, Burns & Rafail 2003). It is particularly common on raccoon dung and has been found in essentially every cave in Indiana where baited pitfalls have been placed. The species occurs in caves across the eastern U.S. and is a mildly troglomorphic troglobite (Marshall & Peck 1985).
		HYMENOPTERA	BRACONIDAE	*Undetermined species*		TX	Braconid wasp			These wasps are parasites of flies larvae and are frequently found in caves. The taxonomy of this family is so confused that it precludes identification.
CHORDATA	AMPHIBIA	CAUDATA	PLETHODONTIDAE	*Eurycea lucifuga*	Rafinesque	TP	Cave salamander		S4/G5	Most of the records for the Cave salamander are from springs, spring-fed brooks or caves, but have also been found under stones on dry, open hillsides, under trash in an open field, and in suburban yards (Minton 2001). Compared to the Longtail salamander, the range of the Cave salamander is relatively restricted. In Indiana it occurs only in the southern half of the state and a more compressed range essentially equal to the karst areas of the Appalachians, Interior Low Plateaus and Ozarks.
	AVES	PASSERIFORMES	TYRANIDAE	*Sayornis phoebe*	Latham	TX	Eastern phoebe		S5/G5	The Eastern phoebe constructs nests under overhangs.
	MAMMALIA	CHIROPTERA	VESPERTILIONIDAE	*Pipistrellus subflavus*	Cuvier	TX	Eastern pipistrelle		S5/G5	The Eastern pipistrelle is a common, permanent inhabitant of southern Indiana. Mumford and Whitaker (1982) reported that almost every cave visited contained at least one bat of this species, although only three caves had 50 or more (one of these was Dillon Cave). It was also noted that in small caves the pipistrelle was frequently the only bat species present. These bats always roost singly and usually occur on the walls or overhanging ledges rather than on the ceilings of caves. Pipistrelles occur in caves during all months of the year, although relatively few occur there during the summer months.
		CARNIVORA	PROCYONIDAE	*Procyon lotor*	Linnaeus	TX	Raccoon		S5/G5	Evidence of raccoons in these caves consists of footprints, wall scratch marks and latrines, the latter are important sources of food for the invertebrate community.

Table 4 Obligate Subterranean Species Summary

Common Name	Scientific Name	Global Rarity Rank	Listing Status	Ecological Status			
Hidden spring snail	*Fontigens cryptica*	G1	State Endangered	Stygobite	X		
Northern cave isopod	*Caecidotea stygia*	G5		Stygobite	X		X
Indiana cave amphipod	*Crangonyx indianensis*	G3		Stygobite	X		X
Packard's groundwater amphipod	*Crangonyx packardi*	G3	State Rare	Stygobite	X		
Barr's cave amphipod	*Crangonyx barri*	G3	State Rare	Stygobite			X
Cave crayfish	*Orconectes inermis testii*	G3	State Threatened	Stygobite	X		X
Barr's cave crayfish ostracod	*Sagittocythere barri*	G3		Stygobite/ Commensal	X		
Subterranean sheet-web spider	*Phanetta subterranea*	G5		Troglobite	X		
Bollman's cave milliped	*Conotyla bollmani*	G3	State Rare	Troglobite	X		
Indiana cave springtail	*Sinella alata*	G3	State Endangered	Troglobite	X		
Mayfield cave beetle	*Pseudanophthalmus shilohensis mayfieldensis*	G1	State Endangered	Troglobite	X		
Cave dung fly	*Spelobia tenebrarum*	G5		Troglobite	X	X	X

Comparative Evaluation

The following is a list of the top faunal caves in Indiana, from cave bioinventories that surveyed about 484 caves (Lewis 1983, 1994, 1995, 1996, 1998; Lewis & Rafail 2002, 2003; Lewis, Burns & Rafail 2004). The list is rank-ordered by the number of obligate subterranean species (troglobites and stygobites) and species of high global rarity.

Cave	Obligate Subterranean	G1-G3
	19	17
	18	15
	15	13

12	10
12	9
11	9
11	9
11	9
11	**8**
11	8
11	7

Conclusions

There were no federally listed species identified during the biological survey of

are areas of special concern due to biological significance from diverse troglobitic (obligate cave dwellers) fauna, and state-listed threatened and endangered species. Mapped cave passage ( ) extended under SR 37 (Roy and Wells 1959), and the minimum groundwater recharge area of the cave extended across SR 37 and the Section 5 corridor.

The cave's biological community appeared to be in relatively good health despite historical and current aquatic impacts from SR 37, which were not directly assessed.

Planning and design of I-69 Section 5 should attempt to minimize potential additional impacts from water derived from Section 5. Further studies may be warranted to refine the recharge area and provide the data necessary to evaluate the alternative drainage and treatment/mitigation options.

Literature Cited

Banta, Arthur M. 1907. The fauna of Mayfield's Cave. Carnegie Institute of Washington Publications, 67: 1-114.

Barr, Thomas C., Jr. 1960. A synopsis of the cave beetles of the genus Pseudanophthalmus of the Mitchell Plain in southern Indiana (Coleoptera, Carabidae). American Midland Naturalist, 63 (2): 307-320.

Blatchley, W.S. 1897. Indiana caves and their fauna. Report of the Indiana State Geologist for 1896, 120-212.

Bollman, C.H. 1889. Catalogue of the myriapods of Indiana. Proceedings of the U.S. National Museum, 11: 403-410.

Borgmeier, T. 1965. Revision of the North American phorid flies. Part III. The species of the genus Megaselia, subgenus Megaselia (Diptera, Phoridae). Studia Entomologica, 8: 1-60.

Busacca, John. 1975. Distribution and biology of Amoebaleria defessa (Osten-Sacken) and Heleomyza brachypterna (Loew) (Diptera: Heleomyzidae) in an Indiana cave. N.S.S. Bulletin, 37(1): 5-8

Carico, James E. 1973. The nearctic species of the genus Dolomedes (Araneae: Pisauridae). Bulletin of the Museum of Comparative Zoology 144 (7): 435-588.

Christiansen, Kenneth and Peter Bellinger. 1998. The collembola of North America, north of the RioGrande. Part 3: Families Entomobryidae, Cyphoderidae, Paronellidae, Oncopoduridae, Tomoceridae. Grinnell College, Grinnell, Iowa, 877-1174.

Eberly, William R. 1955. Summary of the distribution of Indiana crayfishes, including new state and county records. Proceedings of the Indiana Academy of Science 65: 281-283.

Fleming, Laurence E. 1972. The evolution of the eastern North American isopods of the genus Asellus (Crustacea: Asellidae). Part I. International Journal of Speleology 4: 221-236.

Harding, Paul T. and Stephen L. Sutton. 1985. Woodlice in Britain and Ireland: Distribution and Habitat. Institute of Terrestrial Ecology, Huntingdon, Great Britain, 151 pages.

Hart, C. W. and Horton H. Hobbs Jr. 1961. Eight new troglobitic ostracods of the genus Entocythere (Crustacea, Ostracoda) from the eastern United States. Proceedings of the Academy of Natural Sciences of Philadelphia 113 (8): 173-185.

Haskins, Mary F. and James H. Shaddy. 1986. The ecological effects of burning, mowing, and plowing on ground-inhabiting spiders (Araneae) in an old-field ecosystem. Journal of Arachnology 14: 1-13.

Hobbs, Jr., H.H. and T.C. Barr. 1972. Origins and affinities of the troglobitic crayfishes of North America (Decapoda: Astacidae) II: Genus Orconectes. Smithsonian Contributions to Zoology, 105: 1-84.

_____, H. H. Hobbs III and Margaret A. Daniel. 1977. A review of the troglobitic decapod crustaceans of the Americas. Smithsonian Contributions to Zoology 244: 1-183.

Hoffman, Richard L. 1999. Checklist of the millipeds of North and Middle America. Virginia Museum of Natural History Special Publication 8, 584 pages.

Hoffman, Richard L. and Julian J. Lewis. 1997. Pseudotremia conservata, a new cleidogonid milliped (Diplopoda: Chordeumatida), with a synopsis of the cavernicolous millipeds of Indiana. Myriapodologica, 4(13): 107-119.

Holsinger, John R. 1972. The freshwater amphipod crustaceans (Gammaridae) of North America. Water Pollution Control Research Series, Biota of Freshwater Ecosystems Identification Manual, 5: 1-89.

Hubbell, Theodore H. 1936. A monographic revision of the genus Ceuthophilus. University of Florida Publication, Biological Science Series, 2 (1): 551 pages.

Hubricht, Leslie and J.G. Mackin. 1949. The freshwater isopods of the genus Lirceus (Asellota, Asellidae). American Midland Naturalist, 42(2): 334-349.

Hyman, Libbie H. 1937. Studies on the morphology, taxonomy and distribution of North American Triclad Turbellaria. VIII. Some cave planarians of the United States. Transactions of the American Microscopical Society, 56: 457-477.

Kenk, Roman. 1970. Freshwater triclads (Turbellaria) of North America. IV. The polypharyngeal species of Phagocata. Smithsonian Contributions to Zoology, 80: 1-17.

Kenk, Roman. 1972. Freshwater planarians (Turbellaria) of North America. Biota of Freshwater Ecosystems. Identification Manual No. 1, Environmental Protection Agency, 1-18.

Klimaszewski, J. and S.B. Peck. 1986. A review of the cavernicolous staphylinidae (coleoptera) of eastern North America: Part I. Aleocharinae. Quaestiones Entomologicae, 22 (2): 52-113.

Lewis, Julian J. 1983. The obligatory subterranean invertebrates of glaciated southeastern Indiana. N.S.S. Bulletin, 45: 34-40.

Lewis, Julian J. 1994. Lost River cave and karst biological survey. Final Report, U.S. Army Corps of Engineers, Louisville District, Contract No. DACW27-94-M-0110, 63 pages.

Lewis, Julian J. 1995. Inventory of the troglobitic fauna of the Crosley State Fish and Wildlife Area, Jennings County, Indiana. Final Report, Non-game and Endangered Wildlife Program, Indiana Department of Natural Resources, 71 pages.

Lewis, Julian J. 1996. Inventory of the subterranean biota threatened by the urbanization of Clark and Floyd counties, Indiana. Final Report, Non-game and Endangered Wildlife Program, Indiana Department of Natural Resources, 71 pages.

Lewis, Julian J. 1998. The subterranean fauna of the Blue River area. Final Report, The Nature Conservancy, 266 pages.

Lewis, J.J. 2000. Establishing a methodology for non-lethal censusing of Gammarus acherondytes populations in cave stream communities of southwestern Illinois. Final Report. U.S. Fish & Wildlife Service and Illinois Non-game and Endangered Wildlife Program, 36 pages + appendix.

Lewis, Julian J. 2002a. Conservation assessment for Crangonyx packardi Packard's Cave Amphipod. U.S.D.A. Forest Service Region 9, http://www.fs.fed.us/r9/wildlife/tes/ca-verview/docs/invertebrate_Crangonyx_packardiPackardscaveamphipod.pdf

Lewis, Julian J. 2002b. Conservation assessment for Conotyla bollmani Bollman's Cave Millliped. U.S.D.A. Forest Service Region 9, http://www.fs.fed.us/r9/wildlife/tes/ca-overview/docs/invertebrate_Conotyla_bollmaniBollmansCaveMilliped.pdf

Lewis, Julian J. 2003. Pseudotremia reynoldsae, a new species of troglobitic milliped Diplopoda: Chordeumatida: Cleidogonidae), with a synopsis of the cavernicolous millipeds of the Hoosier National Forest in Indiana. Proceedings of the Indiana Academy of Sciences 112 (1): 36-42.

Lewis, Julian J. and Thomas E. Bowman. 1981. The subterranean asellids (Caecidotea) of Illinois (Crustacea: Isopoda: Asellidae). Smithsonian Contributions to Zoology, 335: 1-66.

Lewis, Julian J. and Salisa T. Rafail. 2002. The subterranean fauna of the Big Oaks National Wildlife Refuge. Final Report, U.S. Fish & Wildlife Service and Indiana Natural Heritage Program, 74 pages.

_____ and _____. 2003. The subterranean fauna of Leonard Springs Nature Park (Monroe County, Indiana) (Monroe County, Indiana). Final Report, City of Bloomington Department of Parks and Recreation, 37 pages.

Lewis, Julian J., Ronald Burns and Salisa Rafail. 2004. The subterranean fauna of the Hoosier National Forest. U.S. Department of Agriculture, Forest Service, 215 pages.

Marshall, S.A. and S.B. Peck. 1985. The origin and relationships of Spelobia tenebrarum Aldrich, a troglobitic, eastern North American sphaerocerid fly. Canadian Entomologist, 117: 1013-1015.

Marusik, Yuri M. and Seppo Koponen. 1992. A review of Meta (Araneae, Tetragnathidae), with descriptions of two new species. Journal of Arachnology, 20(2): 137-143.

Millidge, A.F. 1984. The Erigonine spiders of North America. Part 7. Miscellaneous genera (Araneae, Linyphiidae). Journal of Arachnology, 12: 121-169.

Minton, Sherman A. 2001. Amphibians and reptiles of Indiana. Indiana Academy of Science, Monograph 3, second edition 404 pages.

Muchmore, William B. 2000. New species and records of Kleptochthonius from Indiana (Pseudoscorpionida, Chthoniidae). Journal of Arachnology 28: 293-299.

Mumford, Russell. E. And John O. Whitaker. 1982. Mammals of Indiana. Indiana University Press, Bloomington, 537 pages.

Packard, Alpheus S. 1873. On the cave fauna of Indiana. Fifth Annual Report of the Peabody Academy of Science, July 1873, Boston, 93-97.

Powell, Richard L. 1961. Caves of Indiana. Indiana Geologic Survey, Circular 8, 127 pages.

Schultz, George A. 1965. The distribution and general biology of Hyloniscus riparius (Koch) (Isopoda, Oniscoidea) in North America. Crustaceana 8 (2): 133-140.

Shear, William A. 1971. The milliped Family Conotylidae in North America, with a description of the new Family Adritylidae (Diplopoda: Chordeumida). Bulletin of the Museum of Comparative Zoology, 141 (2): 55-97.

Young, O.P. and G. B. Edwards. 1990. Spiders in United States field crops and their potential effect on crop pests. Journal of Arachnology 18: 1-27.

Zhang, Jun and John R. Holsinger. 2003. Systematics of the freshwater amphipod genus Crangonyx (Crangonyctidae) in North America. Virginia Museum of Natural History Special Publication.

Appendix K

Indiana Bat Hibernacula Reconnaissance
Redacted for confidential reasons related to karst.

APPENDIX L

Pollutant Loading Estimate Tables and FHWA Methodology

October 2012

INPUT FOR TABLE #1 AND TABLE #2			
T =	20	days	Days between events, 20 days is maximum
ADT =	40000	veh/day	Current ADT
Area Type =	II		Urban area
K (1) =	87.3	lb/mi-day	Pollutant accumulation rate
K (2) =	6.5		Wash-off coefficient for urban areas (Type II)
Design Freq.	1	Year	Design event
Rain Duration	1	hr	Rainfall duration
Rain Volume	1.21	in	Volume of design event rainfall (NOAA)
r	1.21	in/hr	Runoff rate

Table 1 Regression Equations					
Site Type	II				
Constituent	A	B	Constituent	A	B
Lead	1.02E-03	0.04	TPO4	2.25E-03	-0.32
Copper	3.16E-04	0.064	CL-	0.042	87
Zinc	5.84E-04	0.103	Fe	1.96E-02	-5
TSS	0.63	-188	Cd	4.16E-05	0.021
VSS	0.152	13.5	Cr	4.30E-05	0.036
TVS	0.263	243	Hg	2.44E-06	1.01E-06
TKN	5.46E-03	1.28			
TOC	5.60E-02	25.2			
COD	0.193	275.3			
TN	1.30E-03	0.713			

Table #1-1: 1-Year/1-Hour Pollutant Mass Loading of Karst Features for Pre-Construction (Existing) Conditions - Preferred Alternative #8

ID	Type	Approx. Station	Length of R/W in Drainage Area	Initial TS Load before Event (Po)	TS Load after Event (P)	TS Load at Discharge (Pd)	*Mass Load per Rain Event (Highway)*															
							Lead	Copper	Zinc	TSS	VSS	TVS	TKN	TOC	COD	TN	TPO4	CL-	Fe	Cd	Cr	Hg
		(feet)	(mi)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)
i168	sinkhole	1590+00	0.305	0	533	533	0.584	0.232	0.414	147.763	94.509	383.168	4.190	55.046	378.161	1.406	0.879	109.384	5.446	0.043	0.059	0.001
i020	sinkhole	1590+00	0.233	0	407	407	0.455	0.192	0.340	68.104	75.290	349.913	3.500	47.965	353.757	1.241	0.595	104.074	2.968	0.038	0.053	0.001
i023	sinkhole	1598+00	0.079	0	137	137	0.180	0.107	0.183	0.000	34.343	279.063	2.029	32.879	301.765	0.891	0.000	92.759	0.000	0.027	0.042	0.000
i024	sinkhole	1595+00	0.109	0	190	190	0.234	0.124	0.214	0.000	42.430	293.056	2.319	35.858	312.033	0.960	0.108	94.994	0.000	0.029	0.044	0.000
i025	sinkhole	1600+00	0.179	0	312	312	0.358	0.162	0.285	8.322	60.866	324.956	2.981	42.651	335.443	1.118	0.381	100.088	1.108	0.034	0.049	0.001
i426	sinkhole	1788+00	0.167	0	292	292	0.337	0.156	0.273	0.000	57.813	319.673	2.872	41.526	331.566	1.092	0.336	99.244	0.714	0.033	0.049	0.001
i412	sinkhole	1715+00	0.092	0	161	161	0.204	0.115	0.197	0.000	37.974	285.347	2.159	34.217	306.376	0.922	0.042	93.763	0.000	0.028	0.043	0.000
i040	sinkhole	1778+00	0.361	0	631	631	0.683	0.263	0.471	209.282	109.352	408.850	4.723	60.514	397.007	1.533	1.099	113.485	7.360	0.047	0.063	0.002
i042	sinkhole	1780+00	0.128	0	224	224	0.268	0.135	0.234	0.000	47.493	301.817	2.501	37.724	318.462	1.004	0.183	96.393	0.000	0.030	0.046	0.001
i426	sinkhole	1788+00	0.170	0	296	296	0.342	0.157	0.276	0.000	58.458	320.789	2.895	41.764	332.385	1.098	0.345	99.423	0.797	0.033	0.049	0.001
i192	sinkhole	2131+00	0.162	0	282	282	0.328	0.153	0.268	0.000	56.380	317.195	2.820	40.998	329.747	1.080	0.315	98.849	0.529	0.033	0.048	0.001
i430	sinkhole	1795+00	0.086	0	151	151	0.194	0.112	0.191	0.000	36.419	282.657	2.103	33.644	304.402	0.909	0.019	93.333	0.000	0.027	0.042	0.000
i044	sinkhole	1800+00	0.176	0	307	307	0.353	0.161	0.282	5.243	60.124	323.671	2.955	42.377	334.500	1.112	0.370	99.883	1.012	0.034	0.049	0.001
i182	sinkhole	1867+50	0.038	0	67	67	0.108	0.085	0.142	0.000	23.651	260.563	1.645	28.940	288.189	0.800	0.000	89.805	0.000	0.024	0.039	0.000
i205	sinkhole	1868+00	0.018	0	32	32	0.072	0.074	0.121	0.000	18.296	251.298	1.452	26.967	281.389	0.754	0.000	88.325	0.000	0.022	0.037	0.000
i116	sinkhole	1905+00	0.245	0	427	427	0.475	0.199	0.352	80.813	78.356	355.219	3.610	49.094	357.651	1.268	0.640	104.921	3.363	0.039	0.054	0.001
i174	sinkhole	1936+00	0.128	0	224	224	0.268	0.135	0.234	0.000	47.517	301.858	2.502	37.733	318.493	1.004	0.184	96.399	0.000	0.030	0.046	0.001
i192	sinkhole	2132+00	0.162	0	282	282	0.327	0.153	0.268	0.000	56.341	317.127	2.819	40.984	329.697	1.079	0.314	98.838	0.524	0.033	0.048	0.001
i049	sinkhole	2185+00	0.207	0	362	362	0.409	0.178	0.314	39.752	68.450	338.077	3.254	45.445	345.072	1.183	0.493	102.183	2.086	0.036	0.052	0.001
i084	sinkhole	2197+00	0.055	0	97	97	0.138	0.095	0.159	0.000	28.178	268.397	1.807	30.608	293.938	0.839	0.000	91.056	0.000	0.025	0.040	0.000
i194	sinkhole	2244+00	0.111	0	194	194	0.238	0.125	0.217	0.000	43.045	294.121	2.341	36.085	312.814	0.966	0.117	95.164	0.000	0.029	0.044	0.000
b03	Buried Sink	1653+00	0.088	0	154	154	0.197	0.113	0.193	0.000	36.874	283.443	2.120	33.811	304.978	0.913	0.026	93.459	0.000	0.027	0.043	0.000
b06	Buried Sink	1672+00	0.061	0	107	107	0.149	0.098	0.166	0.000	29.807	271.215	1.866	31.208	296.006	0.852	0.000	91.506	0.000	0.025	0.041	0.000
b09	Buried Sink	1676+00	0.010	0	18	18	0.058	0.070	0.113	0.000	16.184	247.644	1.376	26.189	278.708	0.736	0.000	87.742	0.000	0.022	0.037	0.000
b010	Buried Sink	1676+00	0.056	0	98	98	0.140	0.095	0.160	0.000	28.399	268.778	1.815	30.689	294.217	0.840	0.000	91.117	0.000	0.025	0.040	0.000
b012	Buried Sink	1680+00	0.072	0	126	126	0.169	0.104	0.177	0.000	32.669	276.167	1.969	32.262	299.639	0.877	0.000	92.297	0.000	0.026	0.041	0.000
b015	Buried Sink	1685+00	0.061	0	107	107	0.149	0.098	0.165	0.000	29.741	271.101	1.863	31.183	295.921	0.852	0.000	91.488	0.000	0.025	0.041	0.000
b016	Buried Sink	1695+00	0.131	0	228	228	0.273	0.136	0.236	0.000	48.191	303.024	2.526	37.981	319.348	1.010	0.194	96.586	0.000	0.030	0.046	0.001
b018	Buried Sink	1697+00	0.055	0	97	97	0.139	0.095	0.159	0.000	28.186	268.411	1.808	30.611	293.948	0.839	0.000	91.058	0.000	0.025	0.040	0.000
b019	Buried Sink	1777+00	0.094	0	164	164	0.207	0.116	0.199	0.000	38.419	286.117	2.175	34.381	306.941	0.926	0.049	93.886	0.000	0.028	0.043	0.000
b020	Buried Sink	1786+00	0.073	0	127	127	0.170	0.104	0.177	0.000	32.831	276.447	1.974	32.322	299.845	0.878	0.000	92.341	0.000	0.026	0.041	0.000
sp025	Spring	1584+50	0.146	0	255	255	0.300	0.145	0.252	0.000	52.225	310.004	2.671	39.467	324.471	1.044	0.253	97.700	0.000	0.032	0.047	0.001
sp026	Spring	1585+00	0.146	0	255	255	0.300	0.145	0.252	0.000	52.225	310.004	2.671	39.467	324.471	1.044	0.253	97.700	0.000	0.032	0.047	0.001
sp028	Spring	1586+00	0.146	0	255	255	0.300	0.145	0.252	0.000	52.225	310.004	2.671	39.467	324.471	1.044	0.253	97.700	0.000	0.032	0.047	0.001
sp032	Spring	1632+00	0.148	0	259	259	0.304	0.146	0.254	0.000	52.851	311.087	2.694	39.698	325.265	1.050	0.262	97.873	0.074	0.032	0.047	0.001
sp034	Spring	1660+00	0.337	0	588	588	0.639	0.250	0.446	182.238	102.827	397.560	4.489	58.110	388.722	1.477	1.002	111.683	6.519	0.045	0.061	0.001
sp055	Spring	1792+00	0.364	0	635	635	0.687	0.265	0.474	211.789	109.957	409.896	4.745	60.737	397.775	1.538	1.108	113.653	7.438	0.047	0.063	0.002
sp071	Spring	1895+00	0.569	0	993	992	1.052	0.378	0.683	437.199	164.342	503.996	6.698	80.773	466.829	2.003	1.913	128.680	14.451	0.062	0.079	0.002
sp077	Spring	1923+00	0.137	0	239	239	0.284	0.140	0.243	0.000	49.862	305.915	2.586	38.596	321.470	1.024	0.218	97.047	0.000	0.031	0.046	0.001
sp083	Spring	1939+00	0.057	0	100	100	0.142	0.096	0.161	0.000	28.717	269.329	1.827	30.806	294.621	0.843	0.000	91.205	0.000	0.025	0.040	0.000
sp093	Spring	1965+00	0.157	0	273	273	0.319	0.150	0.262	0.000	55.010	314.823	2.771	40.493	328.007	1.068	0.294	98.470	0.353	0.032	0.048	0.001
sp097	Spring	1972+00	0.132	0	231	231	0.275	0.137	0.238	0.000	48.554	303.653	2.539	38.115	319.809	1.013	0.199	96.686	0.000	0.031	0.046	0.001
sp098	Spring	1974+00	0.141	0	246	246	0.291	0.142	0.247	0.000	50.944	307.788	2.625	38.995	322.844	1.033	0.234	97.346	0.000	0.031	0.047	0.001
sp099	Spring	1975+00	0.069	0	121	121	0.164	0.102	0.174	0.000	31.916	274.864	1.942	31.985	298.683	0.871	0.000	92.089	0.000	0.026	0.041	0.000
sp107	Spring	1984+50	0.262	0	458	458	0.507	0.209	0.370	100.458	83.096	363.420	3.780	50.841	363.669	1.308	0.710	106.231	3.974	0.040	0.056	0.001
sp115	Spring	2117+00	0.270	0	471	471	0.520	0.213	0.378	108.461	85.027	366.761	3.849	51.552	366.121	1.325	0.739	106.764	4.223	0.041	0.056	0.001
sp120	Spring	2139+00	0.133	0	233	233	0.277	0.138	0.239	0.000	48.867	304.194	2.550	38.230	320.207	1.015	0.204	96.772	0.000	0.031	0.046	0.001
sp121	Spring	2140+00	0.022	0	38	38	0.079	0.076	0.125	0.000	19.293	253.023	1.488	27.334	282.655	0.763	0.000	88.601	0.000	0.023	0.038	0.000
sp122	Spring	2143+00	0.247	0	430	430	0.479	0.200	0.354	83.099	78.908	356.173	3.630	49.298	358.351	1.272	0.648	105.073	3.434	0.039	0.055	0.001
sp125	Spring	2145+50	0.164	0	286	285	0.331	0.154	0.270	0.000	56.891	318.077	2.839	41.186	330.395	1.084	0.322	98.989	0.595	0.033	0.048	0.001
sp127	Spring	2146+00	0.164	0	286	285	0.331	0.154	0.270	0.000	56.891	318.077	2.839	41.186	330.395	1.084	0.322	98.989	0.595	0.033	0.048	0.001
sp128	Spring	2148+00	0.164	0	286	285	0.331	0.154	0.270	0.000	56.891	318.077	2.839	41.186	330.395	1.084	0.322	98.989	0.595	0.033	0.048	0.001
sp136	Spring	2162+00	0.028	0	49	49	0.090	0.079	0.131	0.000	20.900	255.804	1.546	27.926	284.696	0.776	0.000	89.045	0.000	0.023	0.038	0.000

INPUT FOR TABLE #1 AND TABLE #2			
T =	20	days	Days between events, 20 days is maximum
ADT =	40000	veh/day	Current ADT
Area Type =	II		Urban area
K (1) =	87.3	lb/mi-day	Pollutant accumulation rate
K (2) =	6.5		Wash-off coefficient for urban areas (Type II)
Design Freq.	2	Year	Design event
Rain Duration	24	hr	Rainfall duration
Rain Volume	3.16	in	Volume of design event rainfall (NOAA)
r	0.13	in/hr	Runoff rate

Table 1 Regression Equations					
Site Type	II				
Constituent	A	B	Constituent	A	B
Lead	1.02E-03	0.04	TPO4	2.25E-03	-0.32
Copper	3.16E-04	0.064	CL-	0.042	87
Zinc	5.84E-04	0.103	Fe	1.96E-02	-5
TSS	0.63	-188	Cd	4.16E-05	0.021
VSS	0.152	13.5	Cr	4.30E-05	0.036
TVS	0.263	243	Hg	2.44E-06	1.01E-06
TKN	5.46E-03	1.28	0	0.00E+00	0
TOC	5.60E-02	25.2	0	0	0
COD	0.193	275.3	0	0	0
TN	1.30E-03	0.713	0	0.00E+00	0

Table #1-2: 2-Year/24-Hour Pollutant Mass Loading of Karst Features for Pre-Construction (Existing) Conditions - Preferred Alternative #8

ID	Type	Approx. Station	Length of R/W in Drainage Area	Initial TS Load before Event (Po)	TS Load after Event (P)	TS Load at Discharge (Pd)	*Mass Load per Rain Event (Highway)*															
							Lead	Copper	Zinc	TSS	VSS	TVS	TKN	TOC	COD	TN	TPO4	CL-	Fe	Cd	Cr	Hg
		(feet)	(mi)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)
i168	sinkhole	1590+00	0.305	0	533	307	0.353	0.161	0.282	5.162	60.104	323.637	2.954	42.370	334.475	1.112	0.370	99.877	1.009	0.034	0.049	0.001
i020	sinkhole	1590+00	0.233	0	407	234	0.279	0.138	0.240	0.000	49.047	304.506	2.557	38.296	320.436	1.017	0.206	96.822	0.000	0.031	0.046	0.001
i023	sinkhole	1598+00	0.079	0	137	79	0.120	0.089	0.149	0.000	25.491	263.747	1.711	29.618	290.525	0.816	0.000	90.313	0.000	0.024	0.039	0.000
i024	sinkhole	1595+00	0.109	0	190	109	0.152	0.099	0.167	0.000	30.143	271.797	1.878	31.332	296.432	0.855	0.000	91.599	0.000	0.026	0.041	0.000
i025	sinkhole	1600+00	0.179	0	312	179	0.223	0.121	0.208	0.000	40.750	290.149	2.259	35.239	309.900	0.946	0.083	94.529	0.000	0.028	0.044	0.000
i426	sinkhole	1788+00	0.167	0	292	168	0.211	0.117	0.201	0.000	38.993	287.109	2.196	34.592	307.669	0.931	0.057	94.044	0.000	0.028	0.043	0.000
i412	sinkhole	1715+00	0.092	0	161	93	0.134	0.093	0.157	0.000	27.580	267.362	1.786	30.387	293.178	0.833	0.000	90.891	0.000	0.025	0.040	0.000
i040	sinkhole	1778+00	0.361	0	631	363	0.410	0.179	0.315	40.553	68.643	338.412	3.261	45.516	345.317	1.185	0.496	102.237	2.111	0.036	0.052	0.001
i042	sinkhole	1780+00	0.128	0	224	129	0.171	0.105	0.178	0.000	33.056	276.837	1.982	32.405	300.131	0.880	0.000	92.404	0.000	0.026	0.042	0.000
i426	sinkhole	1788+00	0.170	0	296	170	0.214	0.118	0.202	0.000	39.364	287.752	2.209	34.729	308.141	0.934	0.063	94.147	0.000	0.028	0.043	0.000
i192	sinkhole	2131+00	0.162	0	282	162	0.206	0.115	0.198	0.000	38.169	285.684	2.166	34.289	306.623	0.924	0.045	93.816	0.000	0.028	0.043	0.000
i430	sinkhole	1795+00	0.086	0	151	87	0.128	0.091	0.154	0.000	26.685	265.814	1.754	30.058	292.042	0.826	0.000	90.643	0.000	0.025	0.040	0.000
i044	sinkhole	1800+00	0.176	0	307	176	0.220	0.120	0.206	0.000	40.322	289.410	2.243	35.082	309.357	0.942	0.077	94.411	0.000	0.028	0.044	0.000
i182	sinkhole	1867+50	0.038	0	67	38	0.079	0.076	0.125	0.000	19.340	253.104	1.490	27.351	282.715	0.763	0.000	88.614	0.000	0.023	0.038	0.000
i205	sinkhole	1868+00	0.018	0	32	18	0.059	0.070	0.114	0.000	16.259	247.774	1.379	26.216	278.803	0.737	0.000	87.762	0.000	0.022	0.037	0.000
i116	sinkhole	1905+00	0.245	0	427	245	0.290	0.142	0.246	0.000	50.811	307.558	2.620	38.946	322.676	1.032	0.232	97.310	0.000	0.031	0.047	0.001
i174	sinkhole	1936+00	0.128	0	224	129	0.171	0.105	0.178	0.000	33.070	276.861	1.983	32.410	300.148	0.880	0.000	92.407	0.000	0.026	0.042	0.000
i192	sinkhole	2132+00	0.162	0	282	162	0.205	0.115	0.198	0.000	38.146	285.645	2.165	34.280	306.594	0.924	0.045	93.810	0.000	0.028	0.043	0.000
i049	sinkhole	2185+00	0.207	0	362	208	0.252	0.130	0.224	0.000	45.112	297.697	2.416	36.847	315.439	0.983	0.148	95.735	0.000	0.030	0.045	0.001
i084	sinkhole	2197+00	0.055	0	97	56	0.097	0.082	0.135	0.000	21.944	257.611	1.583	28.311	286.022	0.785	0.000	89.333	0.000	0.023	0.038	0.000
i194	sinkhole	2244+00	0.111	0	194	112	0.154	0.099	0.168	0.000	30.497	272.409	1.891	31.462	296.882	0.858	0.000	91.697	0.000	0.026	0.041	0.000
b03	Buried Sink	1653+00	0.088	0	154	88	0.130	0.092	0.155	0.000	26.947	266.266	1.763	30.154	292.374	0.828	0.000	90.716	0.000	0.025	0.040	0.000
b06	Buried Sink	1672+00	0.061	0	107	62	0.103	0.084	0.139	0.000	22.881	259.232	1.617	28.656	287.212	0.793	0.000	89.592	0.000	0.024	0.039	0.000
b09	Buried Sink	1676+00	0.010	0	18	10	0.050	0.067	0.109	0.000	15.044	245.672	1.335	25.769	277.261	0.726	0.000	87.427	0.000	0.021	0.036	0.000
b010	Buried Sink	1676+00	0.056	0	98	56	0.098	0.082	0.136	0.000	22.071	257.830	1.588	28.358	286.183	0.786	0.000	89.368	0.000	0.023	0.038	0.000
b012	Buried Sink	1680+00	0.072	0	126	73	0.114	0.087	0.145	0.000	24.528	262.081	1.676	29.263	289.302	0.807	0.000	90.047	0.000	0.024	0.039	0.000
b015	Buried Sink	1685+00	0.061	0	107	61	0.103	0.083	0.139	0.000	22.843	259.166	1.616	28.642	287.163	0.793	0.000	89.582	0.000	0.024	0.039	0.000
b016	Buried Sink	1695+00	0.131	0	228	131	0.174	0.105	0.180	0.000	33.457	277.531	1.997	32.553	300.640	0.884	0.000	92.515	0.000	0.026	0.042	0.000
b018	Buried Sink	1697+00	0.055	0	97	56	0.097	0.082	0.135	0.000	21.949	257.619	1.583	28.313	286.028	0.785	0.000	89.335	0.000	0.023	0.038	0.000
b019	Buried Sink	1777+00	0.094	0	164	94	0.136	0.094	0.158	0.000	27.836	267.805	1.795	30.482	293.503	0.836	0.000	90.961	0.000	0.025	0.040	0.000
b020	Buried Sink	1786+00	0.073	0	127	73	0.115	0.087	0.146	0.000	24.621	262.242	1.679	29.297	289.420	0.808	0.000	90.073	0.000	0.024	0.039	0.000
sp025	Spring	1584+50	0.146	0	255	147	0.189	0.110	0.189	0.000	35.778	281.547	2.080	33.408	303.587	0.904	0.010	93.156	0.000	0.027	0.042	0.000
sp026	Spring	1585+00	0.146	0	255	147	0.189	0.110	0.189	0.000	35.778	281.547	2.080	33.408	303.587	0.904	0.010	93.156	0.000	0.027	0.042	0.000
sp028	Spring	1586+00	0.146	0	255	147	0.189	0.110	0.189	0.000	35.778	281.547	2.080	33.408	303.587	0.904	0.010	93.156	0.000	0.027	0.042	0.000
sp032	Spring	1632+00	0.148	0	259	149	0.192	0.111	0.190	0.000	36.138	282.170	2.093	33.540	304.045	0.907	0.015	93.255	0.000	0.027	0.042	0.000
sp034	Spring	1660+00	0.337	0	588	338	0.385	0.171	0.300	24.995	64.889	331.917	3.126	44.133	340.551	1.153	0.441	101.200	1.627	0.035	0.051	0.001
sp055	Spring	1792+00	0.364	0	635	365	0.412	0.179	0.316	41.995	68.991	339.014	3.273	45.644	345.759	1.188	0.501	102.333	2.155	0.036	0.052	0.001
sp071	Spring	1895+00	0.569	0	993	571	0.622	0.244	0.436	171.672	100.278	393.149	4.397	57.171	385.485	1.455	0.965	110.978	6.190	0.045	0.061	0.001
sp077	Spring	1923+00	0.137	0	239	138	0.180	0.107	0.183	0.000	34.419	279.195	2.031	32.907	301.861	0.892	0.000	92.780	0.000	0.027	0.042	0.000
sp083	Spring	1939+00	0.057	0	100	58	0.099	0.082	0.137	0.000	22.254	258.147	1.594	28.425	286.415	0.788	0.000	89.419	0.000	0.023	0.038	0.000
sp093	Spring	1965+00	0.157	0	273	157	0.200	0.114	0.195	0.000	37.380	284.319	2.138	33.998	305.622	0.917	0.033	93.599	0.000	0.028	0.043	0.000
sp097	Spring	1972+00	0.132	0	231	133	0.175	0.106	0.180	0.000	33.666	277.893	2.004	32.630	300.906	0.885	0.000	92.572	0.000	0.027	0.042	0.000
sp098	Spring	1974+00	0.141	0	246	142	0.185	0.109	0.186	0.000	35.041	280.272	2.054	33.136	302.652	0.897	0.000	92.952	0.000	0.027	0.042	0.000
sp099	Spring	1975+00	0.069	0	121	70	0.111	0.086	0.144	0.000	24.094	261.331	1.661	29.103	288.752	0.804	0.000	89.927	0.000	0.024	0.039	0.000
sp107	Spring	1984+50	0.262	0	458	263	0.309	0.147	0.257	0.000	53.538	312.277	2.718	39.951	326.138	1.055	0.273	98.063	0.163	0.032	0.047	0.001
sp115	Spring	2117+00	0.270	0	471	271	0.316	0.150	0.261	0.000	54.649	314.199	2.758	40.360	327.548	1.065	0.289	98.370	0.306	0.032	0.048	0.001
sp120	Spring	2139+00	0.133	0	233	134	0.177	0.106	0.181	0.000	33.846	278.205	2.011	32.696	301.135	0.887	0.000	92.622	0.000	0.027	0.042	0.000
sp121	Spring	2140+00	0.022	0	38	22	0.062	0.071	0.116	0.000	16.833	248.766	1.400	26.428	279.531	0.742	0.000	87.921	0.000	0.022	0.037	0.000
sp122	Spring	2143+00	0.247	0	430	248	0.293	0.142	0.248	0.000	51.129	308.108	2.632	39.063	323.079	1.035	0.237	97.397	0.000	0.031	0.047	0.001
sp125	Spring	2145+50	0.164	0	286	164	0.208	0.116	0.199	0.000	38.462	286.191	2.177	34.397	306.995	0.926	0.050	93.897	0.000	0.028	0.043	0.000
sp127	Spring	2146+00	0.164	0	286	164	0.208	0.116	0.199	0.000	38.462	286.191	2.177	34.397	306.995	0.926	0.050	93.897	0.000	0.028	0.043	0.000
sp128	Spring	2148+00	0.164	0	286	164	0.208	0.116	0.199	0.000	38.462	286.191	2.177	34.397	306.995	0.926	0.050	93.897	0.000	0.028	0.043	0.000
sp136	Spring	2162+00	0.028	0	49	28	0.069	0.073	0.119	0.000	17.757	250.366	1.433	26.768	280.706	0.749	0.000	88.176	0.000	0.022	0.037	0.000

INPUT FOR TABLE #1 AND TABLE #2			
T =	20	days	Days between events, 20 days is maximum
ADT =	40000	veh/day	Current ADT
Area Type =	II		Urban area
K (1) =	87.3	lb/mi-day	Pollutant accumulation rate
K (2) =	6.5		Wash-off coefficient for urban areas (Type II)
Design Freq.	5	Year	Design event
Rain Duration	24	hr	Rainfall duration
Rain Volume	3.92	in	Volume of design event rainfall (NOAA)
r	0.16	in/hr	Runoff rate

Table 1 Regression Equations					
Site Type	II				
Constituent	A	B	Constituent	A	B
Lead	1.02E-03	0.04	TPO4	2.25E-03	-0.32
Copper	3.16E-04	0.064	CL-	0.042	87
Zinc	5.84E-04	0.103	Fe	1.96E-02	-5
TSS	0.63	-188	Cd	4.16E-05	0.021
VSS	0.152	13.5	Cr	4.30E-05	0.036
TVS	0.263	243	Hg	2.44E-06	1.01E-06
TKN	5.46E-03	1.28	0	0.00E+00	0
TOC	5.60E-02	25.2	0	0	0
COD	0.193	275.3	0	0	0
TN	1.30E-03	0.713	0	0.00E+00	0

Table #1-3: 5-Year/24-Hour Pollutant Mass Loading of Karst Features for Pre-Construction (Existing) Conditions - Preferred Alternative #8

ID	Type	Approx. Station	Length of R/W in Drainage Area	Initial TS Load before Event (Po)	TS Load after Event (P)	TS Load at Discharge (Pd)	*Mass Load per Rain Event (Highway)*															
							Lead	Copper	Zinc	TSS	VSS	TVS	TKN	TOC	COD	TN	TPO4	CL-	Fe	Cd	Cr	Hg
		(feet)	(mi)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)
i168	sinkhole	1590+00	0.305	0	533	349	0.396	0.174	0.307	31.714	66.510	334.722	3.184	44.730	342.609	1.166	0.465	101.648	1.836	0.036	0.051	0.001
i020	sinkhole	1590+00	0.233	0	407	266	0.311	0.148	0.258	0.000	53.934	312.961	2.732	40.097	326.640	1.059	0.279	98.172	0.214	0.032	0.047	0.001
i023	sinkhole	1598+00	0.079	0	137	90	0.132	0.092	0.155	0.000	27.139	266.599	1.770	30.225	292.618	0.830	0.000	90.769	0.000	0.025	0.040	0.000
i024	sinkhole	1595+00	0.109	0	190	125	0.167	0.103	0.176	0.000	32.431	275.755	1.960	32.174	299.337	0.875	0.000	92.231	0.000	0.026	0.041	0.000
i025	sinkhole	1600+00	0.179	0	312	204	0.248	0.128	0.222	0.000	44.495	296.630	2.393	36.619	314.656	0.978	0.139	95.564	0.000	0.029	0.045	0.000
i426	sinkhole	1788+00	0.167	0	292	191	0.235	0.124	0.214	0.000	42.497	293.173	2.322	35.883	312.119	0.961	0.109	95.012	0.000	0.029	0.044	0.000
i412	sinkhole	1715+00	0.092	0	161	105	0.147	0.097	0.165	0.000	29.515	270.711	1.855	31.100	295.635	0.850	0.000	91.425	0.000	0.025	0.041	0.000
i040	sinkhole	1778+00	0.361	0	631	413	0.461	0.194	0.344	71.971	76.223	351.527	3.533	48.308	354.942	1.249	0.608	104.331	3.088	0.038	0.054	0.001
i042	sinkhole	1780+00	0.128	0	224	146	0.189	0.110	0.188	0.000	35.744	281.488	2.079	33.395	303.544	0.903	0.009	93.146	0.000	0.027	0.042	0.000
i426	sinkhole	1788+00	0.170	0	296	194	0.237	0.125	0.216	0.000	42.919	293.903	2.337	36.039	312.655	0.965	0.115	95.129	0.000	0.029	0.044	0.000
i192	sinkhole	2131+00	0.162	0	282	185	0.228	0.122	0.211	0.000	41.560	291.551	2.288	35.538	310.929	0.953	0.095	94.753	0.000	0.029	0.044	0.000
i430	sinkhole	1795+00	0.086	0	151	99	0.141	0.095	0.161	0.000	28.498	268.950	1.819	30.726	294.343	0.841	0.000	91.144	0.000	0.025	0.040	0.000
i044	sinkhole	1800+00	0.176	0	307	201	0.245	0.127	0.220	0.000	44.009	295.789	2.376	36.440	314.039	0.974	0.132	95.430	0.000	0.029	0.045	0.000
i182	sinkhole	1867+50	0.038	0	67	44	0.085	0.078	0.129	0.000	20.142	254.493	1.519	27.647	283.734	0.770	0.000	88.835	0.000	0.023	0.038	0.000
i205	sinkhole	1868+00	0.018	0	32	21	0.061	0.071	0.115	0.000	16.638	248.430	1.393	26.356	279.285	0.740	0.000	87.867	0.000	0.022	0.037	0.000
i116	sinkhole	1905+00	0.245	0	427	279	0.325	0.152	0.266	0.000	55.940	316.433	2.804	40.836	329.188	1.076	0.308	98.727	0.473	0.033	0.048	0.001
i174	sinkhole	1936+00	0.128	0	224	146	0.189	0.110	0.189	0.000	35.760	281.515	2.080	33.401	303.564	0.903	0.010	93.151	0.000	0.027	0.042	0.000
i192	sinkhole	2132+00	0.162	0	282	184	0.228	0.122	0.211	0.000	41.534	291.507	2.287	35.528	310.896	0.953	0.095	94.746	0.000	0.029	0.044	0.000
i049	sinkhole	2185+00	0.207	0	362	237	0.281	0.139	0.241	0.000	49.458	305.216	2.572	38.448	320.957	1.021	0.212	96.936	0.000	0.031	0.046	0.001
i084	sinkhole	2197+00	0.055	0	97	63	0.104	0.084	0.140	0.000	23.105	259.619	1.625	28.739	287.496	0.795	0.000	89.654	0.000	0.024	0.039	0.000
i194	sinkhole	2244+00	0.111	0	194	127	0.170	0.104	0.177	0.000	32.833	276.452	1.974	32.323	299.848	0.878	0.000	92.342	0.000	0.026	0.041	0.000
b03	Buried Sink	1653+00	0.088	0	154	101	0.143	0.096	0.162	0.000	28.795	269.465	1.829	30.835	294.721	0.844	0.000	91.226	0.000	0.025	0.040	0.000
b06	Buried Sink	1672+00	0.061	0	107	70	0.112	0.086	0.144	0.000	24.171	261.463	1.663	29.131	288.849	0.804	0.000	89.949	0.000	0.024	0.039	0.000
b09	Buried Sink	1676+00	0.010	0	18	12	0.052	0.068	0.110	0.000	15.256	246.039	1.343	25.847	277.530	0.728	0.000	87.485	0.000	0.021	0.036	0.000
b010	Buried Sink	1676+00	0.056	0	98	64	0.105	0.084	0.140	0.000	23.249	259.869	1.630	28.792	287.679	0.796	0.000	89.694	0.000	0.024	0.039	0.000
b012	Buried Sink	1680+00	0.072	0	126	83	0.124	0.090	0.151	0.000	26.044	264.704	1.731	29.821	291.227	0.820	0.000	90.466	0.000	0.024	0.040	0.000
b015	Buried Sink	1685+00	0.061	0	107	70	0.111	0.086	0.144	0.000	24.127	261.388	1.662	29.115	288.794	0.804	0.000	89.937	0.000	0.024	0.039	0.000
b016	Buried Sink	1695+00	0.131	0	228	149	0.192	0.111	0.190	0.000	36.201	282.278	2.095	33.563	304.124	0.907	0.016	93.273	0.000	0.027	0.042	0.000
b018	Buried Sink	1697+00	0.055	0	97	63	0.104	0.084	0.140	0.000	23.110	259.628	1.625	28.741	287.503	0.795	0.000	89.655	0.000	0.024	0.039	0.000
b019	Buried Sink	1777+00	0.094	0	164	107	0.149	0.098	0.166	0.000	29.806	271.214	1.866	31.208	296.005	0.852	0.000	91.506	0.000	0.025	0.041	0.000
b020	Buried Sink	1786+00	0.073	0	127	83	0.125	0.090	0.152	0.000	26.149	264.887	1.734	29.860	291.361	0.821	0.000	90.495	0.000	0.024	0.040	0.000
sp025	Spring	1584+50	0.146	0	255	167	0.210	0.117	0.200	0.000	38.841	286.846	2.190	34.536	307.476	0.930	0.055	94.002	0.000	0.028	0.043	0.000
sp026	Spring	1585+00	0.146	0	255	167	0.210	0.117	0.200	0.000	38.841	286.846	2.190	34.536	307.476	0.930	0.055	94.002	0.000	0.028	0.043	0.000
sp028	Spring	1586+00	0.146	0	255	167	0.210	0.117	0.200	0.000	38.841	286.846	2.190	34.536	307.476	0.930	0.055	94.002	0.000	0.028	0.043	0.000
sp032	Spring	1632+00	0.148	0	259	169	0.213	0.118	0.202	0.000	39.250	287.555	2.205	34.687	307.996	0.933	0.061	94.115	0.000	0.028	0.043	0.000
sp034	Spring	1660+00	0.337	0	588	385	0.432	0.186	0.328	54.274	71.953	344.140	3.380	46.735	349.520	1.213	0.545	103.152	2.537	0.037	0.053	0.001
sp055	Spring	1792+00	0.364	0	635	415	0.464	0.195	0.346	73.611	76.619	352.212	3.547	48.454	355.444	1.253	0.614	104.441	3.139	0.038	0.054	0.001
sp071	Spring	1895+00	0.569	0	993	649	0.702	0.269	0.482	221.113	112.207	413.788	4.826	61.566	400.631	1.557	1.141	114.274	7.728	0.048	0.064	0.002
sp077	Spring	1923+00	0.137	0	239	157	0.200	0.113	0.194	0.000	37.294	284.170	2.135	33.966	305.512	0.917	0.032	93.575	0.000	0.028	0.043	0.000
sp083	Spring	1939+00	0.057	0	100	66	0.107	0.085	0.141	0.000	23.457	260.229	1.638	28.869	287.943	0.798	0.000	89.751	0.000	0.024	0.039	0.000
sp093	Spring	1965+00	0.157	0	273	179	0.222	0.120	0.207	0.000	40.663	289.999	2.256	35.207	309.790	0.945	0.082	94.506	0.000	0.028	0.044	0.000
sp097	Spring	1972+00	0.132	0	231	151	0.194	0.112	0.191	0.000	36.438	282.689	2.104	33.651	304.426	0.909	0.020	93.338	0.000	0.027	0.042	0.000
sp098	Spring	1974+00	0.141	0	246	161	0.204	0.115	0.197	0.000	38.002	285.395	2.160	34.227	306.411	0.923	0.043	93.770	0.000	0.028	0.043	0.000
sp099	Spring	1975+00	0.069	0	121	79	0.121	0.089	0.149	0.000	25.551	263.851	1.713	29.640	290.601	0.816	0.000	90.330	0.000	0.024	0.039	0.000
sp107	Spring	1984+50	0.262	0	458	300	0.346	0.159	0.278	0.759	59.042	321.799	2.916	41.979	333.126	1.103	0.354	99.584	0.872	0.033	0.049	0.001
sp115	Spring	2117+00	0.270	0	471	308	0.354	0.161	0.283	5.996	60.305	323.986	2.961	42.444	334.731	1.113	0.373	99.933	1.035	0.034	0.049	0.001
sp120	Spring	2139+00	0.133	0	233	152	0.195	0.112	0.192	0.000	36.643	283.044	2.111	33.726	304.686	0.911	0.023	93.395	0.000	0.027	0.043	0.000
sp121	Spring	2140+00	0.022	0	38	25	0.065	0.072	0.118	0.000	17.291	249.559	1.416	26.597	280.113	0.745	0.000	88.047	0.000	0.022	0.037	0.000
sp122	Spring	2143+00	0.247	0	430	282	0.327	0.153	0.267	0.000	56.301	317.057	2.817	40.969	329.646	1.079	0.314	98.827	0.519	0.033	0.048	0.001
sp125	Spring	2145+50	0.164	0	286	187	0.231	0.123	0.212	0.000	41.894	292.128	2.300	35.661	311.352	0.956	0.100	94.846	0.000	0.029	0.044	0.000
sp127	Spring	2146+00	0.164	0	286	187	0.231	0.123	0.212	0.000	41.894	292.128	2.300	35.661	311.352	0.956	0.100	94.846	0.000	0.029	0.044	0.000
sp128	Spring	2148+00	0.164	0	286	187	0.231	0.123	0.212	0.000	41.894	292.128	2.300	35.661	311.352	0.956	0.100	94.846	0.000	0.029	0.044	0.000
sp136	Spring	2162+00	0.028	0	49	32	0.072	0.074	0.122	0.000	18.342	251.379	1.454	26.984	281.449	0.754	0.000	88.338	0.000	0.022	0.037	0.000

INPUT FOR TABLE #1 AND TABLE #2			
T =	20	days	Days between events, 20 days is maximum
ADT =	40000	veh/day	Current ADT
Area Type =	II	0	Urban area
K (1) =	87.3	lb/mi-day	Pollutant accumulation rate
K (2) =	6.5	0	Wash-off coefficient for urban areas (Type II)
Design Freq.	50	Year	Design event
Rain Duration	0.17	hr	Rainfall duration
Rain Volume	1.20	in	Volume of design event rainfall (NOAA)
r	7.20	in/hr	Runoff rate

Table 1 Regression Equations					
Site Type	II				
Constituent	A	B	Constituent	A	B
Lead	1.02E-03	0.04	TPO4	2.25E-03	-0.32
Copper	3.16E-04	0.064	CL-	0.042	87
Zinc	5.84E-04	0.103	Fe	1.96E-02	-5
TSS	0.63	-188	Cd	4.16E-05	0.021
VSS	0.152	13.5	Cr	4.30E-05	0.036
TVS	0.263	243	Hg	2.44E-06	1.01E-06
TKN	5.46E-03	1.28	0	0.00E+00	0
TOC	5.60E-02	25.2	0	0	0
COD	0.193	275.3	0	0	0
TN	1.30E-03	0.713	0	0.00E+00	0

Table #1-4: 50-Year/10-Min Pollutant Mass Loading of Karst Features for Pre-Construction (Existing) Conditions - Preferred Alternative #8

ID	Type	Approx. Station	Length of R/W in Drainage Area	Initial TS Load before Event (Po)	TS Load after Event (P)	TS Load at Discharge (Pd)	*Mass Load per Rain Event (Highway)*															
							Lead	Copper	Zinc	TSS	VSS	TVS	TKN	TOC	COD	TN	TPO4	CL-	Fe	Cd	Cr	Hg
		(feet)	(mi)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)
i168	sinkhole	1590+00	0.305	0	533	533	0.584	0.232	0.414	147.892	94.541	383.222	4.191	55.057	378.200	1.406	0.880	109.393	5.450	0.043	0.059	0.001
i020	sinkhole	1590+00	0.233	0	407	407	0.455	0.193	0.340	68.202	75.314	349.954	3.500	47.974	353.787	1.242	0.595	104.080	2.971	0.038	0.053	0.001
i023	sinkhole	1598+00	0.079	0	137	137	0.180	0.107	0.183	0.000	34.351	279.077	2.029	32.882	301.775	0.891	0.000	92.761	0.000	0.027	0.042	0.000
i024	sinkhole	1595+00	0.109	0	190	190	0.234	0.124	0.214	0.000	42.441	293.075	2.320	35.862	312.047	0.961	0.108	94.997	0.000	0.029	0.044	0.000
i025	sinkhole	1600+00	0.179	0	312	312	0.358	0.163	0.285	8.397	60.885	324.988	2.982	42.658	335.466	1.118	0.381	100.093	1.110	0.034	0.049	0.001
i426	sinkhole	1788+00	0.167	0	292	292	0.337	0.156	0.273	0.000	57.830	319.703	2.872	41.532	331.588	1.092	0.336	99.249	0.716	0.033	0.049	0.001
i412	sinkhole	1715+00	0.092	0	161	161	0.204	0.115	0.197	0.000	37.984	285.363	2.159	34.220	306.388	0.922	0.042	93.765	0.000	0.028	0.043	0.000
i040	sinkhole	1778+00	0.361	0	631	631	0.683	0.263	0.471	209.435	109.389	408.913	4.724	60.528	397.054	1.533	1.099	113.496	7.365	0.047	0.063	0.002
i042	sinkhole	1780+00	0.128	0	224	224	0.268	0.135	0.234	0.000	47.506	301.840	2.502	37.729	318.479	1.004	0.183	96.396	0.000	0.030	0.046	0.001
i426	sinkhole	1788+00	0.170	0	296	296	0.342	0.158	0.276	0.000	58.475	320.819	2.896	41.770	332.407	1.098	0.346	99.427	0.799	0.033	0.049	0.001
i192	sinkhole	2131+00	0.162	0	282	282	0.328	0.153	0.268	0.000	56.397	317.223	2.821	41.004	329.768	1.080	0.315	98.853	0.531	0.033	0.048	0.001
i430	sinkhole	1795+00	0.086	0	151	151	0.194	0.112	0.191	0.000	36.428	282.672	2.104	33.647	304.413	0.909	0.019	93.335	0.000	0.027	0.042	0.000
i044	sinkhole	1800+00	0.176	0	307	307	0.353	0.161	0.282	5.318	60.142	323.702	2.955	42.384	334.523	1.112	0.370	99.888	1.014	0.034	0.049	0.001
i182	sinkhole	1867+50	0.038	0	67	67	0.108	0.085	0.142	0.000	23.655	260.570	1.645	28.941	288.194	0.800	0.000	89.806	0.000	0.024	0.039	0.000
i205	sinkhole	1868+00	0.018	0	32	32	0.072	0.074	0.121	0.000	18.297	251.301	1.452	26.967	281.391	0.754	0.000	88.326	0.000	0.022	0.037	0.000
i116	sinkhole	1905+00	0.245	0	427	427	0.475	0.199	0.352	80.916	78.381	355.262	3.611	49.104	357.682	1.268	0.640	104.928	3.366	0.039	0.054	0.001
i174	sinkhole	1936+00	0.128	0	224	224	0.268	0.135	0.234	0.000	47.530	301.881	2.502	37.737	318.509	1.004	0.184	96.403	0.000	0.030	0.046	0.001
i192	sinkhole	2132+00	0.162	0	282	282	0.328	0.153	0.268	0.000	56.358	317.156	2.820	40.990	329.718	1.080	0.314	98.842	0.526	0.033	0.048	0.001
i049	sinkhole	2185+00	0.207	0	362	362	0.409	0.178	0.314	39.839	68.471	338.114	3.255	45.452	345.098	1.183	0.494	102.189	2.088	0.036	0.052	0.001
i084	sinkhole	2197+00	0.055	0	97	97	0.139	0.095	0.159	0.000	28.184	268.407	1.807	30.610	293.945	0.839	0.000	91.057	0.000	0.025	0.040	0.000
i194	sinkhole	2244+00	0.111	0	194	194	0.238	0.125	0.217	0.000	43.056	294.140	2.342	36.089	312.829	0.966	0.118	95.167	0.000	0.029	0.044	0.000
b03	Buried Sink	1653+00	0.088	0	154	154	0.197	0.113	0.193	0.000	36.883	283.458	2.120	33.815	304.990	0.913	0.026	93.461	0.000	0.027	0.043	0.000
b06	Buried Sink	1672+00	0.061	0	107	107	0.149	0.098	0.166	0.000	29.813	271.226	1.866	31.210	296.013	0.853	0.000	91.508	0.000	0.025	0.041	0.000
b09	Buried Sink	1676+00	0.010	0	18	18	0.058	0.070	0.113	0.000	16.185	247.646	1.376	26.189	278.710	0.736	0.000	87.742	0.000	0.022	0.037	0.000
b010	Buried Sink	1676+00	0.056	0	98	98	0.140	0.095	0.160	0.000	28.404	268.788	1.815	30.691	294.224	0.840	0.000	91.118	0.000	0.025	0.040	0.000
b012	Buried Sink	1680+00	0.072	0	126	126	0.169	0.104	0.177	0.000	32.676	276.180	1.969	32.265	299.649	0.877	0.000	92.299	0.000	0.026	0.041	0.000
b015	Buried Sink	1685+00	0.061	0	107	107	0.149	0.098	0.165	0.000	29.747	271.111	1.864	31.186	295.929	0.852	0.000	91.489	0.000	0.025	0.041	0.000
b016	Buried Sink	1695+00	0.131	0	228	228	0.273	0.136	0.236	0.000	48.204	303.047	2.527	37.986	319.365	1.010	0.194	96.589	0.000	0.030	0.046	0.001
b018	Buried Sink	1697+00	0.055	0	97	97	0.139	0.095	0.159	0.000	28.192	268.421	1.808	30.613	293.955	0.839	0.000	91.060	0.000	0.025	0.040	0.000
b019	Buried Sink	1777+00	0.094	0	164	164	0.207	0.116	0.199	0.000	38.429	286.133	2.175	34.384	306.953	0.926	0.049	93.888	0.000	0.028	0.043	0.000
b020	Buried Sink	1786+00	0.073	0	127	127	0.170	0.104	0.177	0.000	32.838	276.460	1.975	32.325	299.854	0.878	0.000	92.343	0.000	0.026	0.041	0.000
sp025	Spring	1584+50	0.146	0	255	255	0.300	0.145	0.252	0.000	52.240	310.030	2.672	39.473	324.489	1.044	0.253	97.704	0.000	0.032	0.047	0.001
sp026	Spring	1585+00	0.146	0	255	255	0.300	0.145	0.252	0.000	52.240	310.030	2.672	39.473	324.489	1.044	0.253	97.704	0.000	0.032	0.047	0.001
sp028	Spring	1586+00	0.146	0	255	255	0.300	0.145	0.252	0.000	52.240	310.030	2.672	39.473	324.489	1.044	0.253	97.704	0.000	0.032	0.047	0.001
sp032	Spring	1632+00	0.148	0	259	259	0.304	0.146	0.254	0.000	52.866	311.114	2.694	39.703	325.285	1.050	0.263	97.877	0.076	0.032	0.047	0.001
sp034	Spring	1660+00	0.337	0	588	588	0.640	0.250	0.446	182.381	102.862	397.619	4.490	58.123	388.766	1.477	1.003	111.692	6.523	0.045	0.061	0.001
sp055	Spring	1792+00	0.364	0	635	635	0.688	0.265	0.474	211.942	109.994	409.960	4.746	60.750	397.822	1.538	1.108	113.663	7.443	0.047	0.063	0.002
sp071	Spring	1895+00	0.569	0	993	993	1.053	0.378	0.683	437.439	164.400	504.096	6.700	80.795	466.903	2.004	1.914	128.696	14.458	0.062	0.079	0.002
sp077	Spring	1923+00	0.137	0	239	239	0.284	0.140	0.243	0.000	49.876	305.939	2.587	38.602	321.488	1.024	0.218	97.051	0.000	0.031	0.046	0.001
sp083	Spring	1939+00	0.057	0	100	100	0.142	0.096	0.161	0.000	28.723	269.339	1.827	30.808	294.629	0.843	0.000	91.206	0.000	0.025	0.040	0.000
sp093	Spring	1965+00	0.157	0	273	273	0.319	0.150	0.263	0.000	55.026	314.851	2.772	40.499	328.027	1.068	0.295	98.474	0.355	0.032	0.048	0.001
sp097	Spring	1972+00	0.132	0	231	231	0.275	0.137	0.238	0.000	48.568	303.676	2.540	38.120	319.827	1.013	0.199	96.690	0.000	0.031	0.046	0.001
sp098	Spring	1974+00	0.141	0	246	246	0.291	0.142	0.247	0.000	50.958	307.813	2.626	39.000	322.862	1.033	0.234	97.350	0.000	0.031	0.047	0.001
sp099	Spring	1975+00	0.069	0	121	121	0.164	0.102	0.174	0.000	31.923	274.876	1.942	31.987	298.692	0.871	0.000	92.090	0.000	0.026	0.041	0.000
sp107	Spring	1984+50	0.262	0	458	458	0.507	0.209	0.370	100.569	83.123	363.466	3.781	50.851	363.703	1.308	0.711	106.238	3.978	0.040	0.056	0.001
sp115	Spring	2117+00	0.270	0	471	471	0.520	0.213	0.378	108.575	85.055	366.808	3.850	51.562	366.156	1.325	0.739	106.772	4.227	0.041	0.056	0.001
sp120	Spring	2139+00	0.133	0	233	233	0.277	0.138	0.239	0.000	48.881	304.218	2.551	38.235	320.224	1.016	0.204	96.776	0.000	0.031	0.046	0.001
sp121	Spring	2140+00	0.022	0	38	38	0.079	0.076	0.125	0.000	19.295	253.027	1.488	27.335	282.658	0.763	0.000	88.601	0.000	0.023	0.038	0.000
sp122	Spring	2143+00	0.247	0	430	430	0.479	0.200	0.354	83.203	78.933	356.217	3.630	49.307	358.383	1.273	0.649	105.080	3.437	0.039	0.055	0.001
sp125	Spring	2145+50	0.164	0	286	286	0.331	0.154	0.270	0.000	56.907	318.106	2.839	41.192	330.416	1.084	0.323	98.994	0.597	0.033	0.048	0.001
sp127	Spring	2146+00	0.164	0	286	286	0.331	0.154	0.270	0.000	56.907	318.106	2.839	41.192	330.416	1.084	0.323	98.994	0.597	0.033	0.048	0.001
sp128	Spring	2148+00	0.164	0	286	286	0.331	0.154	0.270	0.000	56.907	318.106	2.839	41.192	330.416	1.084	0.323	98.994	0.597	0.033	0.048	0.001
sp136	Spring	2162+00	0.028	0	49	49	0.090	0.079	0.131	0.000	20.903	255.809	1.546	27.927	284.700	0.776	0.000	89.046	0.000	0.023	0.038	0.000

INPUT FOR TABLE #1 AND TABLE #2			
T =	20	days	Days between events, 20 days is maximum
ADT =	70000	veh/day	ADT in design year
K (1) =	143.6	lb/mi-day	Pollutant accumulation rate
K (2) =	6.5		Wash-off coefficient for urban areas (Type II)
Rain Volume =	1.21	in	Volume of rainfall for 1 year-1 hour (NOAA)
Rain Duration =	1	hr	Duration of rainfall for 1 year-1 hour (NOAA)
r =	1.21	in/hr	Run off rate

Table 1 Regression Equations					
Site Type	II				
Constituent	A	B	Constituent	A	B
Lead	1.02E-03	0.04	TPO4	2.25E-03	-0.32
Copper	3.16E-04	0.064	CL-	0.042	87
Zinc	5.84E-04	0.103	Fe	1.96E-02	-5
TSS	0.63	-188	Cd	4.16E-05	0.021
VSS	0.152	13.5	Cr	4.30E-05	0.036
TVS	0.263	243	Hg	2.44E-06	1.01E-06
TKN	5.46E-03	1.28			
TOC	5.60E-02	25.2			
COD	0.193	275.3			
TN	1.30E-03	0.713			

Table #1-5: 1-Year/1-Hour Pollutant Mass Loading of Karst Features for Post-Construction (Proposed) Conditions - Preferred Alternative #8

ID	Type	Approx. Station	Length of R/W in Drainage Area	Initial TS Load before Event (Po)	TS Load after Event (P)	TS Load at Discharge (Pd)	*Mass Load per Rain Event (Highway)*															
							Lead	Copper	Zinc	TSS	VSS	TVS	TKN	TOC	COD	TN	TPO4	CL-	Fe	Cd	Cr	Hg
		(feet)	(mi)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)
i015	sinkhole	1577+50	0.069	0	199	199	0.243	0.127	0.219	0.000	43.764	295.365	2.367	36.350	313.728	0.972	0.128	95.363	0.000	0.029	0.045	0.000
i219	sinkhole	1557+50	0.085	0	245	244	0.289	0.141	0.246	0.000	50.653	307.285	2.615	38.888	322.475	1.031	0.230	97.266	0.000	0.031	0.047	0.001
i020	sinkhole	1590+00	0.231	0	665	664	0.718	0.274	0.491	230.552	114.484	417.729	4.907	62.405	403.523	1.577	1.175	114.903	8.022	0.049	0.065	0.002
i023	sinkhole	1597+50	0.095	0	272	272	0.317	0.150	0.262	0.000	54.828	314.509	2.765	40.426	327.776	1.066	0.292	98.420	0.329	0.032	0.048	0.001
i017	sinkhole	1575+00	0.278	0	798	797	0.853	0.316	0.569	314.354	134.703	452.713	5.634	69.854	429.196	1.750	1.474	120.490	10.629	0.054	0.070	0.002
i025	sinkhole	1599+00	0.193	0	553	553	0.604	0.239	0.426	160.560	97.597	388.510	4.301	56.183	382.081	1.432	0.925	110.237	5.844	0.044	0.060	0.001
i050	sinkhole	1605+00	0.078	0	225	225	0.269	0.135	0.234	0.000	47.665	302.114	2.507	37.787	318.681	1.005	0.186	96.440	0.000	0.030	0.046	0.001
i168	sinkhole	1588+00	0.325	0	934	934	0.992	0.359	0.648	400.222	155.420	488.559	6.378	77.486	455.501	1.927	1.781	126.215	13.300	0.060	0.076	0.002
i024	sinkhole	1596+00	0.114	0	327	326	0.373	0.167	0.294	17.638	63.114	328.846	3.062	43.479	338.297	1.137	0.414	100.709	1.398	0.035	0.050	0.001
i387	sinkhole	1580+00	0.032	0	93	93	0.135	0.093	0.157	0.000	27.598	267.393	1.786	30.394	293.200	0.834	0.000	90.895	0.000	0.025	0.040	0.000
i379	sinkhole	1570+00	0.336	0	964	964	1.023	0.369	0.666	419.333	160.031	496.537	6.544	79.185	461.356	1.966	1.849	127.489	13.895	0.061	0.077	0.002
i412	sinkhole	1715+00	0.093	0	268	268	0.313	0.149	0.260	0.000	54.245	313.499	2.744	40.211	327.035	1.061	0.283	98.258	0.254	0.032	0.048	0.001
i042	sinkhole	1712+10	0.129	0	371	371	0.418	0.181	0.320	45.696	69.884	340.559	3.305	45.973	346.893	1.195	0.515	102.580	2.271	0.036	0.052	0.001
i040	sinkhole	1777+50	0.414	0	1,188	1,187	1.251	0.439	0.796	560.059	193.984	555.285	7.763	91.694	504.467	2.257	2.352	136.871	18.273	0.070	0.087	0.003
i426	sinkhole	1788+00	0.167	0	480	480	0.529	0.216	0.383	114.226	86.418	369.168	3.899	52.065	367.887	1.337	0.759	107.148	4.403	0.041	0.057	0.001
i044	sinkhole	1800+00	0.201	0	577	577	0.629	0.246	0.440	175.684	101.246	394.823	4.432	57.527	386.714	1.463	0.979	111.246	6.315	0.045	0.061	0.001
i430	sinkhole	1794+50	0.087	0	250	249	0.294	0.143	0.249	0.000	51.415	308.602	2.642	39.169	323.442	1.037	0.241	97.476	0.000	0.031	0.047	0.001
i182	sinkhole	1868+00	0.042	0	121	121	0.163	0.102	0.173	0.000	31.824	274.705	1.938	31.951	298.566	0.870	0.000	92.063	0.000	0.026	0.041	0.000
i205	sinkhole	1869+00	0.018	0	53	53	0.094	0.081	0.134	0.000	21.527	256.889	1.568	28.157	285.493	0.782	0.000	89.218	0.000	0.023	0.038	0.000
i116	sinkhole	1905+00	0.242	0	694	694	0.747	0.283	0.508	248.912	118.914	425.393	5.067	64.037	409.148	1.615	1.240	116.127	8.593	0.050	0.066	0.002
i174	sinkhole	1936+00	0.129	0	371	371	0.418	0.181	0.319	45.504	69.838	340.479	3.304	45.956	346.834	1.195	0.514	102.567	2.265	0.036	0.052	0.001
i192	sinkhole	2131+00	0.162	0	464	464	0.514	0.211	0.374	104.456	84.061	365.089	3.815	51.196	364.894	1.316	0.724	106.497	4.099	0.040	0.056	0.001
i252	sinkhole	2129+00	0.034	0	98	98	0.140	0.095	0.160	0.000	28.329	268.658	1.813	30.663	294.129	0.840	0.000	91.098	0.000	0.025	0.040	0.000
i269	sinkhole	2139+00	0.043	0	123	123	0.165	0.103	0.175	0.000	32.198	275.353	1.952	32.089	299.042	0.873	0.000	92.167	0.000	0.026	0.041	0.000
i054	sinkhole	2155+00	0.136	0	390	390	0.438	0.187	0.331	57.682	72.776	345.563	3.409	47.038	350.565	1.220	0.557	103.379	2.643	0.037	0.053	0.001
i048	sinkhole	2153+00	0.059	0	169	169	0.212	0.117	0.202	0.000	39.203	287.474	2.203	34.670	307.937	0.933	0.060	94.102	0.000	0.028	0.043	0.000
i078	sinkhole	2149+00	0.106	0	305	305	0.351	0.160	0.281	4.226	59.878	323.247	2.946	42.287	334.188	1.110	0.367	99.815	0.980	0.034	0.049	0.001
i055	sinkhole	2192+50	0.091	0	262	261	0.307	0.147	0.256	0.000	53.238	311.757	2.707	39.840	325.756	1.053	0.268	97.980	0.124	0.032	0.047	0.001
i049	sinkhole	2185+00	0.201	0	576	576	0.627	0.246	0.439	174.846	101.044	394.474	4.425	57.453	386.458	1.462	0.976	111.190	6.289	0.045	0.061	0.001
i084	sinkhole	2197+50	0.056	0	162	162	0.205	0.115	0.197	0.000	38.062	285.498	2.162	34.249	306.487	0.923	0.044	93.787	0.000	0.028	0.043	0.000
i064	sinkhole	2209+00	0.118	0	338	338	0.384	0.171	0.300	24.670	64.811	331.781	3.123	44.104	340.451	1.152	0.440	101.178	1.616	0.035	0.051	0.001
i194	sinkhole	2244+00	0.111	0	319	319	0.365	0.165	0.289	12.665	61.915	326.770	3.019	43.037	336.774	1.127	0.397	100.378	1.243	0.034	0.050	0.001
b16	Buried Sink	1694+00	0.131	0	377	377	0.425	0.183	0.323	49.696	70.849	342.228	3.340	46.329	348.118	1.203	0.529	102.846	2.395	0.037	0.052	0.001
b03	Buried Sink	1652+50	0.088	0	254	254	0.299	0.144	0.251	0.000	52.064	309.726	2.665	39.408	324.266	1.043	0.251	97.656	0.000	0.032	0.047	0.001
b06	Buried Sink	1672+50	0.069	0	197	197	0.241	0.126	0.218	0.000	43.465	294.847	2.356	36.240	313.348	0.969	0.124	95.280	0.000	0.029	0.044	0.000
b10	Buried Sink	1677+00	0.063	0	181	180	0.224	0.121	0.208	0.000	40.931	290.463	2.265	35.306	310.130	0.948	0.086	94.580	0.000	0.029	0.044	0.000
b09	Buried Sink	1675+50	0.057	0	164	163	0.207	0.116	0.198	0.000	38.349	285.995	2.173	34.355	306.851	0.926	0.048	93.866	0.000	0.028	0.043	0.000
b08	Buried Sink	1675+00	0.052	0	150	150	0.193	0.111	0.191	0.000	36.310	282.467	2.099	33.604	304.262	0.908	0.018	93.303	0.000	0.027	0.042	0.000
b12	Buried Sink	1681+00	0.079	0	228	228	0.273	0.136	0.236	0.000	48.190	303.022	2.526	37.980	319.347	1.010	0.193	96.585	0.000	0.030	0.046	0.001
b15	Buried Sink	1685+00	0.060	0	173	173	0.217	0.119	0.204	0.000	39.852	288.597	2.227	34.909	308.761	0.938	0.070	94.282	0.000	0.028	0.043	0.000
b18	Buried Sink	1697+50	0.050	0	145	145	0.188	0.110	0.187	0.000	35.487	281.043	2.070	33.300	303.218	0.901	0.005	93.075	0.000	0.027	0.042	0.000
b17	Buried Sink	1695+00	0.086	0	247	247	0.292	0.142	0.247	0.000	51.052	307.974	2.629	39.035	322.981	1.034	0.236	97.376	0.000	0.031	0.047	0.001
b19	Buried Sink	1718+00	0.080	0	231	231	0.275	0.137	0.238	0.000	48.577	303.692	2.540	38.123	319.838	1.013	0.199	96.692	0.000	0.031	0.046	0.001
b20	Buried Sink	1787+00	0.063	0	180	180	0.224	0.121	0.208	0.000	40.858	290.337	2.263	35.279	310.038	0.947	0.085	94.560	0.000	0.028	0.044	0.000
sp021	Spring	1757+00	0.079	0	226	226	0.270	0.135	0.235	0.000	47.840	302.417	2.514	37.852	318.903	1.007	0.188	96.489	0.000	0.030	0.046	0.001
sp025	Spring	1583+00	0.198	0	567	567	0.619	0.243	0.434	169.374	99.724	392.189	4.377	56.967	384.781	1.450	0.956	110.825	6.118	0.045	0.060	0.001
sp026	Spring	1583+50	0.198	0	567	567	0.619	0.243	0.434	169.374	99.724	392.189	4.377	56.967	384.781	1.450	0.956	110.825	6.118	0.045	0.060	0.001
sp028	Spring	1585+00	0.198	0	567	567	0.619	0.243	0.434	169.374	99.724	392.189	4.377	56.967	384.781	1.450	0.956	110.825	6.118	0.045	0.060	0.001

sp032	Spring	1585+00	0.294	0	843	843	0.900	0.330	0.595	343.071	141.631	464.701	5.883	72.406	437.993	1.809	1.577	122.405	11.522	0.056	0.072	0.002
sp055	Spring	1791+00	0.294	0	843	843	0.900	0.330	0.595	343.052	141.627	464.693	5.882	72.405	437.987	1.809	1.577	122.403	11.522	0.056	0.072	0.002
sp071	Spring	1895+00	0.467	0	1,341	1,341	1.407	0.488	0.886	656.520	217.257	595.554	8.599	100.268	534.018	2.456	2.696	143.301	21.274	0.077	0.094	0.003
sp077	Spring	1923+00	0.135	0	388	388	0.435	0.186	0.329	56.215	72.422	344.950	3.397	46.908	350.115	1.217	0.552	103.281	2.598	0.037	0.053	0.001
sp083	Spring	1939+50	0.057	0	165	165	0.208	0.116	0.199	0.000	38.509	286.272	2.178	34.414	307.055	0.927	0.050	93.910	0.000	0.028	0.043	0.000
sp093	Spring	1965+00	0.150	0	431	431	0.479	0.200	0.355	83.350	78.969	356.278	3.632	49.320	358.428	1.273	0.649	105.090	3.442	0.039	0.055	0.001
sp097	Spring	1972+50	0.133	0	382	382	0.430	0.185	0.326	52.597	71.549	343.440	3.365	46.586	349.007	1.209	0.539	103.040	2.485	0.037	0.052	0.001
sp098	Spring	1973+50	0.162	0	465	465	0.514	0.211	0.375	105.058	84.206	365.340	3.820	51.250	365.078	1.318	0.727	106.537	4.117	0.040	0.056	0.001
sp099	Spring	1974+00	0.037	0	106	106	0.148	0.098	0.165	0.000	29.649	270.942	1.860	31.150	295.805	0.851	0.000	91.462	0.000	0.025	0.041	0.000
sp105	Spring	1982+00	0.030	0	86	86	0.128	0.091	0.153	0.000	26.594	265.656	1.750	30.024	291.926	0.825	0.000	90.618	0.000	0.025	0.040	0.000
sp106	Spring	1923+00	0.030	0	86	86	0.128	0.091	0.153	0.000	26.594	265.656	1.750	30.024	291.926	0.825	0.000	90.618	0.000	0.025	0.040	0.000
sp107	Spring	1985+00	0.070	0	201	201	0.245	0.128	0.220	0.000	44.052	295.863	2.377	36.456	314.093	0.974	0.132	95.442	0.000	0.029	0.045	0.000
sp110	Spring	1991+00	0.080	0	230	230	0.274	0.137	0.237	0.000	48.417	303.415	2.534	38.064	319.635	1.012	0.197	96.648	0.000	0.031	0.046	0.001
sp112	Spring	2110+50	0.110	0	316	316	0.362	0.164	0.287	10.990	61.510	326.071	3.005	42.888	336.260	1.124	0.391	100.266	1.191	0.034	0.050	0.001
sp115	Spring	2122+50	0.269	0	774	773	0.829	0.308	0.555	299.293	131.069	446.425	5.503	68.515	424.582	1.719	1.420	119.486	10.160	0.053	0.069	0.002
sp120	Spring	2140+00	0.150	0	431	431	0.479	0.200	0.355	83.350	78.969	356.278	3.632	49.320	358.428	1.273	0.649	105.090	3.442	0.039	0.055	0.001
sp121	Spring	2110+00	0.020	0	57	57	0.099	0.082	0.137	0.000	22.229	258.104	1.594	28.416	286.384	0.788	0.000	89.412	0.000	0.023	0.038	0.000
sp122	Spring	2141+00	0.056	0	161	161	0.204	0.115	0.197	0.000	37.960	285.323	2.159	34.212	306.358	0.922	0.042	93.759	0.000	0.028	0.043	0.000
sp124	Spring	2144+00	0.080	0	230	230	0.274	0.137	0.237	0.000	48.417	303.415	2.534	38.064	319.635	1.012	0.197	96.648	0.000	0.031	0.046	0.001
sp125	Spring	2145+00	0.220	0	632	632	0.684	0.264	0.472	209.980	109.521	409.141	4.729	60.576	397.221	1.534	1.101	113.532	7.382	0.047	0.063	0.002
sp127	Spring	2146+00	0.270	0	776	775	0.831	0.309	0.556	300.431	131.344	446.900	5.513	68.616	424.930	1.721	1.424	119.562	10.196	0.053	0.069	0.002
sp128	Spring	2148+00	0.270	0	776	775	0.831	0.309	0.556	300.431	131.344	446.900	5.513	68.616	424.930	1.721	1.424	119.562	10.196	0.053	0.069	0.002
sp136	Spring	2161+50	0.030	0	86	86	0.128	0.091	0.153	0.000	26.594	265.656	1.750	30.024	291.926	0.825	0.000	90.618	0.000	0.025	0.040	0.000
sp167	Spring	2287+00	0.030	0	86	86	0.128	0.091	0.153	0.000	26.594	265.656	1.750	30.024	291.926	0.825	0.000	90.618	0.000	0.025	0.040	0.000

INPUT FOR TABLE #1 AND TABLE #2			
T =	20	days	Days between events, 20 days is maximum
ADT =	70000	veh/day	ADT in design year
K (1) =	143.6	lb/mi-day	Pollutant accumulation rate
K (2) =	6.5	0	Wash-off coefficient for urban areas (Type II)
Rain Volume =	3.16	in	Volume of rainfall for 2-year/24-hour (NOAA)
Rain Duration =	24	hr	Duration of rainfall for 2-year/24-hour (NOAA)
r =	0.13	in/hr	Run off rate

Table 1 Regression Equations					
Site Type	II	0			
Constituent	A	B	Constituent	A	B
Lead	1.02E-03	0.04	TPO4	2.25E-03	-0.32
Copper	3.16E-04	0.064	CL-	0.042	87
Zinc	5.84E-04	0.103	Fe	1.96E-02	-5
TSS	0.63	-188	Cd	4.16E-05	0.021
VSS	0.152	13.5	Cr	4.30E-05	0.036
TVS	0.263	243	Hg	2.44E-06	1.01E-06
TKN	5.46E-03	1.28	0	0.00E+00	0
TOC	5.60E-02	25.2	0	0	0
COD	0.193	275.3	0	0	0
TN	1.30E-03	0.713	0	0.00E+00	0

Table #1-6: 2-Year/24-Hour Pollutant Mass Loading of Karst Features for Post-Construction (Proposed) Conditions - Preferred Alternative #8

ID	Type	Approx. Station	Length of R/W in Drainage Area	Initial TS Load before Event (Po)	TS Load after Event (P)	TS Load at Discharge (Pd)	*Mass Load per Rain Event (Highway)*															
							Lead	Copper	Zinc	TSS	VSS	TVS	TKN	TOC	COD	TN	TPO4	CL-	Fe	Cd	Cr	Hg
		(feet)	(mi)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)
i015	sinkhole	1577+50	0.069	0	199	115	0.157	0.100	0.170	0.000	30.911	273.125	1.905	31.615	297.407	0.862	0.000	91.811	0.000	0.026	0.041	0.000
i219	sinkhole	1557+50	0.085	0	245	141	0.183	0.108	0.185	0.000	34.874	279.983	2.048	33.075	302.439	0.896	0.000	92.906	0.000	0.027	0.042	0.000
i020	sinkhole	1590+00	0.231	0	665	382	0.430	0.185	0.326	52.790	71.595	343.520	3.367	46.604	349.066	1.210	0.540	103.053	2.491	0.037	0.052	0.001
i023	sinkhole	1597+50	0.095	0	272	156	0.200	0.113	0.194	0.000	37.276	284.138	2.134	33.959	305.489	0.916	0.032	93.570	0.000	0.028	0.043	0.000
i017	sinkhole	1575+00	0.278	0	798	459	0.508	0.209	0.371	101.000	83.227	363.646	3.785	50.889	363.835	1.309	0.712	106.267	3.991	0.040	0.056	0.001
i025	sinkhole	1599+00	0.193	0	553	318	0.365	0.165	0.289	12.524	61.880	326.711	3.018	43.024	336.730	1.127	0.396	100.368	1.239	0.034	0.050	0.001
i050	sinkhole	1605+00	0.078	0	225	129	0.172	0.105	0.179	0.000	33.155	277.008	1.986	32.441	300.257	0.881	0.000	92.431	0.000	0.026	0.042	0.000
i168	sinkhole	1588+00	0.325	0	934	537	0.588	0.234	0.417	150.400	95.146	384.268	4.213	55.280	378.968	1.411	0.889	109.560	5.528	0.043	0.059	0.001
i024	sinkhole	1596+00	0.114	0	327	188	0.232	0.123	0.213	0.000	42.043	292.386	2.305	35.716	311.542	0.957	0.103	94.887	0.000	0.029	0.044	0.000
i387	sinkhole	1580+00	0.032	0	93	53	0.094	0.081	0.134	0.000	21.610	257.033	1.571	28.188	285.598	0.782	0.000	89.241	0.000	0.023	0.038	0.000
i379	sinkhole	1570+00	0.336	0	964	555	0.606	0.239	0.427	161.394	97.798	388.858	4.308	56.257	382.336	1.434	0.928	110.293	5.870	0.044	0.060	0.001
i412	sinkhole	1715+00	0.093	0	268	154	0.197	0.113	0.193	0.000	36.940	283.557	2.122	33.836	305.063	0.913	0.027	93.477	0.000	0.027	0.043	0.000
i042	sinkhole	1712+10	0.129	0	371	213	0.258	0.131	0.228	0.000	45.937	299.125	2.445	37.151	316.487	0.990	0.160	95.963	0.000	0.030	0.045	0.001
i040	sinkhole	1777+50	0.414	0	1,188	683	0.737	0.280	0.502	242.352	117.331	422.655	5.010	63.454	407.138	1.601	1.217	115.690	8.389	0.049	0.065	0.002
i426	sinkhole	1788+00	0.167	0	480	276	0.322	0.151	0.264	0.000	55.449	315.583	2.787	40.655	328.564	1.072	0.301	98.591	0.409	0.032	0.048	0.001
i044	sinkhole	1800+00	0.201	0	577	332	0.379	0.169	0.297	21.224	63.979	330.343	3.093	43.798	339.396	1.145	0.427	100.948	1.509	0.035	0.050	0.001
i430	sinkhole	1794+50	0.087	0	250	143	0.186	0.109	0.187	0.000	35.312	280.740	2.064	33.236	302.995	0.900	0.003	93.027	0.000	0.027	0.042	0.000
i182	sinkhole	1868+00	0.042	0	121	69	0.111	0.086	0.144	0.000	24.042	261.240	1.659	29.084	288.685	0.803	0.000	89.913	0.000	0.024	0.039	0.000
i205	sinkhole	1869+00	0.018	0	53	30	0.071	0.074	0.121	0.000	18.118	250.990	1.446	26.901	281.164	0.752	0.000	88.276	0.000	0.022	0.037	0.000
i116	sinkhole	1905+00	0.242	0	694	399	0.447	0.190	0.336	63.352	74.144	347.929	3.458	47.542	352.301	1.232	0.578	103.757	2.820	0.038	0.053	0.001
i174	sinkhole	1936+00	0.129	0	371	213	0.257	0.131	0.228	0.000	45.911	299.079	2.444	37.141	316.453	0.990	0.160	95.956	0.000	0.030	0.045	0.001
i192	sinkhole	2131+00	0.162	0	464	267	0.312	0.148	0.259	0.000	54.093	313.237	2.738	40.155	326.843	1.060	0.281	98.217	0.234	0.032	0.047	0.001
i252	sinkhole	2129+00	0.034	0	98	56	0.097	0.082	0.136	0.000	22.031	257.761	1.586	28.343	286.132	0.786	0.000	89.357	0.000	0.023	0.038	0.000
i269	sinkhole	2139+00	0.043	0	123	71	0.112	0.086	0.144	0.000	24.257	261.612	1.666	29.163	288.959	0.805	0.000	89.972	0.000	0.024	0.039	0.000
i054	sinkhole	2155+00	0.136	0	390	224	0.269	0.135	0.234	0.000	47.601	302.003	2.505	37.763	318.599	1.005	0.185	96.423	0.000	0.030	0.046	0.001
i048	sinkhole	2153+00	0.059	0	169	97	0.139	0.095	0.160	0.000	28.287	268.585	1.811	30.648	294.076	0.839	0.000	91.086	0.000	0.025	0.040	0.000
i078	sinkhole	2149+00	0.106	0	305	176	0.219	0.119	0.206	0.000	40.181	289.165	2.238	35.030	309.178	0.941	0.075	94.372	0.000	0.028	0.044	0.000
i055	sinkhole	2192+50	0.091	0	262	150	0.193	0.112	0.191	0.000	36.361	282.555	2.101	33.622	304.327	0.909	0.018	93.317	0.000	0.027	0.042	0.000
i049	sinkhole	2185+00	0.201	0	576	331	0.378	0.169	0.297	20.742	63.863	330.142	3.089	43.755	339.248	1.144	0.426	100.916	1.494	0.035	0.050	0.001
i084	sinkhole	2197+50	0.056	0	162	93	0.135	0.093	0.157	0.000	27.630	267.449	1.788	30.406	293.242	0.834	0.000	90.904	0.000	0.025	0.040	0.000
i064	sinkhole	2209+00	0.118	0	338	194	0.238	0.125	0.216	0.000	43.019	294.075	2.340	36.075	312.781	0.965	0.117	95.156	0.000	0.029	0.044	0.000
i194	sinkhole	2244+00	0.111	0	319	183	0.227	0.122	0.210	0.000	41.352	291.192	2.280	35.461	310.665	0.951	0.092	94.696	0.000	0.029	0.044	0.000
b16	Buried Sink	1694+00	0.131	0	377	217	0.261	0.133	0.230	0.000	46.492	300.085	2.465	37.355	317.192	0.995	0.168	96.116	0.000	0.030	0.045	0.001
b03	Buried Sink	1652+50	0.088	0	254	146	0.189	0.110	0.188	0.000	35.686	281.387	2.077	33.374	303.470	0.903	0.008	93.130	0.000	0.027	0.042	0.000
b06	Buried Sink	1672+50	0.069	0	197	113	0.156	0.100	0.169	0.000	30.739	272.827	1.899	31.551	297.189	0.860	0.000	91.763	0.000	0.026	0.041	0.000
b10	Buried Sink	1677+00	0.063	0	181	104	0.146	0.097	0.164	0.000	29.281	270.305	1.847	31.014	295.337	0.848	0.000	91.360	0.000	0.025	0.040	0.000
b09	Buried Sink	1675+50	0.057	0	164	94	0.136	0.094	0.158	0.000	27.795	267.735	1.794	30.467	293.451	0.835	0.000	90.950	0.000	0.025	0.040	0.000
b08	Buried Sink	1675+00	0.052	0	150	86	0.128	0.091	0.153	0.000	26.622	265.705	1.751	30.035	291.962	0.825	0.000	90.626	0.000	0.025	0.040	0.000
b12	Buried Sink	1681+00	0.079	0	228	131	0.174	0.105	0.180	0.000	33.457	277.530	1.997	32.552	300.640	0.884	0.000	92.514	0.000	0.026	0.042	0.000
b15	Buried Sink	1685+00	0.060	0	173	100	0.142	0.096	0.161	0.000	28.660	269.231	1.825	30.785	294.550	0.843	0.000	91.189	0.000	0.025	0.040	0.000
b18	Buried Sink	1697+50	0.050	0	145	83	0.125	0.090	0.152	0.000	26.149	264.886	1.734	29.860	291.361	0.821	0.000	90.495	0.000	0.024	0.040	0.000
b17	Buried Sink	1695+00	0.086	0	247	142	0.185	0.109	0.186	0.000	35.103	280.379	2.056	33.159	302.730	0.898	0.000	92.969	0.000	0.027	0.042	0.000
b19	Buried Sink	1718+00	0.080	0	231	133	0.175	0.106	0.181	0.000	33.679	277.916	2.005	32.635	300.923	0.886	0.000	92.576	0.000	0.027	0.042	0.000
b20	Buried Sink	1787+00	0.063	0	180	104	0.146	0.097	0.163	0.000	29.239	270.233	1.845	30.999	295.285	0.848	0.000	91.349	0.000	0.025	0.040	0.000
sp021	Spring	1757+00	0.079	0	226	130	0.173	0.105	0.179	0.000	33.256	277.182	1.990	32.478	300.384	0.882	0.000	92.459	0.000	0.026	0.042	0.000
sp025	Spring	1583+00	0.198	0	567	326	0.373	0.167	0.294	17.594	63.104	328.827	3.062	43.475	338.284	1.137	0.414	100.706	1.396	0.035	0.050	0.001
sp026	Spring	1583+50	0.198	0	567	326	0.373	0.167	0.294	17.594	63.104	328.827	3.062	43.475	338.284	1.137	0.414	100.706	1.396	0.035	0.050	0.001
sp028	Spring	1585+00	0.198	0	567	326	0.373	0.167	0.294	17.594	63.104	328.827	3.062	43.475	338.284	1.137	0.414	100.706	1.396	0.035	0.050	0.001

sp032	Spring	1585+00	0.294	0	843	485	0.535	0.217	0.386	117.521	87.213	370.543	3.928	52.357	368.896	1.343	0.771	107.368	4.505	0.041	0.057	0.001
sp055	Spring	1791+00	0.294	0	843	485	0.535	0.217	0.386	117.510	87.210	370.538	3.928	52.356	368.893	1.343	0.771	107.367	4.505	0.041	0.057	0.001
sp071	Spring	1895+00	0.467	0	1,341	771	0.827	0.308	0.553	297.846	130.720	445.821	5.491	68.386	424.138	1.716	1.415	119.390	10.115	0.053	0.069	0.002
sp077	Spring	1923+00	0.135	0	388	223	0.267	0.134	0.233	0.000	47.397	301.651	2.498	37.688	318.341	1.003	0.182	96.366	0.000	0.030	0.046	0.001
sp083	Spring	1939+50	0.057	0	165	95	0.137	0.094	0.158	0.000	27.887	267.894	1.797	30.501	293.568	0.836	0.000	90.975	0.000	0.025	0.040	0.000
sp093	Spring	1965+00	0.150	0	431	248	0.293	0.142	0.248	0.000	51.164	308.168	2.633	39.076	323.123	1.035	0.238	97.407	0.000	0.031	0.047	0.001
sp097	Spring	1972+50	0.133	0	382	220	0.264	0.133	0.231	0.000	46.895	300.782	2.480	37.503	317.703	0.999	0.174	96.228	0.000	0.030	0.045	0.001
sp098	Spring	1973+50	0.162	0	465	268	0.313	0.149	0.259	0.000	54.177	313.381	2.741	40.186	326.949	1.061	0.282	98.240	0.245	0.032	0.048	0.001
sp099	Spring	1974+00	0.037	0	106	61	0.102	0.083	0.139	0.000	22.790	259.075	1.614	28.623	287.096	0.792	0.000	89.567	0.000	0.024	0.039	0.000
sp105	Spring	1982+00	0.030	0	86	50	0.091	0.080	0.132	0.000	21.033	256.034	1.551	27.975	284.865	0.777	0.000	89.081	0.000	0.023	0.038	0.000
sp106	Spring	1923+00	0.030	0	86	50	0.091	0.080	0.132	0.000	21.033	256.034	1.551	27.975	284.865	0.777	0.000	89.081	0.000	0.023	0.038	0.000
sp107	Spring	1985+00	0.070	0	201	116	0.158	0.101	0.171	0.000	31.076	273.412	1.911	31.675	297.617	0.863	0.000	91.857	0.000	0.026	0.041	0.000
sp110	Spring	1991+00	0.080	0	230	132	0.175	0.106	0.180	0.000	33.587	277.756	2.002	32.601	300.806	0.885	0.000	92.550	0.000	0.026	0.042	0.000
sp112	Spring	2110+50	0.110	0	316	182	0.225	0.121	0.209	0.000	41.120	290.790	2.272	35.376	310.370	0.949	0.089	94.632	0.000	0.029	0.044	0.000
sp115	Spring	2122+50	0.269	0	774	445	0.494	0.205	0.363	92.336	81.137	360.029	3.710	50.119	361.181	1.291	0.681	105.689	3.722	0.040	0.055	0.001
sp120	Spring	2140+00	0.150	0	431	248	0.293	0.142	0.248	0.000	51.164	308.168	2.633	39.076	323.123	1.035	0.238	97.407	0.000	0.031	0.047	0.001
sp121	Spring	2110+00	0.020	0	57	33	0.074	0.074	0.122	0.000	18.522	251.689	1.460	27.050	281.676	0.756	0.000	88.388	0.000	0.022	0.037	0.000
sp122	Spring	2141+00	0.056	0	161	93	0.134	0.093	0.157	0.000	27.572	267.348	1.785	30.384	293.168	0.833	0.000	90.888	0.000	0.025	0.040	0.000
sp124	Spring	2144+00	0.080	0	230	132	0.175	0.106	0.180	0.000	33.587	277.756	2.002	32.601	300.806	0.885	0.000	92.550	0.000	0.026	0.042	0.000
sp125	Spring	2145+00	0.220	0	632	363	0.411	0.179	0.315	40.955	68.740	338.580	3.264	45.552	345.440	1.185	0.498	102.264	2.123	0.036	0.052	0.001
sp127	Spring	2146+00	0.270	0	776	446	0.495	0.205	0.363	92.990	81.294	360.302	3.715	50.177	361.381	1.293	0.684	105.733	3.742	0.040	0.055	0.001
sp128	Spring	2148+00	0.270	0	776	446	0.495	0.205	0.363	92.990	81.294	360.302	3.715	50.177	361.381	1.293	0.684	105.733	3.742	0.040	0.055	0.001
sp136	Spring	2161+50	0.030	0	86	50	0.091	0.080	0.132	0.000	21.033	256.034	1.551	27.975	284.865	0.777	0.000	89.081	0.000	0.023	0.038	0.000
sp167	Spring	2287+00	0.030	0	86	50	0.091	0.080	0.132	0.000	21.033	256.034	1.551	27.975	284.865	0.777	0.000	89.081	0.000	0.023	0.038	0.000

INPUT FOR TABLE #1 AND TABLE #2			
T =	20	days	Days between events, 20 days is maximum
ADT =	70000	veh/day	ADT in design year
K (1) =	143.6	lb/mi-day	Pollutant accumulation rate
K (2) =	6.5		Wash-off coefficient for urban areas (Type II)
Rain Volume =	3.92	in	Volume of rainfall for 5-year/24-hour (NOAA)
Rain Duration =	24	hr	Duration of rainfall for 5-year/24-hour (NOAA)
r =	0.16	in/hr	Run off rate

Table 1 Regression Equations					
Site Type	II	0			
Constituent	A	B	Constituent	A	B
Lead	1.02E-03	0.04	TPO4	2.25E-03	-0.32
Copper	3.16E-04	0.064	CL-	0.042	87
Zinc	5.84E-04	0.103	Fe	1.96E-02	-5
TSS	0.63	-188	Cd	4.16E-05	0.021
VSS	0.152	13.5	Cr	4.30E-05	0.036
TVS	0.263	243	Hg	2.44E-06	1.01E-06
TKN	5.46E-03	1.28	0	0.00E+00	0
TOC	5.60E-02	25.2	0	0	0
COD	0.193	275.3	0	0	0
TN	1.30E-03	0.713	0	0.00E+00	0

Table #1-7: 5-Year/24-Hour Pollutant Mass Loading of Karst Features for Post-Construction (Proposed) Conditions - Preferred Alternative #8

ID	Type	Approx. Station	Length of R/W in Drainage Area	Initial TS Load before Event (Po)	TS Load after Event (P)	TS Load at Discharge (Pd)	*Mass Load per Rain Event (Highway)*															
							Lead	Copper	Zinc	TSS	VSS	TVS	TKN	TOC	COD	TN	TPO4	CL-	Fe	Cd	Cr	Hg
		(feet)	(mi)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)
i015	sinkhole	1577+50	0.069	0	199	130	0.173	0.105	0.179	0.000	33.304	277.266	1.991	32.496	300.446	0.882	0.000	92.472	0.000	0.026	0.042	0.000
i219	sinkhole	1557+50	0.085	0	245	160	0.203	0.115	0.196	0.000	37.812	285.066	2.153	34.157	306.170	0.921	0.040	93.718	0.000	0.028	0.043	0.000
i020	sinkhole	1590+00	0.231	0	665	435	0.483	0.201	0.357	85.889	79.581	357.338	3.654	49.546	359.206	1.278	0.658	105.259	3.521	0.039	0.055	0.001
i023	sinkhole	1597+50	0.095	0	272	178	0.221	0.120	0.207	0.000	40.544	289.793	2.251	35.164	309.639	0.944	0.080	94.473	0.000	0.028	0.044	0.000
i017	sinkhole	1575+00	0.278	0	798	522	0.572	0.229	0.408	140.727	92.812	380.230	4.129	54.420	376.005	1.391	0.854	108.915	5.227	0.043	0.058	0.001
i025	sinkhole	1599+00	0.193	0	553	362	0.409	0.178	0.314	40.088	68.531	338.218	3.257	45.475	345.175	1.184	0.495	102.206	2.096	0.036	0.052	0.001
i050	sinkhole	1605+00	0.078	0	225	147	0.190	0.110	0.189	0.000	35.857	281.683	2.083	33.437	303.687	0.904	0.011	93.177	0.000	0.027	0.042	0.000
i168	sinkhole	1588+00	0.325	0	934	611	0.663	0.257	0.460	196.916	106.369	403.687	4.616	59.415	393.219	1.507	1.055	112.661	6.975	0.046	0.062	0.001
i024	sinkhole	1596+00	0.114	0	327	214	0.258	0.131	0.228	0.000	45.966	299.175	2.446	37.161	316.524	0.991	0.161	95.971	0.000	0.030	0.045	0.001
i387	sinkhole	1580+00	0.032	0	93	61	0.102	0.083	0.138	0.000	22.725	258.962	1.611	28.599	287.013	0.792	0.000	89.549	0.000	0.024	0.039	0.000
i379	sinkhole	1570+00	0.336	0	964	631	0.683	0.263	0.471	209.422	109.386	408.908	4.724	60.526	397.050	1.533	1.099	113.495	7.364	0.047	0.063	0.002
i412	sinkhole	1715+00	0.093	0	268	175	0.219	0.119	0.205	0.000	40.162	289.133	2.238	35.023	309.154	0.941	0.075	94.367	0.000	0.028	0.044	0.000
i042	sinkhole	1712+10	0.129	0	371	243	0.288	0.141	0.245	0.000	50.396	306.840	2.605	38.793	322.148	1.029	0.226	97.195	0.000	0.031	0.046	0.001
i040	sinkhole	1777+50	0.414	0	1,188	777	0.833	0.310	0.557	301.509	131.604	447.351	5.522	68.712	425.261	1.723	1.428	119.634	10.229	0.053	0.069	0.002
i426	sinkhole	1788+00	0.167	0	480	314	0.360	0.163	0.286	9.769	61.216	325.561	2.994	42.779	335.886	1.121	0.386	100.185	1.153	0.034	0.049	0.001
i044	sinkhole	1800+00	0.201	0	577	378	0.425	0.183	0.324	49.984	70.918	342.349	3.343	46.354	348.206	1.204	0.530	102.866	2.404	0.037	0.052	0.001
i430	sinkhole	1794+50	0.087	0	250	163	0.206	0.116	0.198	0.000	38.310	285.928	2.171	34.341	306.803	0.925	0.047	93.855	0.000	0.028	0.043	0.000
i182	sinkhole	1868+00	0.042	0	121	79	0.120	0.089	0.149	0.000	25.491	263.747	1.711	29.618	290.525	0.816	0.000	90.313	0.000	0.024	0.039	0.000
i205	sinkhole	1869+00	0.018	0	53	35	0.075	0.075	0.123	0.000	18.753	252.089	1.469	27.135	281.970	0.758	0.000	88.451	0.000	0.022	0.037	0.000
i116	sinkhole	1905+00	0.242	0	694	454	0.503	0.207	0.368	97.903	82.480	362.353	3.758	50.614	362.886	1.303	0.701	106.060	3.895	0.040	0.056	0.001
i174	sinkhole	1936+00	0.129	0	371	243	0.287	0.141	0.245	0.000	50.366	306.787	2.604	38.782	322.110	1.028	0.226	97.187	0.000	0.031	0.046	0.001
i192	sinkhole	2131+00	0.162	0	464	304	0.350	0.160	0.280	3.375	59.673	322.892	2.939	42.211	333.928	1.108	0.363	99.758	0.954	0.034	0.049	0.001
i252	sinkhole	2129+00	0.034	0	98	64	0.105	0.084	0.140	0.000	23.204	259.790	1.629	28.775	287.621	0.796	0.000	89.681	0.000	0.024	0.039	0.000
i269	sinkhole	2139+00	0.043	0	123	80	0.122	0.089	0.150	0.000	25.736	264.171	1.720	29.708	290.836	0.818	0.000	90.381	0.000	0.024	0.039	0.000
i054	sinkhole	2155+00	0.136	0	390	255	0.300	0.145	0.252	0.000	52.288	310.114	2.673	39.490	324.551	1.045	0.254	97.718	0.002	0.032	0.047	0.001
i048	sinkhole	2153+00	0.059	0	169	111	0.153	0.099	0.168	0.000	30.320	272.102	1.884	31.397	296.656	0.857	0.000	91.648	0.000	0.026	0.041	0.000
i078	sinkhole	2149+00	0.106	0	305	200	0.244	0.127	0.220	0.000	43.849	295.511	2.370	36.381	313.835	0.973	0.129	95.386	0.000	0.029	0.045	0.000
i055	sinkhole	2192+50	0.091	0	262	171	0.214	0.118	0.203	0.000	39.503	287.992	2.214	34.780	308.317	0.935	0.065	94.185	0.000	0.028	0.043	0.000
i049	sinkhole	2185+00	0.201	0	576	377	0.424	0.183	0.323	49.436	70.786	342.120	3.338	46.305	348.038	1.203	0.528	102.829	2.387	0.037	0.052	0.001
i084	sinkhole	2197+50	0.056	0	162	106	0.148	0.097	0.165	0.000	29.572	270.810	1.857	31.121	295.708	0.850	0.000	91.441	0.000	0.025	0.041	0.000
i064	sinkhole	2209+00	0.118	0	338	221	0.265	0.134	0.232	0.000	47.076	301.096	2.486	37.570	317.933	1.000	0.177	96.278	0.000	0.030	0.045	0.001
i194	sinkhole	2244+00	0.111	0	319	208	0.253	0.130	0.225	0.000	45.181	297.817	2.418	36.872	315.527	0.984	0.149	95.754	0.000	0.030	0.045	0.001
b16	Buried Sink	1694+00	0.131	0	377	247	0.292	0.142	0.247	0.000	51.027	307.932	2.628	39.026	322.950	1.034	0.236	97.369	0.000	0.031	0.047	0.001
b03	Buried Sink	1652+50	0.088	0	254	166	0.209	0.116	0.200	0.000	38.735	286.664	2.186	34.497	307.342	0.929	0.054	93.973	0.000	0.028	0.043	0.000
b06	Buried Sink	1672+50	0.069	0	197	129	0.172	0.105	0.178	0.000	33.108	276.927	1.984	32.424	300.197	0.881	0.000	92.418	0.000	0.026	0.042	0.000
b10	Buried Sink	1677+00	0.063	0	181	118	0.160	0.101	0.172	0.000	31.450	274.058	1.925	31.813	298.092	0.867	0.000	91.960	0.000	0.026	0.041	0.000
b09	Buried Sink	1675+50	0.057	0	164	107	0.149	0.098	0.165	0.000	29.760	271.135	1.864	31.191	295.946	0.852	0.000	91.493	0.000	0.025	0.041	0.000
b08	Buried Sink	1675+00	0.052	0	150	98	0.140	0.095	0.160	0.000	28.426	268.826	1.816	30.699	294.252	0.841	0.000	91.124	0.000	0.025	0.040	0.000
b12	Buried Sink	1681+00	0.079	0	228	149	0.192	0.111	0.190	0.000	36.200	282.277	2.095	33.563	304.123	0.907	0.016	93.272	0.000	0.027	0.042	0.000
b15	Buried Sink	1685+00	0.060	0	173	113	0.156	0.100	0.169	0.000	30.744	272.837	1.899	31.553	297.196	0.860	0.000	91.765	0.000	0.026	0.041	0.000
b18	Buried Sink	1697+50	0.050	0	145	95	0.137	0.094	0.158	0.000	27.888	267.894	1.797	30.501	293.569	0.836	0.000	90.976	0.000	0.025	0.040	0.000
b17	Buried Sink	1695+00	0.086	0	247	162	0.205	0.115	0.197	0.000	38.073	285.517	2.163	34.253	306.501	0.923	0.044	93.790	0.000	0.028	0.043	0.000
b19	Buried Sink	1718+00	0.080	0	231	151	0.194	0.112	0.191	0.000	36.453	282.715	2.105	33.656	304.445	0.909	0.020	93.342	0.000	0.027	0.042	0.000
b20	Buried Sink	1787+00	0.063	0	180	118	0.160	0.101	0.172	0.000	31.403	273.976	1.923	31.796	298.032	0.866	0.000	91.947	0.000	0.026	0.041	0.000
sp021	Spring	1757+00	0.079	0	226	148	0.191	0.111	0.189	0.000	35.971	281.881	2.087	33.479	303.832	0.905	0.013	93.209	0.000	0.027	0.042	0.000
sp025	Spring	1583+00	0.198	0	567	371	0.419	0.181	0.320	45.856	69.922	340.625	3.307	45.987	346.941	1.196	0.515	102.590	2.276	0.036	0.052	0.001
sp026	Spring	1583+50	0.198	0	567	371	0.419	0.181	0.320	45.856	69.922	340.625	3.307	45.987	346.941	1.196	0.515	102.590	2.276	0.036	0.052	0.001
sp028	Spring	1585+00	0.198	0	567	371	0.419	0.181	0.320	45.856	69.922	340.625	3.307	45.987	346.941	1.196	0.515	102.590	2.276	0.036	0.052	0.001

sp032	Spring	1585+00	0.294	0	843	552	0.603	0.238	0.425	159.518	97.346	388.075	4.292	56.090	381.762	1.430	0.921	110.168	5.812	0.044	0.060	0.001
sp055	Spring	1791+00	0.294	0	843	552	0.603	0.238	0.425	159.506	97.343	388.070	4.292	56.089	381.758	1.430	0.921	110.167	5.811	0.044	0.060	0.001
sp071	Spring	1895+00	0.467	0	1,341	877	0.935	0.341	0.615	364.631	146.833	473.701	6.069	74.323	444.598	1.853	1.654	123.842	12.193	0.057	0.074	0.002
sp077	Spring	1923+00	0.135	0	388	254	0.299	0.144	0.251	0.000	52.057	309.713	2.665	39.405	324.257	1.043	0.251	97.654	0.000	0.032	0.047	0.001
sp083	Spring	1939+50	0.057	0	165	108	0.150	0.098	0.166	0.000	29.865	271.316	1.868	31.229	296.080	0.853	0.000	91.522	0.000	0.025	0.041	0.000
sp093	Spring	1965+00	0.150	0	431	282	0.327	0.153	0.268	0.000	56.341	317.126	2.819	40.983	329.697	1.079	0.314	98.838	0.524	0.033	0.048	0.001
sp097	Spring	1972+50	0.133	0	382	250	0.295	0.143	0.249	0.000	51.486	308.725	2.644	39.195	323.532	1.038	0.242	97.496	0.000	0.031	0.047	0.001
sp098	Spring	1973+50	0.162	0	465	304	0.350	0.160	0.281	3.769	59.768	323.056	2.942	42.246	334.048	1.109	0.365	99.785	0.966	0.034	0.049	0.001
sp099	Spring	1974+00	0.037	0	106	70	0.111	0.086	0.144	0.000	24.067	261.284	1.660	29.093	288.718	0.803	0.000	89.920	0.000	0.024	0.039	0.000
sp105	Spring	1982+00	0.030	0	86	56	0.097	0.082	0.136	0.000	22.068	257.825	1.588	28.357	286.179	0.786	0.000	89.368	0.000	0.023	0.038	0.000
sp106	Spring	1923+00	0.030	0	86	56	0.097	0.082	0.136	0.000	22.068	257.825	1.588	28.357	286.179	0.786	0.000	89.368	0.000	0.023	0.038	0.000
sp107	Spring	1985+00	0.070	0	201	132	0.174	0.106	0.180	0.000	33.492	277.592	1.998	32.566	300.685	0.884	0.000	92.524	0.000	0.026	0.042	0.000
sp110	Spring	1991+00	0.080	0	230	150	0.193	0.112	0.191	0.000	36.348	282.534	2.101	33.618	304.312	0.908	0.018	93.313	0.000	0.027	0.042	0.000
sp112	Spring	2110+50	0.110	0	316	207	0.251	0.129	0.224	0.000	44.917	297.359	2.409	36.775	315.191	0.982	0.145	95.681	0.000	0.030	0.045	0.001
sp115	Spring	2122+50	0.269	0	774	506	0.556	0.224	0.399	130.871	90.434	376.116	4.044	53.544	372.986	1.371	0.819	108.258	4.920	0.042	0.058	0.001
sp120	Spring	2140+00	0.150	0	431	282	0.327	0.153	0.268	0.000	56.341	317.126	2.819	40.983	329.697	1.079	0.314	98.838	0.524	0.033	0.048	0.001
sp121	Spring	2110+00	0.020	0	57	38	0.078	0.076	0.125	0.000	19.212	252.883	1.485	27.304	282.553	0.762	0.000	88.578	0.000	0.023	0.038	0.000
sp122	Spring	2141+00	0.056	0	161	105	0.147	0.097	0.164	0.000	29.506	270.695	1.855	31.097	295.624	0.850	0.000	91.423	0.000	0.025	0.041	0.000
sp124	Spring	2144+00	0.080	0	230	150	0.193	0.112	0.191	0.000	36.348	282.534	2.101	33.618	304.312	0.908	0.018	93.313	0.000	0.027	0.042	0.000
sp125	Spring	2145+00	0.220	0	632	413	0.462	0.195	0.344	72.427	76.333	351.718	3.537	48.349	355.082	1.250	0.610	104.362	3.102	0.038	0.054	0.001
sp127	Spring	2146+00	0.270	0	776	507	0.557	0.224	0.399	131.615	90.614	376.427	4.050	53.610	373.214	1.373	0.821	108.308	4.944	0.042	0.058	0.001
sp128	Spring	2148+00	0.270	0	776	507	0.557	0.224	0.399	131.615	90.614	376.427	4.050	53.610	373.214	1.373	0.821	108.308	4.944	0.042	0.058	0.001
sp136	Spring	2161+50	0.030	0	86	56	0.097	0.082	0.136	0.000	22.068	257.825	1.588	28.357	286.179	0.786	0.000	89.368	0.000	0.023	0.038	0.000
sp167	Spring	2287+00	0.030	0	86	56	0.097	0.082	0.136	0.000	22.068	257.825	1.588	28.357	286.179	0.786	0.000	89.368	0.000	0.023	0.038	0.000

INPUT FOR TABLE #1 AND TABLE #2			
T =	20	days	Days between events, 20 days is maximum
ADT =	70000	veh/day	ADT in design year
K (1) =	143.6	lb/mi-day	Pollutant accumulation rate
K (2) =	6.5		Wash-off coefficient for urban areas (Type II)
Rain Volume =	1.20	in	Volume of rainfall for 50-year/10-min (NOAA)
Rain Duration =	0.17	hr	Duration of rainfall for 50-year/10-min (NOAA)
r =	7.20	in/hr	Run off rate

Table 1 Regression Equations					
Site Type	II	0			
Constituent	A	B	Constituent	A	B
Lead	1.02E-03	0.04	TPO4	2.25E-03	-0.32
Copper	3.16E-04	0.064	CL-	0.042	87
Zinc	5.84E-04	0.103	Fe	1.96E-02	-5
TSS	0.63	-188	Cd	4.16E-05	0.021
VSS	0.152	13.5	Cr	4.30E-05	0.036
TVS	0.263	243	Hg	2.44E-06	1.01E-06
TKN	5.46E-03	1.28	0	0.00E+00	0
TOC	5.60E-02	25.2	0	0	0
COD	0.193	275.3	0	0	0
TN	1.30E-03	0.713	0	0.00E+00	0

Table #1-8: 50-Year/10-Min Pollutant Mass Loading of Karst Features for Post-Construction (Proposed) Conditions - Preferred Alternative #8

ID	Type	Approx. Station	Length of R/W in Drainage Area	Initial TS Load before Event (Po)	TS Load after Event (P)	TS Load at Discharge (Pd)	*Mass Load per Rain Event (Highway)*															
							Lead	Copper	Zinc	TSS	VSS	TVS	TKN	TOC	COD	TN	TPO4	CL-	Fe	Cd	Cr	Hg
		(feet)	(mi)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)
i015	sinkhole	1577+50	0.069	0	199	199	0.243	0.127	0.219	0.000	43.776	295.386	2.368	36.354	313.743	0.972	0.128	95.366	0.000	0.029	0.045	0.000
i219	sinkhole	1557+50	0.085	0	245	245	0.289	0.141	0.246	0.000	50.668	307.310	2.615	38.893	322.493	1.031	0.230	97.270	0.000	0.031	0.047	0.001
i020	sinkhole	1590+00	0.231	0	665	665	0.718	0.274	0.491	230.713	114.523	417.796	4.909	62.419	403.572	1.577	1.175	114.914	8.027	0.049	0.065	0.002
i023	sinkhole	1597+50	0.095	0	272	272	0.317	0.150	0.262	0.000	54.844	314.536	2.765	40.432	327.796	1.067	0.292	98.424	0.331	0.032	0.048	0.001
i017	sinkhole	1575+00	0.278	0	798	798	0.854	0.316	0.569	314.547	134.750	452.794	5.635	69.871	429.255	1.750	1.475	120.503	10.635	0.054	0.070	0.002
i025	sinkhole	1599+00	0.193	0	553	553	0.605	0.239	0.426	160.694	97.629	388.566	4.302	56.195	382.122	1.433	0.925	110.246	5.848	0.044	0.060	0.001
i050	sinkhole	1605+00	0.078	0	225	225	0.269	0.135	0.234	0.000	47.678	302.137	2.508	37.792	318.697	1.005	0.186	96.444	0.000	0.030	0.046	0.001
i168	sinkhole	1588+00	0.325	0	934	934	0.993	0.359	0.648	400.448	155.475	488.654	6.380	77.507	455.571	1.927	1.782	126.230	13.307	0.060	0.076	0.002
i024	sinkhole	1596+00	0.114	0	327	327	0.373	0.167	0.294	17.717	63.133	328.879	3.063	43.486	338.321	1.137	0.415	100.714	1.400	0.035	0.050	0.001
i387	sinkhole	1580+00	0.032	0	93	93	0.135	0.093	0.157	0.000	27.603	267.402	1.787	30.396	293.207	0.834	0.000	90.897	0.000	0.025	0.040	0.000
i379	sinkhole	1570+00	0.336	0	964	964	1.024	0.369	0.666	419.566	160.087	496.635	6.546	79.206	461.427	1.967	1.850	127.504	13.902	0.061	0.077	0.002
i412	sinkhole	1715+00	0.093	0	268	268	0.314	0.149	0.260	0.000	54.260	313.526	2.744	40.217	327.055	1.062	0.283	98.263	0.256	0.032	0.048	0.001
i042	sinkhole	1712+10	0.129	0	371	371	0.419	0.181	0.320	45.786	69.905	340.596	3.306	45.981	346.920	1.195	0.515	102.586	2.273	0.036	0.052	0.001
i040	sinkhole	1777+50	0.414	0	1,188	1,188	1.252	0.439	0.797	560.346	194.053	555.405	7.766	91.720	504.555	2.257	2.353	136.890	18.282	0.070	0.087	0.003
i426	sinkhole	1788+00	0.167	0	480	480	0.530	0.216	0.383	114.342	86.446	369.216	3.900	52.075	367.922	1.337	0.760	107.156	4.406	0.041	0.057	0.001
i044	sinkhole	1800+00	0.201	0	577	577	0.629	0.246	0.440	175.823	101.280	394.882	4.433	57.540	386.757	1.464	0.979	111.255	6.319	0.045	0.061	0.001
i430	sinkhole	1794+50	0.087	0	250	250	0.295	0.143	0.249	0.000	51.429	308.628	2.642	39.174	323.460	1.037	0.241	97.480	0.000	0.031	0.047	0.001
i182	sinkhole	1868+00	0.042	0	121	121	0.163	0.102	0.173	0.000	31.831	274.717	1.938	31.953	298.575	0.870	0.000	92.065	0.000	0.026	0.041	0.000
i205	sinkhole	1869+00	0.018	0	53	53	0.094	0.081	0.134	0.000	21.530	256.895	1.568	28.159	285.497	0.782	0.000	89.219	0.000	0.023	0.038	0.000
i116	sinkhole	1905+00	0.242	0	694	694	0.748	0.283	0.508	249.080	118.954	425.463	5.068	64.052	409.199	1.615	1.241	116.139	8.598	0.050	0.066	0.002
i174	sinkhole	1936+00	0.129	0	371	371	0.418	0.181	0.320	45.594	69.859	340.516	3.304	45.964	346.861	1.195	0.514	102.573	2.267	0.036	0.052	0.001
i192	sinkhole	2131+00	0.162	0	464	464	0.514	0.211	0.374	104.568	84.088	365.136	3.816	51.206	364.928	1.317	0.725	106.505	4.102	0.040	0.056	0.001
i252	sinkhole	2129+00	0.034	0	98	98	0.140	0.095	0.160	0.000	28.335	268.668	1.813	30.665	294.136	0.840	0.000	91.099	0.000	0.025	0.040	0.000
i269	sinkhole	2139+00	0.043	0	123	123	0.166	0.103	0.175	0.000	32.205	275.365	1.952	32.091	299.051	0.873	0.000	92.169	0.000	0.026	0.041	0.000
i054	sinkhole	2155+00	0.136	0	390	390	0.438	0.187	0.331	57.777	72.799	345.602	3.410	47.047	350.594	1.220	0.558	103.385	2.646	0.037	0.053	0.001
i048	sinkhole	2153+00	0.059	0	169	169	0.213	0.117	0.202	0.000	39.213	287.491	2.204	34.673	307.949	0.933	0.061	94.105	0.000	0.028	0.043	0.000
i078	sinkhole	2149+00	0.106	0	305	305	0.351	0.160	0.281	4.300	59.896	323.278	2.947	42.293	334.211	1.110	0.367	99.820	0.983	0.034	0.049	0.001
i055	sinkhole	2192+50	0.091	0	262	262	0.307	0.147	0.256	0.000	53.253	311.783	2.708	39.846	325.776	1.053	0.268	97.984	0.126	0.032	0.047	0.001
i049	sinkhole	2185+00	0.201	0	576	576	0.628	0.246	0.439	174.985	101.077	394.532	4.426	57.465	386.500	1.462	0.976	111.199	6.293	0.045	0.061	0.001
i084	sinkhole	2197+50	0.056	0	162	162	0.205	0.115	0.197	0.000	38.071	285.514	2.163	34.253	306.499	0.923	0.044	93.789	0.000	0.028	0.043	0.000
i064	sinkhole	2209+00	0.118	0	338	338	0.384	0.171	0.300	24.752	64.831	331.815	3.124	44.111	340.476	1.152	0.440	101.183	1.619	0.035	0.051	0.001
i194	sinkhole	2244+00	0.111	0	319	319	0.365	0.165	0.289	12.742	61.933	326.802	3.020	43.044	336.797	1.127	0.397	100.383	1.245	0.034	0.050	0.001
b16	Buried Sink	1694+00	0.131	0	377	377	0.425	0.183	0.323	49.787	70.871	342.267	3.341	46.337	348.146	1.204	0.529	102.852	2.398	0.037	0.052	0.001
b03	Buried Sink	1652+50	0.088	0	254	254	0.299	0.144	0.251	0.000	52.079	309.752	2.666	39.413	324.285	1.043	0.251	97.660	0.000	0.032	0.047	0.001
b06	Buried Sink	1672+50	0.069	0	197	197	0.241	0.126	0.218	0.000	43.477	294.867	2.357	36.244	313.362	0.969	0.124	95.283	0.000	0.029	0.044	0.000
b10	Buried Sink	1677+00	0.063	0	181	181	0.224	0.121	0.208	0.000	40.941	290.481	2.266	35.310	310.143	0.948	0.086	94.583	0.000	0.029	0.044	0.000
b09	Buried Sink	1675+50	0.057	0	164	164	0.207	0.116	0.199	0.000	38.358	286.012	2.173	34.358	306.864	0.926	0.048	93.869	0.000	0.028	0.043	0.000
b08	Buried Sink	1675+00	0.052	0	150	150	0.193	0.111	0.191	0.000	36.318	282.482	2.100	33.607	304.273	0.908	0.018	93.305	0.000	0.027	0.042	0.000
b12	Buried Sink	1681+00	0.079	0	228	228	0.273	0.136	0.236	0.000	48.203	303.045	2.527	37.985	319.364	1.010	0.194	96.589	0.000	0.030	0.046	0.001
b15	Buried Sink	1685+00	0.060	0	173	173	0.217	0.119	0.204	0.000	39.863	288.614	2.227	34.913	308.774	0.938	0.070	94.284	0.000	0.028	0.043	0.000
b18	Buried Sink	1697+50	0.050	0	145	145	0.188	0.110	0.188	0.000	35.495	281.058	2.070	33.304	303.228	0.901	0.006	93.078	0.000	0.027	0.042	0.000
b17	Buried Sink	1695+00	0.086	0	247	247	0.292	0.142	0.247	0.000	51.066	307.999	2.629	39.040	322.999	1.034	0.236	97.380	0.000	0.031	0.047	0.001
b19	Buried Sink	1718+00	0.080	0	231	231	0.275	0.137	0.238	0.000	48.590	303.715	2.540	38.128	319.855	1.013	0.199	96.696	0.000	0.031	0.046	0.001
b20	Buried Sink	1787+00	0.063	0	180	180	0.224	0.121	0.208	0.000	40.869	290.356	2.263	35.283	310.051	0.947	0.085	94.562	0.000	0.028	0.044	0.000
sp021	Spring	1757+00	0.079	0	226	226	0.271	0.135	0.235	0.000	47.853	302.440	2.514	37.856	318.920	1.007	0.189	96.492	0.000	0.030	0.046	0.001
sp025	Spring	1583+00	0.198	0	567	567	0.619	0.243	0.434	169.511	99.757	392.247	4.378	56.979	384.823	1.451	0.957	110.834	6.123	0.045	0.060	0.001
sp026	Spring	1583+50	0.198	0	567	567	0.619	0.243	0.434	169.511	99.757	392.247	4.378	56.979	384.823	1.451	0.957	110.834	6.123	0.045	0.060	0.001
sp028	Spring	1585+00	0.198	0	567	567	0.619	0.243	0.434	169.511	99.757	392.247	4.378	56.979	384.823	1.451	0.957	110.834	6.123	0.045	0.060	0.001

sp032	Spring	1585+00	0.294	0	843	843	0.900	0.330	0.595	343.275	141.681	464.786	5.884	72.424	438.056	1.809	1.577	122.418	11.529	0.056	0.072	0.002
sp055	Spring	1791+00	0.294	0	843	843	0.900	0.330	0.595	343.256	141.676	464.778	5.884	72.423	438.050	1.809	1.577	122.417	11.528	0.056	0.072	0.002
sp071	Spring	1895+00	0.467	0	1,341	1,341	1.408	0.488	0.886	656.844	217.335	595.689	8.602	100.297	534.117	2.456	2.697	143.323	21.284	0.077	0.094	0.003
sp077	Spring	1923+00	0.135	0	388	388	0.436	0.187	0.329	56.309	72.444	344.989	3.397	46.916	350.144	1.217	0.553	103.287	2.601	0.037	0.053	0.001
sp083	Spring	1939+50	0.057	0	165	165	0.208	0.116	0.199	0.000	38.519	286.289	2.179	34.417	307.067	0.927	0.050	93.913	0.000	0.028	0.043	0.000
sp093	Spring	1965+00	0.150	0	431	431	0.479	0.200	0.355	83.455	78.994	356.321	3.633	49.329	358.460	1.273	0.649	105.097	3.445	0.039	0.055	0.001
sp097	Spring	1972+50	0.133	0	382	382	0.430	0.185	0.326	52.690	71.571	343.478	3.366	46.595	349.035	1.210	0.540	103.046	2.488	0.037	0.052	0.001
sp098	Spring	1973+50	0.162	0	465	465	0.515	0.211	0.375	105.171	84.233	365.387	3.821	51.260	365.113	1.318	0.727	106.545	4.121	0.040	0.056	0.001
sp099	Spring	1974+00	0.037	0	106	106	0.148	0.098	0.165	0.000	29.655	270.953	1.860	31.152	295.813	0.851	0.000	91.464	0.000	0.025	0.041	0.000
sp105	Spring	1982+00	0.030	0	86	86	0.128	0.091	0.153	0.000	26.599	265.664	1.751	30.026	291.932	0.825	0.000	90.619	0.000	0.025	0.040	0.000
sp106	Spring	1923+00	0.030	0	86	86	0.128	0.091	0.153	0.000	26.599	265.664	1.751	30.026	291.932	0.825	0.000	90.619	0.000	0.025	0.040	0.000
sp107	Spring	1985+00	0.070	0	201	201	0.245	0.128	0.220	0.000	44.064	295.883	2.378	36.460	314.108	0.974	0.132	95.445	0.000	0.029	0.045	0.000
sp110	Spring	1991+00	0.080	0	230	230	0.274	0.137	0.237	0.000	48.430	303.438	2.535	38.069	319.652	1.012	0.197	96.652	0.000	0.031	0.046	0.001
sp112	Spring	2110+50	0.110	0	316	316	0.362	0.164	0.288	11.067	61.529	326.102	3.005	42.895	336.284	1.124	0.391	100.271	1.193	0.034	0.050	0.001
sp115	Spring	2122+50	0.269	0	774	774	0.829	0.309	0.555	299.480	131.114	446.503	5.505	68.532	424.639	1.719	1.421	119.499	10.166	0.053	0.069	0.002
sp120	Spring	2140+00	0.150	0	431	431	0.479	0.200	0.355	83.455	78.994	356.321	3.633	49.329	358.460	1.273	0.649	105.097	3.445	0.039	0.055	0.001
sp121	Spring	2110+00	0.020	0	57	57	0.099	0.082	0.137	0.000	22.233	258.110	1.594	28.417	286.388	0.788	0.000	89.413	0.000	0.023	0.038	0.000
sp122	Spring	2141+00	0.056	0	161	161	0.204	0.115	0.197	0.000	37.970	285.339	2.159	34.215	306.370	0.922	0.042	93.761	0.000	0.028	0.043	0.000
sp124	Spring	2144+00	0.080	0	230	230	0.274	0.137	0.237	0.000	48.430	303.438	2.535	38.069	319.652	1.012	0.197	96.652	0.000	0.031	0.046	0.001
sp125	Spring	2145+00	0.220	0	632	632	0.685	0.264	0.472	210.133	109.558	409.205	4.730	60.590	397.268	1.535	1.102	113.542	7.386	0.047	0.063	0.002
sp127	Spring	2146+00	0.270	0	776	776	0.831	0.309	0.556	300.618	131.389	446.979	5.515	68.633	424.988	1.721	1.425	119.575	10.201	0.053	0.069	0.002
sp128	Spring	2148+00	0.270	0	776	776	0.831	0.309	0.556	300.618	131.389	446.979	5.515	68.633	424.988	1.721	1.425	119.575	10.201	0.053	0.069	0.002
sp136	Spring	2161+50	0.030	0	86	86	0.128	0.091	0.153	0.000	26.599	265.664	1.751	30.026	291.932	0.825	0.000	90.619	0.000	0.025	0.040	0.000
sp167	Spring	2287+00	0.030	0	86	86	0.128	0.091	0.153	0.000	26.599	265.664	1.751	30.026	291.932	0.825	0.000	90.619	0.000	0.025	0.040	0.000

Table #2-1: 1-Year/1-Hour Average Pollutant Concentration of Karst Features for Pre-Construction (Existing) Conditions - Preferred Alternative #8

ID	Type	Approx. Station	Runoff Area inside R/W	Runoff Volume inside R/W	*Average Concentration*															
					Lead	Copper	Zinc	TSS	VSS	TVS	TKN	TOC	COD	TN	TPO4	CL-	Fe	Cd	Cr	Hg
		(feet)	(acres)	(cf)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
i168	sinkhole	1590+00	5.521	24,250	0.386	0.154	0.274	97.711	62.496	253.377	2.771	36.400	250.066	0.930	0.581	72.332	3.601	0.029	0.039	0.001
i020	sinkhole	1590+00	0.583	2,561	2.847	1.205	2.132	426.482	471.483	2191.232	21.915	300.366	2215.303	7.774	3.724	651.731	18.584	0.237	0.335	0.006
i023	sinkhole	1598+00	2.239	9,836	0.293	0.175	0.298	0.000	55.991	454.975	3.307	53.604	491.986	1.453	0.000	151.231	0.000	0.044	0.068	0.001
i024	sinkhole	1595+00	0.488	2,143	1.752	0.929	1.602	0.000	317.429	2192.437	17.350	268.266	2334.410	7.185	0.810	710.676	0.000	0.216	0.331	0.003
i025	sinkhole	1600+00	2.240	9,839	0.583	0.265	0.464	13.563	99.203	529.631	4.859	69.515	546.723	1.822	0.621	163.129	1.806	0.055	0.081	0.001
i426	sinkhole	1788+00	2.591	11,382	0.475	0.220	0.385	0.000	81.449	450.365	4.046	58.503	467.120	1.538	0.473	139.818	1.006	0.047	0.068	0.001
i412	sinkhole	1715+00	0.659	2,895	1.131	0.636	1.092	0.000	210.379	1580.828	11.962	189.562	1697.328	5.110	0.234	519.447	0.000	0.153	0.238	0.002
i040	sinkhole	1778+00	9.851	43,269	0.253	0.098	0.175	77.562	40.527	151.523	1.750	22.427	147.134	0.568	0.407	42.059	2.728	0.018	0.023	0.001
i042	sinkhole	1780+00	1.807	7,937	0.542	0.272	0.472	0.000	95.955	609.792	5.053	76.217	643.422	2.028	0.370	194.752	0.000	0.061	0.092	0.001
i426	sinkhole	1788+00	1.210	5,313	1.031	0.475	0.832	0.000	176.450	968.272	8.738	126.059	1003.273	3.313	1.043	300.098	2.406	0.101	0.147	0.002
i192	sinkhole	2131+00	1.705	7,489	0.702	0.328	0.573	0.000	120.731	679.227	6.039	87.792	706.107	2.312	0.674	211.670	1.133	0.070	0.103	0.001
i430	sinkhole	1795+00	1.235	5,424	0.573	0.330	0.565	0.000	107.662	835.581	6.218	99.457	899.863	2.687	0.057	275.908	0.000	0.081	0.126	0.001
i044	sinkhole	1800+00	2.715	11,925	0.475	0.216	0.379	7.051	80.849	435.242	3.973	56.985	449.803	1.495	0.498	134.313	1.361	0.045	0.066	0.001
i182	sinkhole	1867+50	0.323	1,419	1.222	0.962	1.605	0.000	267.324	2945.149	18.589	327.106	3257.398	9.040	0.000	1015.064	0.000	0.269	0.439	0.002
i205	sinkhole	1868+00	0.561	2,464	0.470	0.481	0.790	0.000	119.063	1635.391	9.451	175.494	1831.221	4.907	0.000	574.801	0.000	0.145	0.243	0.001
i116	sinkhole	1905+00	2.353	10,335	0.737	0.309	0.546	125.387	121.576	551.150	5.601	76.174	554.924	1.967	0.993	162.793	5.218	0.060	0.084	0.002
i174	sinkhole	1936+00	1.210	5,315	0.809	0.406	0.705	0.000	143.370	910.781	7.549	113.849	960.971	3.029	0.554	290.861	0.000	0.091	0.138	0.002
i192	sinkhole	2132+00	1.705	7,489	0.701	0.328	0.573	0.000	120.642	679.056	6.036	87.757	705.972	2.311	0.673	211.639	1.123	0.070	0.103	0.001
i049	sinkhole	2185+00	6.772	29,745	0.220	0.096	0.169	21.431	36.902	182.262	1.754	24.500	186.032	0.638	0.266	55.088	1.124	0.019	0.028	0.000
i084	sinkhole	2197+00	0.426	1,871	1.187	0.810	1.366	0.000	241.492	2300.197	15.488	262.313	2519.080	7.186	0.000	780.359	0.000	0.214	0.344	0.002
i194	sinkhole	2244+00	0.857	3,764	1.015	0.534	0.922	0.000	183.374	1252.971	9.974	153.724	1332.608	4.114	0.500	405.403	0.000	0.124	0.189	0.002
b03	Buried Sink	1653+00	2.925	12,847	0.246	0.141	0.241	0.000	46.024	353.782	2.646	42.202	380.662	1.139	0.032	116.651	0.000	0.034	0.053	0.000
b06	Buried Sink	1672+00	2.703	11,872	0.202	0.132	0.224	0.000	40.259	366.323	2.520	42.152	399.807	1.151	0.000	123.595	0.000	0.034	0.055	0.000
b09	Buried Sink	1676+00	0.956	4,199	0.222	0.266	0.433	0.000	61.806	945.730	5.256	100.013	1064.359	2.811	0.000	335.077	0.000	0.083	0.140	0.000
b010	Buried Sink	1676+00	0.970	4,261	0.527	0.357	0.603	0.000	106.886	1011.623	6.832	115.506	1107.370	3.163	0.000	342.944	0.000	0.094	0.151	0.001
b012	Buried Sink	1680+00	1.622	7,124	0.380	0.234	0.398	0.000	73.533	621.609	4.431	72.617	674.442	1.974	0.000	207.745	0.000	0.059	0.093	0.001
b015	Buried Sink	1685+00	1.290	5,666	0.422	0.277	0.468	0.000	84.170	767.250	5.274	88.253	837.496	2.411	0.000	258.922	0.000	0.072	0.115	0.001
b016	Buried Sink	1695+00	5.139	22,572	0.194	0.097	0.168	0.000	34.236	215.276	1.795	26.982	226.873	0.717	0.137	68.617	0.000	0.022	0.033	0.000
b018	Buried Sink	1697+00	0.474	2,082	1.067	0.728	1.228	0.000	217.098	2067.372	13.922	235.772	2264.061	6.459	0.000	701.353	0.000	0.193	0.309	0.002
b019	Buried Sink	1777+00	2.781	12,215	0.272	0.152	0.261	0.000	50.436	375.611	2.855	45.135	402.949	1.216	0.064	123.252	0.000	0.037	0.057	0.001
b020	Buried Sink	1786+00	1.835	8,060	0.338	0.207	0.353	0.000	65.319	550.012	3.928	64.307	596.564	1.747	0.000	183.720	0.000	0.052	0.083	0.001
sp025	Spring	1584+50	1.453	6,382	0.753	0.363	0.633	0.000	131.223	778.930	6.711	99.167	815.279	2.624	0.636	245.486	0.000	0.079	0.118	0.002
sp026	Spring	1585+00	1.453	6,382	0.753	0.363	0.633	0.000	131.223	778.930	6.711	99.167	815.279	2.624	0.636	245.486	0.000	0.079	0.118	0.002
sp028	Spring	1586+00	1.453	6,382	0.753	0.363	0.633	0.000	131.223	778.930	6.711	99.167	815.279	2.624	0.636	245.486	0.000	0.079	0.118	0.002
sp032	Spring	1632+00	2.997	13,164	0.370	0.178	0.310	0.000	64.382	378.959	3.281	48.359	396.230	1.279	0.320	119.227	0.090	0.039	0.057	0.001
sp034	Spring	1660+00	6.832	30,008	0.342	0.133	0.238	97.384	54.949	212.447	2.399	31.053	207.725	0.789	0.536	59.681	3.483	0.024	0.033	0.001
sp055	Spring	1792+00	13.084	57,469	0.192	0.074	0.132	59.096	30.682	114.375	1.324	16.948	110.992	0.429	0.309	31.713	2.075	0.013	0.018	0.000
sp071	Spring	1895+00	20.725	91,030	0.185	0.067	0.120	77.016	28.950	88.783	1.180	14.229	82.236	0.353	0.337	22.668	2.546	0.011	0.014	0.000
sp077	Spring	1923+00	3.016	13,247	0.344	0.169	0.294	0.000	60.358	370.311	3.131	46.721	389.139	1.240	0.264	117.476	0.000	0.037	0.056	0.001
sp083	Spring	1939+00	1.114	4,893	0.466	0.313	0.529	0.000	94.112	882.662	5.986	100.960	965.551	2.763	0.000	298.902	0.000	0.082	0.132	0.001
sp093	Spring	1965+00	0.903	3,966	1.288	0.608	1.061	0.000	222.408	1272.845	11.204	163.716	1326.146	4.318	1.191	398.118	1.426	0.131	0.193	0.003
sp097	Spring	1972+00	2.195	9,641	0.458	0.228	0.395	0.000	80.758	505.055	4.223	63.395	531.928	1.685	0.331	160.815	0.000	0.051	0.076	0.001
sp098	Spring	1974+00	5.678	24,939	0.187	0.091	0.159	0.000	32.756	197.903	1.688	25.073	207.584	0.664	0.151	62.592	0.000	0.020	0.030	0.000
sp099	Spring	1975+00	1.249	5,486	0.478	0.299	0.508	0.000	93.290	803.436	5.675	93.492	873.061	2.545	0.000	269.178	0.000	0.076	0.120	0.001
sp107	Spring	1984+50	10.203	44,815	0.181	0.075	0.133	35.946	29.734	130.040	1.353	18.192	130.129	0.468	0.254	38.012	1.422	0.014	0.020	0.000
sp115	Spring	2117+00	7.953	34,932	0.239	0.098	0.173	49.790	39.032	168.364	1.767	23.665	168.070	0.608	0.339	49.011	1.939	0.019	0.026	0.001
sp120	Spring	2139+00	3.094	13,590	0.327	0.162	0.282	0.000	57.662	358.944	3.009	45.111	377.839	1.198	0.240	114.190	0.000	0.036	0.054	0.001
sp121	Spring	2140+00	0.325	1,427	0.886	0.854	1.407	0.000	216.725	2842.322	16.716	307.057	3175.194	8.566	0.000	995.291	0.000	0.254	0.423	0.001
sp122	Spring	2143+00	4.853	21,316	0.360	0.150	0.267	62.515	59.362	267.946	2.730	37.086	269.584	0.957	0.488	79.046	2.584	0.029	0.041	0.001
sp125	Spring	2145+50	3.327	14,613	0.363	0.169	0.296	0.000	62.429	349.041	3.115	45.195	362.557	1.190	0.354	108.626	0.653	0.036	0.053	0.001
sp127	Spring	2146+00	3.327	14,613	0.363	0.169	0.296	0.000	62.429	349.041	3.115	45.195	362.557	1.190	0.354	108.626	0.653	0.036	0.053	0.001
sp128	Spring	2148+00	3.327	14,613	0.363	0.169	0.296	0.000	62.429	349.041	3.115	45.195	362.557	1.190	0.354	108.626	0.653	0.036	0.053	0.001
sp136	Spring	2162+00	0.426	1,871	0.768	0.680	1.126	0.000	179.117	2192.273	13.248	239.332	2439.881	6.653	0.000	763.124	0.000	0.197	0.326	0.001
			0.300																	

Acute Aquatic Criterion, AAC (Table 2, 327 IAC 2-1-6)	0.262	0.042	0.254	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	860	n/a	0.011	3.679	n/a
Chronic Aquatic Criterion, CAC (Table 2, 327 IAC 2-1-6)	0.010	0.026	0.230	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	230	n/a	0.002	0.438	n/a
Point of Water Intake Human Health (Table 1, 327 IAC 2-1-6)	0.050	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.010	n/a	n/a	n/a	0.010	170.000	0.00014
Values in shaded cells exceed one of the water quality standards	**0.010**	**0.026**	**0.230**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**0.010**	**n/a**	**230**	**n/a**	**0.002**	**0.438**	**0.00014**
Number of features exceeding water quality standards	53	53	44							53		22		53		53
Highest concentration	2.847	1.205	2.132							9.040		1015.064		0.269	0.439	0.006
Highest concentration feature ID	i020	i020	i020							i182		i182		i182	i182	i020

Table #2-2: 2-Year/24-Hour Average Pollutant Concentration of Karst Features for Pre-Construction (Existing) Conditions - Preferred Alternative #8

ID	Type	Approx. Station	Runoff Area inside R/W	Runoff Volume inside R/W	*Average Concentration*															
					Lead	Copper	Zinc	TSS	VSS	TVS	TKN	TOC	COD	TN	TPO4	CL-	Fe	Cd	Cr	Hg
		(feet)	(acres)	(cf)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
i168	sinkhole	1590+00	5.521	63,330	0.089	0.041	0.071	1.307	15.219	81.947	0.748	10.728	84.692	0.281	0.094	25.290	0.256	0.009	0.012	0.000
i020	sinkhole	1590+00	0.583	6,687	0.668	0.331	0.574	0.000	117.609	730.167	6.131	91.830	768.364	2.439	0.494	232.168	0.000	0.074	0.110	0.001
i023	sinkhole	1598+00	2.239	25,687	0.075	0.056	0.093	0.000	15.913	164.653	1.068	18.490	181.370	0.509	0.000	56.381	0.000	0.015	0.025	0.000
i024	sinkhole	1595+00	0.488	5,598	0.435	0.282	0.478	0.000	86.350	778.609	5.379	89.755	849.181	2.450	0.000	262.400	0.000	0.073	0.117	0.001
i025	sinkhole	1600+00	2.240	25,695	0.139	0.075	0.130	0.000	25.431	181.079	1.410	21.992	193.405	0.590	0.052	58.995	0.000	0.018	0.027	0.000
i426	sinkhole	1788+00	2.591	29,726	0.114	0.063	0.108	0.000	21.035	154.883	1.185	18.661	165.974	0.502	0.031	50.733	0.000	0.015	0.023	0.000
i412	sinkhole	1715+00	0.659	7,559	0.285	0.198	0.333	0.000	58.506	567.164	3.788	64.462	621.928	1.768	0.000	192.809	0.000	0.053	0.085	0.000
i040	sinkhole	1778+00	9.851	112,999	0.058	0.025	0.045	5.755	9.741	48.024	0.463	6.459	49.004	0.168	0.070	14.508	0.300	0.005	0.007	0.000
i042	sinkhole	1780+00	1.807	20,728	0.132	0.081	0.138	0.000	25.573	214.171	1.534	25.070	232.192	0.681	0.000	71.487	0.000	0.020	0.032	0.000
i426	sinkhole	1788+00	1.210	13,874	0.247	0.136	0.234	0.000	45.496	332.578	2.553	40.139	356.143	1.080	0.073	108.813	0.000	0.032	0.050	0.000
i192	sinkhole	2131+00	1.705	19,557	0.169	0.095	0.162	0.000	31.297	234.246	1.776	28.115	251.416	0.758	0.037	76.925	0.000	0.023	0.035	0.000
i430	sinkhole	1795+00	1.235	14,166	0.145	0.103	0.174	0.000	30.206	300.889	1.985	34.024	330.577	0.935	0.000	102.604	0.000	0.028	0.045	0.000
i044	sinkhole	1800+00	2.715	31,143	0.113	0.062	0.106	0.000	20.762	149.018	1.155	18.064	159.289	0.485	0.040	48.613	0.000	0.015	0.022	0.000
i182	sinkhole	1867+50	0.323	3,705	0.343	0.330	0.543	0.000	83.703	1095.447	6.448	118.378	1223.603	3.302	0.000	383.524	0.000	0.098	0.163	0.000
i205	sinkhole	1868+00	0.561	6,435	0.146	0.174	0.283	0.000	40.515	617.428	3.437	65.329	694.751	1.836	0.000	218.695	0.000	0.054	0.092	0.000
i116	sinkhole	1905+00	2.353	26,991	0.173	0.084	0.146	0.000	30.188	182.726	1.557	23.139	191.707	0.613	0.138	57.813	0.000	0.019	0.028	0.000
i174	sinkhole	1936+00	1.210	13,880	0.198	0.121	0.206	0.000	38.207	319.868	2.291	37.444	346.773	1.017	0.000	106.762	0.000	0.030	0.048	0.000
i192	sinkhole	2132+00	1.705	19,558	0.168	0.094	0.162	0.000	31.277	234.205	1.775	28.107	251.382	0.757	0.037	76.917	0.000	0.023	0.035	0.000
i049	sinkhole	2185+00	6.772	77,680	0.052	0.027	0.046	0.000	9.313	61.454	0.499	7.606	65.117	0.203	0.031	19.763	0.000	0.006	0.009	0.000
i084	sinkhole	2197+00	0.426	4,887	0.317	0.268	0.444	0.000	72.012	845.375	5.196	92.905	938.609	2.577	0.000	293.156	0.000	0.076	0.126	0.000
i194	sinkhole	2244+00	0.857	9,830	0.251	0.162	0.275	0.000	49.747	444.361	3.084	51.322	484.281	1.400	0.000	149.578	0.000	0.042	0.067	0.000
b03	Buried Sink	1653+00	2.925	33,552	0.062	0.044	0.074	0.000	12.879	127.258	0.843	14.412	139.736	0.396	0.000	43.356	0.000	0.012	0.019	0.000
b06	Buried Sink	1672+00	2.703	31,006	0.053	0.043	0.072	0.000	11.834	134.072	0.836	14.821	148.543	0.410	0.000	46.336	0.000	0.012	0.020	0.000
b09	Buried Sink	1676+00	0.956	10,966	0.074	0.098	0.159	0.000	21.999	359.246	1.953	37.682	405.439	1.062	0.000	127.844	0.000	0.031	0.053	0.000
b010	Buried Sink	1676+00	0.970	11,127	0.141	0.118	0.196	0.000	31.809	371.584	2.288	40.869	412.446	1.133	0.000	128.797	0.000	0.034	0.055	0.000
b012	Buried Sink	1680+00	1.622	18,606	0.098	0.075	0.125	0.000	21.140	225.881	1.445	25.221	249.342	0.696	0.000	77.609	0.000	0.021	0.034	0.000
b015	Buried Sink	1685+00	1.290	14,797	0.111	0.090	0.151	0.000	24.755	280.856	1.751	31.039	311.196	0.859	0.000	97.079	0.000	0.026	0.042	0.000
b016	Buried Sink	1695+00	5.139	58,948	0.047	0.029	0.049	0.000	9.101	75.497	0.543	8.855	81.783	0.240	0.000	25.167	0.000	0.007	0.011	0.000
b018	Buried Sink	1697+00	0.474	5,437	0.285	0.241	0.400	0.000	64.734	759.791	4.670	83.502	843.577	2.316	0.000	263.473	0.000	0.069	0.113	0.000
b019	Buried Sink	1777+00	2.781	31,900	0.068	0.047	0.079	0.000	13.993	134.621	0.902	15.323	147.539	0.420	0.000	45.725	0.000	0.013	0.020	0.000
b020	Buried Sink	1786+00	1.835	21,049	0.087	0.066	0.111	0.000	18.757	199.784	1.279	22.319	220.489	0.616	0.000	68.620	0.000	0.018	0.030	0.000
sp025	Spring	1584+50	1.453	16,667	0.182	0.106	0.181	0.000	34.423	270.882	2.001	32.142	292.087	0.869	0.009	89.627	0.000	0.026	0.041	0.000
sp026	Spring	1585+00	1.453	16,667	0.182	0.106	0.181	0.000	34.423	270.882	2.001	32.142	292.087	0.869	0.009	89.627	0.000	0.026	0.041	0.000
sp028	Spring	1586+00	1.453	16,667	0.182	0.106	0.181	0.000	34.423	270.882	2.001	32.142	292.087	0.869	0.009	89.627	0.000	0.026	0.041	0.000
sp032	Spring	1632+00	2.997	34,378	0.090	0.052	0.089	0.000	16.857	131.619	0.976	15.645	141.823	0.423	0.007	43.499	0.000	0.013	0.020	0.000
sp034	Spring	1660+00	6.832	78,369	0.079	0.035	0.061	5.114	13.278	67.917	0.640	9.030	69.683	0.236	0.090	20.707	0.333	0.007	0.010	0.000
sp055	Spring	1792+00	13.084	150,084	0.044	0.019	0.034	4.487	7.371	36.222	0.350	4.877	36.943	0.127	0.054	10.934	0.230	0.004	0.006	0.000
sp071	Spring	1895+00	20.725	237,732	0.042	0.016	0.029	11.580	6.764	26.519	0.297	3.856	26.002	0.098	0.065	7.486	0.418	0.003	0.004	0.000
sp077	Spring	1923+00	3.016	34,596	0.084	0.050	0.085	0.000	15.954	129.411	0.942	15.253	139.917	0.413	0.000	43.005	0.000	0.012	0.019	0.000
sp083	Spring	1939+00	1.114	12,778	0.124	0.103	0.171	0.000	27.927	323.949	2.001	35.671	359.423	0.989	0.000	112.212	0.000	0.029	0.048	0.000
sp093	Spring	1965+00	0.903	10,358	0.310	0.176	0.301	0.000	57.870	440.163	3.310	52.633	473.142	1.420	0.052	144.903	0.000	0.043	0.066	0.001
sp097	Spring	1972+00	2.195	25,178	0.112	0.067	0.115	0.000	21.442	176.986	1.277	20.781	191.642	0.564	0.000	58.958	0.000	0.017	0.027	0.000
sp098	Spring	1974+00	5.678	65,131	0.045	0.027	0.046	0.000	8.627	69.005	0.506	8.158	74.515	0.221	0.000	22.885	0.000	0.007	0.010	0.000
sp099	Spring	1975+00	1.249	14,327	0.124	0.096	0.161	0.000	26.968	292.498	1.859	32.574	323.190	0.899	0.000	100.652	0.000	0.027	0.044	0.000
sp107	Spring	1984+50	10.203	117,037	0.042	0.020	0.035	0.000	7.336	42.786	0.372	5.474	44.686	0.145	0.037	13.436	0.022	0.004	0.006	0.000
sp115	Spring	2117+00	7.953	91,227	0.056	0.026	0.046	0.000	9.606	55.229	0.485	7.094	57.576	0.187	0.051	17.291	0.054	0.006	0.008	0.000
sp120	Spring	2139+00	3.094	35,491	0.080	0.048	0.082	0.000	15.293	125.701	0.909	14.773	136.061	0.401	0.000	41.849	0.000	0.012	0.019	0.000
sp121	Spring	2140+00	0.325	3,728	0.268	0.305	0.498	0.000	72.404	1070.047	6.021	113.677	1202.381	3.190	0.000	378.184	0.000	0.094	0.159	0.000
sp122	Spring	2143+00	4.853	55,668	0.084	0.041	0.071	0.000	14.728	88.754	0.758	11.253	93.066	0.298	0.068	28.056	0.000	0.009	0.013	0.000
sp125	Spring	2145+50	3.327	38,163	0.087	0.049	0.084	0.000	16.161	120.254	0.915	14.453	128.995	0.389	0.021	39.454	0.000	0.012	0.018	0.000
sp127	Spring	2146+00	3.327	38,163	0.087	0.049	0.084	0.000	16.161	120.254	0.915	14.453	128.995	0.389	0.021	39.454	0.000	0.012	0.018	0.000
sp128	Spring	2148+00	3.327	38,163	0.087	0.049	0.084	0.000	16.161	120.254	0.915	14.453	128.995	0.389	0.021	39.454	0.000	0.012	0.018	0.000
sp136	Spring	2162+00	0.426	4,887	0.225	0.239	0.392	0.000	58.272	821.601	4.702	87.843	921.162	2.459	0.000	289.359	0.000	0.073	0.122	0.000

Acute Aquatic Criterion, AAC (Table 2, 327 IAC 2-1-6)	0.262	0.042	0.254	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	860	n/a	0.011	3.679	n/a
Chronic Aquatic Criterion, CAC (Table 2, 327 IAC 2-1-6)	0.010	0.026	0.230	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	230	n/a	0.002	0.438	n/a
Point of Water Intake Human Health (Table 1, 327 IAC 2-1-6)	0.050	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.010	n/a	n/a	n/a	0.010	170.000	0.00014
Values in shaded cells exceed one of the water quality standards	**0.010**	**0.026**	**0.230**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**0.010**	**n/a**	**230**	**n/a**	**0.002**	**0.438**	**0.00014**
Number of features exceeding water quality standards	53	49	12							53		7		53		38
Highest concentration	0.668	0.331	0.574							3.302		383.524		0.098	0.163	0.001
Highest concentration feature ID	i020	i020	i020							i182		i182		i182	i182	i020

Table #2-3: 5-Year/24-Hour Average Pollutant Concentration of Karst Features for Pre-Construction (Existing) Conditions - Preferred Alternative #8

ID	Type	Approx. Station	Runoff Area inside R/W	Runoff Volume inside R/W	*Average Concentration*															
					Lead	Copper	Zinc	TSS	VSS	TVS	TKN	TOC	COD	TN	TPO4	CL-	Fe	Cd	Cr	Hg
		(feet)	(acres)	(cf)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
i168	sinkhole	1590+00	5.521	78,562	0.081	0.036	0.063	6.473	13.576	68.322	0.650	9.130	69.932	0.238	0.095	20.748	0.375	0.007	0.010	0.000
i020	sinkhole	1590+00	0.583	8,296	0.602	0.286	0.499	0.000	104.253	604.947	5.282	77.506	631.389	2.047	0.538	189.765	0.413	0.062	0.092	0.001
i023	sinkhole	1598+00	2.239	31,864	0.066	0.046	0.078	0.000	13.658	134.166	0.891	15.211	147.260	0.418	0.000	45.679	0.000	0.012	0.020	0.000
i024	sinkhole	1595+00	0.488	6,944	0.386	0.239	0.406	0.000	74.892	636.795	4.526	74.300	691.252	2.020	0.000	212.987	0.000	0.060	0.096	0.001
i025	sinkhole	1600+00	2.240	31,874	0.125	0.065	0.112	0.000	22.385	149.232	1.204	18.423	158.301	0.492	0.070	48.078	0.000	0.015	0.023	0.000
i426	sinkhole	1788+00	2.591	36,875	0.102	0.054	0.093	0.000	18.481	127.492	1.010	15.604	135.731	0.418	0.048	41.318	0.000	0.013	0.019	0.000
i412	sinkhole	1715+00	0.659	9,377	0.252	0.166	0.281	0.000	50.473	462.931	3.173	53.183	505.553	1.454	0.000	156.342	0.000	0.043	0.069	0.000
i040	sinkhole	1778+00	9.851	140,176	0.053	0.022	0.039	8.233	8.720	40.214	0.404	5.526	40.604	0.143	0.070	11.935	0.353	0.004	0.006	0.000
i042	sinkhole	1780+00	1.807	25,713	0.118	0.069	0.118	0.000	22.292	175.549	1.297	20.827	189.304	0.563	0.006	58.090	0.000	0.017	0.026	0.000
i426	sinkhole	1788+00	1.210	17,211	0.221	0.117	0.201	0.000	39.988	273.830	2.177	33.577	291.301	0.899	0.108	88.632	0.000	0.027	0.041	0.000
i192	sinkhole	2131+00	1.705	24,260	0.151	0.081	0.139	0.000	27.470	192.710	1.512	23.490	205.518	0.630	0.063	62.630	0.000	0.019	0.029	0.000
i430	sinkhole	1795+00	1.235	17,574	0.128	0.087	0.147	0.000	26.004	245.415	1.660	28.037	268.586	0.768	0.000	83.168	0.000	0.023	0.037	0.000
i044	sinkhole	1800+00	2.715	38,633	0.102	0.053	0.091	0.000	18.267	122.774	0.986	15.125	130.349	0.404	0.055	39.611	0.000	0.012	0.019	0.000
i182	sinkhole	1867+50	0.323	4,596	0.295	0.271	0.448	0.000	70.275	887.910	5.298	96.459	989.930	2.686	0.000	309.941	0.000	0.080	0.132	0.000
i205	sinkhole	1868+00	0.561	7,983	0.123	0.142	0.231	0.000	33.422	499.041	2.798	52.944	561.022	1.486	0.000	176.506	0.000	0.044	0.074	0.000
i116	sinkhole	1905+00	2.353	33,482	0.156	0.073	0.127	0.000	26.792	151.550	1.343	19.558	157.659	0.515	0.148	47.283	0.226	0.016	0.023	0.000
i174	sinkhole	1936+00	1.210	17,218	0.176	0.103	0.176	0.000	33.305	262.188	1.937	31.108	282.723	0.841	0.009	86.755	0.000	0.025	0.039	0.000
i192	sinkhole	2132+00	1.705	24,261	0.151	0.081	0.139	0.000	27.452	192.673	1.512	23.483	205.488	0.630	0.063	62.623	0.000	0.019	0.029	0.000
i049	sinkhole	2185+00	6.772	96,363	0.047	0.023	0.040	0.000	8.230	50.791	0.428	6.398	53.410	0.170	0.035	16.131	0.000	0.005	0.008	0.000
i084	sinkhole	2197+00	0.426	6,062	0.276	0.222	0.370	0.000	61.122	686.789	4.299	76.025	760.533	2.103	0.000	237.168	0.000	0.063	0.102	0.000
i194	sinkhole	2244+00	0.857	12,195	0.223	0.137	0.233	0.000	43.175	363.525	2.596	42.503	394.291	1.155	0.000	121.427	0.000	0.035	0.055	0.000
b03	Buried Sink	1653+00	2.925	41,622	0.055	0.037	0.062	0.000	11.094	103.818	0.705	11.880	113.548	0.325	0.000	35.147	0.000	0.010	0.016	0.000
b06	Buried Sink	1672+00	2.703	38,463	0.047	0.036	0.060	0.000	10.077	109.009	0.693	12.145	120.426	0.335	0.000	37.501	0.000	0.010	0.016	0.000
b09	Buried Sink	1676+00	0.956	13,603	0.061	0.080	0.129	0.000	17.984	290.029	1.583	30.468	327.151	0.858	0.000	103.127	0.000	0.025	0.043	0.000
b010	Buried Sink	1676+00	0.970	13,803	0.122	0.098	0.163	0.000	27.010	301.910	1.894	33.450	334.220	0.925	0.000	104.205	0.000	0.027	0.045	0.000
b012	Buried Sink	1680+00	1.622	23,080	0.086	0.063	0.105	0.000	18.094	183.910	1.202	20.719	202.338	0.570	0.000	62.854	0.000	0.017	0.027	0.000
b015	Buried Sink	1685+00	1.290	18,356	0.097	0.075	0.126	0.000	21.077	228.345	1.452	25.435	252.287	0.702	0.000	78.567	0.000	0.021	0.034	0.000
b016	Buried Sink	1695+00	5.139	73,126	0.042	0.024	0.042	0.000	7.938	61.901	0.460	7.360	66.691	0.199	0.004	20.454	0.000	0.006	0.009	0.000
b018	Buried Sink	1697+00	0.474	6,745	0.248	0.200	0.333	0.000	54.944	617.262	3.864	68.330	683.532	1.891	0.000	213.154	0.000	0.056	0.092	0.000
b019	Buried Sink	1777+00	2.781	39,573	0.061	0.040	0.067	0.000	12.078	109.903	0.756	12.646	119.948	0.345	0.000	37.080	0.000	0.010	0.016	0.000
b020	Buried Sink	1786+00	1.835	26,111	0.077	0.055	0.093	0.000	16.059	162.675	1.065	18.338	178.934	0.504	0.000	55.576	0.000	0.015	0.024	0.000
sp025	Spring	1584+50	1.453	20,676	0.163	0.090	0.155	0.000	30.124	222.474	1.699	26.786	238.474	0.721	0.043	72.907	0.000	0.022	0.033	0.000
sp026	Spring	1585+00	1.453	20,676	0.163	0.090	0.155	0.000	30.124	222.474	1.699	26.786	238.474	0.721	0.043	72.907	0.000	0.022	0.033	0.000
sp028	Spring	1586+00	1.453	20,676	0.163	0.090	0.155	0.000	30.124	222.474	1.699	26.786	238.474	0.721	0.043	72.907	0.000	0.022	0.033	0.000
sp032	Spring	1632+00	2.997	42,646	0.080	0.044	0.076	0.000	14.759	108.126	0.829	13.043	115.812	0.351	0.023	35.389	0.000	0.011	0.016	0.000
sp034	Spring	1660+00	6.832	97,217	0.071	0.031	0.054	8.952	11.869	56.765	0.557	7.709	57.653	0.200	0.090	17.015	0.419	0.006	0.009	0.000
sp055	Spring	1792+00	13.084	186,180	0.040	0.017	0.030	6.340	6.599	30.336	0.306	4.173	30.614	0.108	0.053	8.995	0.270	0.003	0.005	0.000
sp071	Spring	1895+00	20.725	294,908	0.038	0.015	0.026	12.023	6.101	22.500	0.262	3.348	21.784	0.085	0.062	6.214	0.420	0.003	0.003	0.000
sp077	Spring	1923+00	3.016	42,916	0.075	0.042	0.073	0.000	13.935	106.180	0.798	12.691	114.154	0.342	0.012	34.964	0.000	0.010	0.016	0.000
sp083	Spring	1939+00	1.114	15,852	0.108	0.086	0.143	0.000	23.730	263.249	1.657	29.204	291.285	0.807	0.000	90.793	0.000	0.024	0.039	0.000
sp093	Spring	1965+00	0.903	12,849	0.277	0.150	0.259	0.000	50.747	361.913	2.815	43.938	386.612	1.180	0.102	117.941	0.000	0.035	0.055	0.001
sp097	Spring	1972+00	2.195	31,234	0.100	0.057	0.098	0.000	18.708	145.135	1.080	17.277	156.294	0.467	0.010	47.920	0.000	0.014	0.022	0.000
sp098	Spring	1974+00	5.678	80,796	0.041	0.023	0.039	0.000	7.542	56.643	0.429	6.793	60.814	0.183	0.008	18.611	0.000	0.005	0.009	0.000
sp099	Spring	1975+00	1.249	17,773	0.109	0.080	0.135	0.000	23.053	238.063	1.545	26.743	262.199	0.736	0.000	81.501	0.000	0.022	0.036	0.000
sp107	Spring	1984+50	10.203	145,185	0.038	0.018	0.031	0.084	6.521	35.543	0.322	4.637	36.794	0.122	0.039	10.999	0.096	0.004	0.005	0.000
sp115	Spring	2117+00	7.953	113,168	0.050	0.023	0.040	0.850	8.545	45.908	0.420	6.014	47.431	0.158	0.053	14.160	0.147	0.005	0.007	0.000
sp120	Spring	2139+00	3.094	44,026	0.071	0.041	0.070	0.000	13.347	103.093	0.769	12.284	110.976	0.332	0.008	34.017	0.000	0.010	0.015	0.000
sp121	Spring	2140+00	0.325	4,625	0.227	0.249	0.408	0.000	59.955	865.337	4.911	92.223	971.283	2.585	0.000	305.302	0.000	0.076	0.129	0.000
sp122	Spring	2143+00	4.853	69,056	0.076	0.036	0.062	0.000	13.074	73.625	0.654	9.513	76.548	0.251	0.073	22.949	0.121	0.008	0.011	0.000
sp125	Spring	2145+50	3.327	47,342	0.078	0.042	0.072	0.000	14.190	98.950	0.779	12.079	105.462	0.324	0.034	32.126	0.000	0.010	0.015	0.000
sp127	Spring	2146+00	3.327	47,342	0.078	0.042	0.072	0.000	14.190	98.950	0.779	12.079	105.462	0.324	0.034	32.126	0.000	0.010	0.015	0.000
sp128	Spring	2148+00	3.327	47,342	0.078	0.042	0.072	0.000	14.190	98.950	0.779	12.079	105.462	0.324	0.034	32.126	0.000	0.010	0.015	0.000
sp136	Spring	2162+00	0.426	6,062	0.192	0.196	0.322	0.000	48.523	664.989	3.846	71.383	744.535	1.996	0.000	233.687	0.000	0.059	0.099	0.000

Acute Aquatic Criterion, AAC (Table 2, 327 IAC 2-1-6)	0.262	0.042	0.254	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	860	n/a	0.011	3.679	n/a
Chronic Aquatic Criterion, CAC (Table 2, 327 IAC 2-1-6)	0.010	0.026	0.230	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	230	n/a	0.002	0.438	n/a
Point of Water Intake Human Health (Table 1, 327 IAC 2-1-6)	0.050	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.010	n/a	n/a	n/a	0.010	170.000	0.00014
Values in shaded cells exceed one of the water quality standards	**0.010**	**0.026**	**0.230**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**0.010**	**n/a**	**230**	**n/a**	**0.002**	**0.438**	**0.00014**
Number of features exceeding water quality standards	53	45	11							53		4		53		37
Highest concentration	0.602	0.286	0.499							2.686		309.941		0.080	0.132	0.001
Highest concentration feature ID	i020	i020	i020							i182		i182		i182	i182	i020

Table #2-4: 50-Year/10-Min Average Pollutant Concentration of Karst Features for Pre-Construction (Existing) Conditions - Preferred Alternative #8

ID	Type	Approx. Station	Runoff Area inside R/W	Runoff Volume inside R/W	*Average Concentration*															
					Lead	Copper	Zinc	TSS	VSS	TVS	TKN	TOC	COD	TN	TPO4	CL-	Fe	Cd	Cr	Hg
		(feet)	(acres)	(cf)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
i168	sinkhole	1590+00	5.521	24,049	0.389	0.155	0.276	98.611	63.038	255.525	2.795	36.711	252.176	0.938	0.587	72.941	3.634	0.029	0.039	0.001
i020	sinkhole	1590+00	0.583	2,540	2.872	1.216	2.150	430.658	475.562	2209.751	22.103	302.924	2233.955	7.840	3.757	657.204	18.758	0.239	0.338	0.006
i023	sinkhole	1598+00	2.239	9,754	0.296	0.176	0.301	0.000	56.471	458.789	3.336	54.056	496.103	1.465	0.000	152.495	0.000	0.044	0.069	0.001
i024	sinkhole	1595+00	0.488	2,126	1.767	0.937	1.616	0.000	320.158	2210.852	17.498	270.533	2353.970	7.246	0.818	716.621	0.000	0.218	0.333	0.004
i025	sinkhole	1600+00	2.240	9,757	0.588	0.267	0.468	13.800	100.060	534.096	4.901	70.105	551.317	1.838	0.627	164.497	1.824	0.056	0.081	0.001
i426	sinkhole	1788+00	2.591	11,288	0.479	0.222	0.388	0.000	82.152	454.160	4.080	58.999	471.043	1.551	0.478	140.990	1.017	0.047	0.069	0.001
i412	sinkhole	1715+00	0.659	2,871	1.141	0.642	1.101	0.000	212.185	1594.092	12.063	191.161	1711.539	5.153	0.237	523.790	0.000	0.155	0.240	0.002
i040	sinkhole	1778+00	9.851	42,911	0.255	0.098	0.176	78.265	40.878	152.810	1.766	22.619	148.378	0.573	0.411	42.413	2.752	0.018	0.024	0.001
i042	sinkhole	1780+00	1.807	7,871	0.546	0.274	0.476	0.000	96.781	614.920	5.096	76.862	648.818	2.045	0.374	196.383	0.000	0.062	0.093	0.001
i426	sinkhole	1788+00	1.210	5,269	1.040	0.479	0.839	0.000	177.973	976.432	8.813	127.129	1011.700	3.341	1.052	302.613	2.433	0.101	0.148	0.002
i192	sinkhole	2131+00	1.705	7,427	0.708	0.331	0.578	0.000	121.773	684.949	6.091	88.536	712.036	2.332	0.680	213.444	1.148	0.071	0.104	0.001
i430	sinkhole	1795+00	1.235	5,380	0.578	0.333	0.570	0.000	108.585	842.589	6.270	100.296	907.395	2.710	0.058	278.215	0.000	0.081	0.127	0.001
i044	sinkhole	1800+00	2.715	11,827	0.479	0.218	0.383	7.210	81.547	438.911	4.007	57.469	453.582	1.508	0.502	135.439	1.375	0.046	0.067	0.001
i182	sinkhole	1867+50	0.323	1,407	1.233	0.970	1.619	0.000	269.596	2969.769	18.746	329.848	3284.600	9.116	0.000	1023.535	0.000	0.271	0.443	0.002
i205	sinkhole	1868+00	0.561	2,444	0.474	0.485	0.797	0.000	120.068	1649.041	9.530	176.961	1846.496	4.948	0.000	579.594	0.000	0.146	0.245	0.001
i116	sinkhole	1905+00	2.353	10,250	0.744	0.311	0.551	126.594	122.628	555.811	5.649	76.823	559.598	1.984	1.002	164.161	5.267	0.061	0.085	0.002
i174	sinkhole	1936+00	1.210	5,271	0.816	0.410	0.711	0.000	144.605	918.440	7.613	114.812	969.030	3.055	0.559	293.296	0.000	0.092	0.139	0.002
i192	sinkhole	2132+00	1.705	7,427	0.707	0.331	0.578	0.000	121.683	684.776	6.088	88.502	711.900	2.331	0.679	213.412	1.137	0.071	0.104	0.001
i049	sinkhole	2185+00	6.772	29,499	0.222	0.097	0.171	21.657	37.221	183.800	1.769	24.708	187.597	0.643	0.268	55.551	1.135	0.020	0.028	0.000
i084	sinkhole	2197+00	0.426	1,856	1.197	0.817	1.378	0.000	243.553	2319.450	15.619	264.516	2540.134	7.247	0.000	786.876	0.000	0.216	0.347	0.002
i194	sinkhole	2244+00	0.857	3,733	1.024	0.539	0.930	0.000	184.951	1263.497	10.059	155.023	1343.775	4.149	0.505	408.795	0.000	0.125	0.191	0.002
b03	Buried Sink	1653+00	2.925	12,741	0.248	0.142	0.243	0.000	46.419	356.750	2.668	42.558	383.849	1.149	0.033	117.626	0.000	0.034	0.054	0.000
b06	Buried Sink	1672+00	2.703	11,774	0.204	0.133	0.226	0.000	40.603	369.391	2.541	42.506	403.149	1.161	0.000	124.627	0.000	0.035	0.055	0.000
b09	Buried Sink	1676+00	0.956	4,164	0.223	0.268	0.436	0.000	62.325	953.618	5.300	100.848	1073.234	2.834	0.000	337.870	0.000	0.084	0.142	0.000
b010	Buried Sink	1676+00	0.970	4,225	0.531	0.360	0.608	0.000	107.798	1020.091	6.890	116.477	1116.625	3.190	0.000	345.807	0.000	0.095	0.153	0.001
b012	Buried Sink	1680+00	1.622	7,065	0.383	0.236	0.401	0.000	74.162	626.818	4.468	73.229	680.083	1.990	0.000	209.481	0.000	0.060	0.094	0.001
b015	Buried Sink	1685+00	1.290	5,619	0.425	0.279	0.472	0.000	84.889	773.675	5.318	88.995	844.498	2.431	0.000	261.084	0.000	0.073	0.116	0.001
b016	Buried Sink	1695+00	5.139	22,385	0.195	0.098	0.169	0.000	34.531	217.086	1.810	27.211	228.775	0.723	0.139	69.191	0.000	0.022	0.033	0.000
b018	Buried Sink	1697+00	0.474	2,065	1.076	0.734	1.238	0.000	218.951	2084.676	14.040	237.753	2282.984	6.513	0.000	707.209	0.000	0.194	0.312	0.002
b019	Buried Sink	1777+00	2.781	12,114	0.274	0.153	0.263	0.000	50.869	378.763	2.880	45.516	406.323	1.226	0.065	124.283	0.000	0.037	0.057	0.001
b020	Buried Sink	1786+00	1.835	7,993	0.341	0.209	0.356	0.000	65.878	554.621	3.961	64.848	601.554	1.762	0.000	185.255	0.000	0.053	0.083	0.001
sp025	Spring	1584+50	1.453	6,329	0.760	0.366	0.638	0.000	132.354	785.487	6.769	100.007	822.120	2.646	0.642	247.542	0.000	0.080	0.119	0.002
sp026	Spring	1585+00	1.453	6,329	0.760	0.366	0.638	0.000	132.354	785.487	6.769	100.007	822.120	2.646	0.642	247.542	0.000	0.080	0.119	0.002
sp028	Spring	1586+00	1.453	6,329	0.760	0.366	0.638	0.000	132.354	785.487	6.769	100.007	822.120	2.646	0.642	247.542	0.000	0.080	0.119	0.002
sp032	Spring	1632+00	2.997	13,055	0.374	0.179	0.312	0.000	64.937	382.149	3.309	48.769	399.556	1.289	0.323	120.225	0.094	0.039	0.058	0.001
sp034	Spring	1660+00	6.832	29,760	0.345	0.135	0.241	98.272	55.425	214.250	2.419	31.318	209.479	0.796	0.540	60.183	3.515	0.024	0.033	0.001
sp055	Spring	1792+00	13.084	56,994	0.193	0.074	0.133	59.632	30.948	115.346	1.335	17.093	111.931	0.433	0.312	31.980	2.094	0.013	0.018	0.000
sp071	Spring	1895+00	20.725	90,278	0.187	0.067	0.121	77.701	29.202	89.540	1.190	14.351	82.934	0.356	0.340	22.860	2.568	0.011	0.014	0.000
sp077	Spring	1923+00	3.016	13,138	0.347	0.170	0.296	0.000	60.878	373.426	3.157	47.117	392.404	1.250	0.267	118.460	0.000	0.038	0.057	0.001
sp083	Spring	1939+00	1.114	4,853	0.470	0.316	0.534	0.000	94.916	890.051	6.037	101.808	973.622	2.786	0.000	301.398	0.000	0.083	0.133	0.001
sp093	Spring	1965+00	0.903	3,933	1.299	0.613	1.070	0.000	224.326	1283.564	11.299	165.104	1337.280	4.355	1.201	401.454	1.446	0.132	0.195	0.003
sp097	Spring	1972+00	2.195	9,561	0.462	0.230	0.399	0.000	81.454	509.303	4.259	63.931	536.390	1.699	0.334	162.161	0.000	0.051	0.077	0.001
sp098	Spring	1974+00	5.678	24,733	0.189	0.092	0.160	0.000	33.038	199.568	1.702	25.286	209.326	0.670	0.152	63.116	0.000	0.020	0.030	0.000
sp099	Spring	1975+00	1.249	5,441	0.482	0.302	0.512	0.000	94.089	810.168	5.723	94.279	880.363	2.566	0.000	271.427	0.000	0.077	0.121	0.001
sp107	Spring	1984+50	10.203	44,444	0.183	0.075	0.134	36.286	29.991	131.140	1.364	18.347	131.226	0.472	0.256	38.331	1.435	0.014	0.020	0.000
sp115	Spring	2117+00	7.953	34,643	0.241	0.098	0.175	50.257	39.370	169.789	1.782	23.867	169.487	0.613	0.342	49.423	1.956	0.019	0.026	0.001
sp120	Spring	2139+00	3.094	13,477	0.330	0.164	0.284	0.000	58.159	361.964	3.035	45.493	381.008	1.208	0.242	115.146	0.000	0.037	0.055	0.001
sp121	Spring	2140+00	0.325	1,416	0.894	0.861	1.419	0.000	218.556	2866.051	16.857	309.625	3201.686	8.638	0.000	1003.592	0.000	0.256	0.426	0.001
sp122	Spring	2143+00	4.853	21,140	0.363	0.152	0.269	63.115	59.876	270.212	2.754	37.402	271.855	0.965	0.492	79.710	2.608	0.030	0.041	0.001
sp125	Spring	2145+50	3.327	14,492	0.367	0.171	0.299	0.000	62.967	351.981	3.142	45.579	365.602	1.200	0.357	109.536	0.661	0.036	0.053	0.001
sp127	Spring	2146+00	3.327	14,492	0.367	0.171	0.299	0.000	62.967	351.981	3.142	45.579	365.602	1.200	0.357	109.536	0.661	0.036	0.053	0.001
sp128	Spring	2148+00	3.327	14,492	0.367	0.171	0.299	0.000	62.967	351.981	3.142	45.579	365.602	1.200	0.357	109.536	0.661	0.036	0.053	0.001
sp136	Spring	2162+00	0.426	1,856	0.775	0.686	1.136	0.000	180.634	2210.584	13.359	241.336	2460.244	6.709	0.000	769.490	0.000	0.199	0.329	0.001

Acute Aquatic Criterion, AAC (Table 2, 327 IAC 2-1-6)	0.262	0.042	0.254	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	860	n/a	0.011	3.679	n/a
Chronic Aquatic Criterion, CAC (Table 2, 327 IAC 2-1-6)	0.010	0.026	0.230	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	230	n/a	0.002	0.438	n/a
Point of Water Intake Human Health (Table 1, 327 IAC 2-1-6)	0.050	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.010	n/a	n/a	n/a	0.010	170.000	0.00014
Values in shaded cells exceed one of the water quality standards	**0.010**	**0.026**	**0.230**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**0.010**	**n/a**	**230**	**n/a**	**0.002**	**0.438**	**0.00014**
Number of features exceeding water quality standards	53	53	44							53		22		53		53
Highest concentration	2.872	1.216	2.150							9.116		1023.535		0.271	0.443	0.006
Highest concentration feature ID	i020	i020	i020							i182		i182		i182	i182	i020

Table #2-5: 1-Year/1-Hour Average Pollutant Concentration of Karst Features for Post-Construction (Proposed) Conditions - Preferred Alternative #8

ID	Type	Approx. Station	Runoff Area inside R/W	Runoff Volume inside R/W	*Average Concentration*															
					Lead	Copper	Zinc	TSS	VSS	TVS	TKN	TOC	COD	TN	TPO4	CL-	Fe	Cd	Cr	Hg
		(feet)	(acres)	(cf)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
i015	sinkhole	1577+50	0.825	3,624	1.076	0.562	0.970	0.000	193.662	1307.023	10.475	160.853	1388.278	4.300	0.566	421.989	0.000	0.130	0.197	0.002
i219	sinkhole	1557+50	0.950	4,171	1.112	0.543	0.945	0.000	194.719	1181.246	10.051	149.491	1239.638	3.962	0.884	373.904	0.000	0.120	0.179	0.002
i020	sinkhole	1590+00	14.658	64,382	0.179	0.068	0.122	57.424	28.515	104.044	1.222	15.543	100.506	0.393	0.293	28.619	1.998	0.012	0.016	0.000
i023	sinkhole	1597+50	2.135	9,377	0.543	0.256	0.448	0.000	93.764	537.853	4.728	69.134	560.542	1.824	0.499	168.311	0.563	0.055	0.082	0.001
i017	sinkhole	1575+00	0.615	2,701	5.065	1.876	3.376	1865.989	799.589	2687.277	33.442	414.648	2547.681	10.386	8.750	715.223	63.092	0.322	0.417	0.012
i025	sinkhole	1599+00	2.239	9,836	0.985	0.389	0.695	261.772	159.119	633.413	7.012	91.599	622.932	2.335	1.508	179.727	9.528	0.072	0.097	0.002
i050	sinkhole	1605+00	1.345	5,906	0.731	0.367	0.636	0.000	129.422	820.316	6.808	102.601	865.297	2.729	0.504	261.859	0.000	0.082	0.124	0.001
i168	sinkhole	1588+00	17.116	75,179	0.212	0.077	0.138	85.368	33.151	104.210	1.360	16.528	97.159	0.411	0.380	26.922	2.837	0.013	0.016	0.000
i024	sinkhole	1596+00	0.488	2,145	2.788	1.250	2.195	131.877	471.889	2458.695	22.895	325.081	2529.360	8.504	3.099	752.977	10.450	0.259	0.374	0.006
i387	sinkhole	1580+00	0.318	1,398	1.544	1.070	1.802	0.000	316.511	3066.668	20.488	348.581	3362.651	9.560	0.000	1042.460	0.000	0.285	0.459	0.003
i379	sinkhole	1570+00	6.487	28,493	0.576	0.207	0.375	235.997	90.064	279.447	3.683	44.565	259.647	1.107	1.041	71.750	7.820	0.034	0.044	0.001
i412	sinkhole	1715+00	0.659	2,897	1.735	0.823	1.437	0.000	300.292	1735.493	15.188	222.604	1810.427	5.876	1.567	543.947	1.406	0.178	0.263	0.004
i042	sinkhole	1712+10	1.807	7,939	0.845	0.366	0.646	92.304	141.162	687.915	6.677	92.864	700.709	2.414	1.040	207.207	4.586	0.074	0.105	0.002
i040	sinkhole	1777+50	9.872	43,363	0.463	0.162	0.295	207.112	71.736	205.346	2.871	33.909	186.554	0.835	0.870	50.615	6.757	0.026	0.032	0.001
i426	sinkhole	1788+00	2.591	11,382	0.746	0.304	0.540	160.926	121.748	520.094	5.493	73.350	518.290	1.883	1.070	150.954	6.203	0.058	0.080	0.002
i044	sinkhole	1800+00	2.738	12,025	0.839	0.329	0.587	234.276	135.013	526.503	5.910	76.714	515.689	1.952	1.305	148.348	8.421	0.060	0.081	0.002
i430	sinkhole	1794+50	1.266	5,559	0.849	0.412	0.717	0.000	148.311	890.197	7.621	112.986	933.002	2.992	0.696	281.181	0.000	0.091	0.135	0.002
i182	sinkhole	1868+00	0.320	1,406	1.859	1.165	1.978	0.000	363.077	3134.101	22.113	364.527	3406.335	9.923	0.000	1050.346	0.000	0.297	0.470	0.003
i205	sinkhole	1869+00	0.561	2,466	0.610	0.525	0.870	0.000	139.981	1670.418	10.198	183.093	1856.410	5.083	0.000	580.139	0.000	0.151	0.249	0.001
i116	sinkhole	1905+00	2.353	10,333	1.160	0.439	0.788	386.269	184.534	660.138	7.862	99.374	634.927	2.506	1.925	180.210	13.335	0.077	0.102	0.003
i174	sinkhole	1936+00	1.210	5,313	1.262	0.547	0.964	137.350	210.798	1027.703	9.972	138.714	1046.885	3.606	1.551	309.589	6.835	0.110	0.157	0.003
i192	sinkhole	2131+00	1.705	7,489	1.100	0.451	0.801	223.678	180.004	781.786	8.168	109.629	781.368	2.819	1.551	228.048	8.777	0.086	0.120	0.002
i252	sinkhole	2129+00	0.333	1,462	1.531	1.040	1.755	0.000	310.785	2947.322	19.886	336.393	3226.750	9.213	0.000	999.388	0.000	0.275	0.441	0.003
i269	sinkhole	2139+00	0.337	1,479	1.794	1.115	1.895	0.000	348.985	2984.446	21.153	347.799	3241.202	9.461	0.000	998.959	0.000	0.283	0.448	0.003
i054	sinkhole	2155+00	4.934	21,670	0.324	0.139	0.245	42.684	53.853	255.713	2.523	34.808	259.414	0.903	0.412	76.499	1.956	0.028	0.039	0.001
i048	sinkhole	2153+00	0.658	2,892	1.178	0.651	1.119	0.000	217.411	1594.249	12.219	192.268	1707.730	5.173	0.335	521.865	0.000	0.155	0.240	0.002
i078	sinkhole	2149+00	3.398	14,925	0.377	0.172	0.302	4.541	64.336	347.310	3.165	45.435	359.066	1.192	0.394	107.245	1.053	0.036	0.053	0.001
i055	sinkhole	2192+50	0.760	3,337	1.473	0.704	1.229	0.000	255.803	1497.968	13.009	191.429	1565.236	5.059	1.289	470.788	0.596	0.153	0.227	0.003
i049	sinkhole	2185+00	8.743	38,402	0.262	0.103	0.183	73.012	42.194	164.723	1.848	23.991	161.376	0.610	0.408	46.430	2.626	0.019	0.025	0.001
i084	sinkhole	2197+50	0.426	1,872	1.755	0.986	1.691	0.000	326.067	2445.811	18.524	293.405	2625.617	7.908	0.373	803.454	0.000	0.237	0.368	0.003
i064	sinkhole	2209+00	0.691	3,036	2.030	0.902	1.585	130.309	342.337	1752.501	16.497	232.962	1798.297	6.084	2.322	534.432	8.538	0.185	0.267	0.004
i194	sinkhole	2244+00	0.857	3,765	1.554	0.701	1.231	53.949	263.731	1391.911	12.860	183.320	1434.523	4.801	1.690	427.569	5.294	0.146	0.212	0.003
b16	Buried Sink	1694+00	5.170	22,707	0.300	0.129	0.228	35.095	50.034	241.683	2.359	32.717	245.842	0.850	0.374	72.631	1.691	0.026	0.037	0.001
b03	Buried Sink	1652+50	3.550	15,594	0.307	0.148	0.258	0.000	53.539	318.500	2.741	40.524	333.452	1.072	0.258	100.422	0.000	0.032	0.048	0.001
b06	Buried Sink	1672+50	3.611	15,859	0.244	0.128	0.221	0.000	43.951	298.141	2.383	36.645	316.848	0.980	0.125	96.344	0.000	0.030	0.045	0.000
b10	Buried Sink	1677+00	0.976	4,288	0.838	0.453	0.779	0.000	153.053	1086.124	8.471	132.020	1159.666	3.543	0.322	353.660	0.000	0.107	0.164	0.002
b09	Buried Sink	1675+50	1.340	5,887	0.563	0.315	0.541	0.000	104.467	779.084	5.918	93.587	835.899	2.521	0.130	255.702	0.000	0.076	0.117	0.001
b08	Buried Sink	1675+00	1.074	4,715	0.657	0.379	0.648	0.000	123.483	960.619	7.140	114.280	1034.742	3.088	0.060	317.306	0.000	0.093	0.144	0.001
b12	Buried Sink	1681+00	1.622	7,123	0.614	0.306	0.532	0.000	108.492	682.213	5.687	85.508	718.965	2.273	0.436	217.449	0.000	0.069	0.103	0.001
b15	Buried Sink	1685+00	1.290	5,665	0.614	0.336	0.578	0.000	112.800	816.856	6.302	98.807	873.929	2.656	0.198	266.859	0.000	0.080	0.123	0.001
b18	Buried Sink	1697+50	0.675	2,965	1.014	0.593	1.014	0.000	191.932	1520.024	11.194	180.106	1639.954	4.873	0.030	503.398	0.000	0.146	0.228	0.002
b17	Buried Sink	1695+00	1.017	4,468	1.048	0.510	0.888	0.000	183.242	1105.426	9.436	140.109	1159.290	3.712	0.847	349.517	0.000	0.112	0.167	0.002
b19	Buried Sink	1718+00	2.821	12,389	0.356	0.177	0.308	0.000	62.876	393.085	3.288	49.345	413.984	1.311	0.258	125.154	0.000	0.040	0.059	0.001
b20	Buried Sink	1787+00	1.835	8,060	0.445	0.241	0.414	0.000	81.295	577.673	4.502	70.194	616.871	1.884	0.169	188.142	0.000	0.057	0.087	0.001
sp021	Spring	1757+00	2.923	12,838	0.338	0.169	0.293	0.000	59.756	377.743	3.140	47.280	398.335	1.257	0.235	120.522	0.000	0.038	0.057	0.001
sp025	Spring	1583+00	4.850	21,304	0.466	0.183	0.327	127.492	75.064	295.210	3.295	42.880	289.634	1.092	0.720	83.420	4.605	0.034	0.045	0.001
sp026	Spring	1583+50	4.850	21,303	0.466	0.183	0.327	127.497	75.068	295.223	3.295	42.882	289.647	1.092	0.720	83.424	4.606	0.034	0.045	0.001
sp028	Spring	1585+00	4.852	21,312	0.465	0.183	0.327	127.444	75.036	295.100	3.294	42.864	289.526	1.091	0.720	83.390	4.604	0.034	0.045	0.001
sp032	Spring	1585+00	10.928	48,000	0.301	0.110	0.199	114.612	47.316	155.246	1.965	24.189	146.323	0.604	0.527	40.893	3.849	0.019	0.024	0.001
sp055	Spring	1791+00	16.968	74,530	0.194	0.071	0.128	73.810	30.472	99.982	1.266	15.578	94.236	0.389	0.339	26.336	2.479	0.012	0.016	0.000
sp071	Spring	1895+00	20.726	91,034	0.248	0.086	0.156	115.646	38.270	104.907	1.515	17.662	94.067	0.433	0.475	25.243	3.747	0.014	0.016	0.001
sp077	Spring	1923+00	3.017	13,253	0.527	0.226	0.399	68.021	87.631	417.391	4.110	56.759	423.641	1.472	0.668	124.971	3.143	0.045	0.064	0.001
sp083	Spring	1939+50	1.114	4,891	0.681	0.380	0.653	0.000	126.244	938.486	7.141	112.819	1006.618	3.039	0.165	307.867	0.000	0.091	0.141	0.001
sp093	Spring	1965+00	1.429	6,275	1.225	0.511	0.906	213.017	201.819	910.534	9.281	126.046	916.028	3.253	1.659	268.577	8.797	0.099	0.139	0.003
sp097	Spring	1972+50	4.715	20,712	0.333	0.143	0.252	40.723	55.396	265.902	2.605	36.069	270.213	0.936	0.418	79.777	1.924	0.029	0.041	0.001

sp098	Spring	1973+50	6.559	28,810	0.286	0.117	0.209	58.476	46.870	203.352	2.126	28.526	203.206	0.733	0.404	59.300	2.292	0.022	0.031	0.001
sp099	Spring	1974+00	1.281	5,626	0.423	0.278	0.470	0.000	84.511	772.293	5.302	88.789	843.162	2.426	0.000	260.704	0.000	0.072	0.116	0.001
sp105	Spring	1982+00	0.522	2,294	0.894	0.638	1.072	0.000	185.929	1857.320	12.237	209.912	2040.986	5.768	0.000	633.552	0.000	0.172	0.278	0.001
sp106	Spring	1923+00	0.522	2,294	0.894	0.638	1.072	0.000	185.926	1857.288	12.237	209.908	2040.951	5.768	0.000	633.541	0.000	0.172	0.278	0.001
sp107	Spring	1985+00	14.565	63,973	0.061	0.032	0.055	0.000	11.042	74.162	0.596	9.138	78.732	0.244	0.033	23.924	0.000	0.007	0.011	0.000
sp110	Spring	1991+00	1.235	5,427	0.811	0.404	0.701	0.000	143.074	896.610	7.489	112.482	944.541	2.989	0.582	285.601	0.000	0.090	0.136	0.002
sp112	Spring	2110+50	1.493	6,559	0.886	0.401	0.703	26.871	150.394	797.251	7.346	104.862	822.165	2.747	0.955	245.153	2.912	0.083	0.121	0.002
sp115	Spring	2122+50	12.272	53,902	0.247	0.092	0.165	89.038	38.992	132.810	1.637	20.383	126.311	0.511	0.423	35.547	3.023	0.016	0.021	0.001
sp120	Spring	2140+00	4.583	20,130	0.382	0.159	0.282	66.398	62.908	283.817	2.893	39.289	285.530	1.014	0.517	83.717	2.742	0.031	0.043	0.001
sp121	Spring	2110+00	0.811	3,563	0.444	0.370	0.614	0.000	100.037	1161.529	7.171	127.879	1288.796	3.545	0.000	402.376	0.000	0.105	0.173	0.001
sp122	Spring	2141+00	10.555	46,362	0.071	0.040	0.068	0.000	13.130	98.687	0.747	11.833	105.963	0.319	0.015	32.429	0.000	0.010	0.015	0.000
sp124	Spring	2144+00	2.030	8,914	0.493	0.246	0.427	0.000	87.095	545.804	4.559	68.472	574.981	1.820	0.354	173.857	0.000	0.055	0.083	0.001
sp125	Spring	2145+00	16.716	73,422	0.149	0.058	0.103	45.861	23.920	89.358	1.033	13.230	86.755	0.335	0.241	24.796	1.612	0.010	0.014	0.000
sp127	Spring	2146+00	16.716	73,422	0.181	0.067	0.121	65.615	28.686	97.605	1.204	14.986	92.807	0.376	0.311	26.113	2.227	0.012	0.015	0.000
sp128	Spring	2148+00	16.716	73,422	0.181	0.067	0.121	65.616	28.686	97.606	1.204	14.986	92.807	0.376	0.311	26.113	2.227	0.012	0.015	0.000
sp136	Spring	2161+50	0.560	2,458	0.834	0.595	1.000	0.000	173.503	1733.196	11.420	195.883	1904.587	5.382	0.000	591.212	0.000	0.160	0.259	0.001
sp167	Spring	2287+00	0.393	1,727	1.188	0.847	1.424	0.000	246.988	2467.264	16.256	278.847	2711.245	7.662	0.000	841.610	0.000	0.228	0.369	0.002

0.300

Acute Aquatic Criterion, AAC (Table 2, 327 IAC 2-1-6)	0.262	0.042	0.254	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	860	n/a	0.011	3.679	n/a
Chronic Aquatic Criterion, CAC (Table 2, 327 IAC 2-1-6)	0.010	0.026	0.230	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	230	n/a	0.002	0.438	n/a
Point of Water Intake Human Health (Table 1, 327 IAC 2-1-6)	0.050	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.010	n/a	n/a	n/a	0.010	170.000	0.00014
Values in shaded cells exceed one of the water quality standards	**0.010**	**0.026**	**0.230**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**0.010**	**n/a**	**230**	**n/a**	**0.002**	**0.438**	**0.00014**
Number of features exceeding water quality standards	72	72	57							72		34		72		70
Highest concentration	5.065	1.876	3.376							10.386		1050.346		0.322	0.470	0.012
Highest concentration feature ID	i017	i017	i017							i017		i182		i017	i182	i017

Table #2-6: 2-Year/24-Hour Average Pollutant Concentration of Karst Features for Post-Construction (Proposed) Conditions - Preferred Alternative #8

ID	Type	Approx. Station	Runoff Area inside R/W	Runoff Volume inside R/W	*Average Concentration*															
					Lead	Copper	Zinc	TSS	VSS	TVS	TKN	TOC	COD	TN	TPO4	CL-	Fe	Cd	Cr	Hg
		(feet)	(acres)	(cf)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
i015	sinkhole	1577+50	0.825	9,464	0.266	0.170	0.288	0.000	52.376	462.790	3.229	53.568	503.934	1.460	0.000	155.566	0.000	0.044	0.069	0.000
i219	sinkhole	1557+50	0.950	10,894	0.270	0.160	0.272	0.000	51.333	412.124	3.014	48.685	445.180	1.319	0.000	136.754	0.000	0.040	0.062	0.001
i020	sinkhole	1590+00	14.658	168,138	0.041	0.018	0.031	5.035	6.828	32.762	0.321	4.445	33.291	0.115	0.051	9.828	0.238	0.004	0.005	0.000
i023	sinkhole	1597+50	2.135	24,488	0.131	0.074	0.127	0.000	24.409	186.063	1.397	22.238	200.044	0.600	0.021	61.272	0.000	0.018	0.028	0.000
i017	sinkhole	1575+00	0.615	7,055	1.154	0.475	0.843	229.568	189.170	826.546	8.602	115.667	826.975	2.976	1.619	241.538	9.072	0.091	0.127	0.003
i025	sinkhole	1599+00	2.239	25,687	0.228	0.103	0.180	7.819	38.631	203.961	1.884	26.859	210.216	0.703	0.247	62.658	0.773	0.021	0.031	0.000
i050	sinkhole	1605+00	1.345	15,423	0.179	0.109	0.186	0.000	34.471	288.005	2.065	33.729	312.176	0.916	0.000	96.100	0.000	0.027	0.043	0.000
i168	sinkhole	1588+00	17.116	196,335	0.048	0.019	0.034	12.284	7.771	31.385	0.344	4.515	30.952	0.115	0.073	8.948	0.452	0.004	0.005	0.000
i024	sinkhole	1596+00	0.488	5,601	0.663	0.353	0.609	0.000	120.365	837.082	6.600	102.252	891.922	2.740	0.293	271.654	0.000	0.082	0.126	0.001
i387	sinkhole	1580+00	0.318	3,652	0.415	0.355	0.589	0.000	94.902	1128.767	6.901	123.788	1254.211	3.436	0.000	391.904	0.000	0.102	0.168	0.001
i379	sinkhole	1570+00	6.487	74,412	0.131	0.052	0.092	34.780	21.075	83.799	0.928	12.123	82.393	0.309	0.200	23.768	1.265	0.009	0.013	0.000
i412	sinkhole	1715+00	0.659	7,565	0.418	0.239	0.409	0.000	78.304	601.072	4.498	71.724	646.657	1.936	0.057	198.148	0.000	0.058	0.090	0.001
i042	sinkhole	1712+10	1.807	20,732	0.199	0.102	0.176	0.000	35.531	231.363	1.891	28.735	244.792	0.766	0.124	74.224	0.000	0.023	0.035	0.000
i040	sinkhole	1777+50	9.872	113,245	0.104	0.040	0.071	34.318	16.614	59.849	0.709	8.985	57.652	0.227	0.172	16.382	1.188	0.007	0.009	0.000
i426	sinkhole	1788+00	2.591	29,726	0.173	0.082	0.143	0.000	29.912	170.244	1.503	21.932	177.246	0.578	0.162	53.186	0.221	0.018	0.026	0.000
i044	sinkhole	1800+00	2.738	31,405	0.193	0.086	0.152	10.837	32.669	168.679	1.579	22.364	173.301	0.585	0.218	51.546	0.771	0.018	0.026	0.000
i430	sinkhole	1794+50	1.266	14,518	0.206	0.121	0.206	0.000	39.004	310.092	2.279	36.711	334.673	0.994	0.003	102.753	0.000	0.030	0.047	0.000
i182	sinkhole	1868+00	0.320	3,671	0.484	0.375	0.627	0.000	105.028	1141.258	7.246	127.056	1261.156	3.509	0.000	392.795	0.000	0.104	0.170	0.001
i205	sinkhole	1869+00	0.561	6,440	0.177	0.183	0.301	0.000	45.112	624.935	3.600	66.981	700.062	1.874	0.000	219.796	0.000	0.055	0.093	0.000
i116	sinkhole	1905+00	2.353	26,986	0.266	0.113	0.200	37.645	44.057	206.744	2.055	28.250	209.342	0.732	0.343	61.654	1.676	0.022	0.032	0.001
i174	sinkhole	1936+00	1.210	13,874	0.298	0.152	0.263	0.000	53.063	345.670	2.825	42.927	365.750	1.144	0.185	110.904	0.000	0.035	0.052	0.001
i192	sinkhole	2131+00	1.705	19,557	0.256	0.122	0.212	0.000	44.354	256.839	2.245	32.925	267.995	0.869	0.230	80.533	0.192	0.026	0.039	0.001
i252	sinkhole	2129+00	0.333	3,817	0.409	0.343	0.570	0.000	92.547	1082.787	6.664	119.062	1201.967	3.302	0.000	375.367	0.000	0.098	0.161	0.001
i269	sinkhole	2139+00	0.337	3,864	0.466	0.358	0.599	0.000	100.672	1085.752	6.916	121.034	1199.245	3.341	0.000	373.406	0.000	0.099	0.162	0.001
i054	sinkhole	2155+00	4.934	56,593	0.076	0.038	0.066	0.000	13.488	85.573	0.710	10.700	90.275	0.285	0.052	27.321	0.000	0.009	0.013	0.000
i048	sinkhole	2153+00	0.658	7,551	0.296	0.201	0.339	0.000	60.068	570.346	3.846	65.081	624.475	1.783	0.000	193.423	0.000	0.053	0.085	0.001
i078	sinkhole	2149+00	3.398	38,977	0.090	0.049	0.085	0.000	16.531	118.967	0.921	14.412	127.201	0.387	0.031	38.826	0.000	0.012	0.018	0.000
i055	sinkhole	2192+50	0.760	8,716	0.356	0.205	0.351	0.000	66.899	519.862	3.866	61.861	559.920	1.672	0.034	171.690	0.000	0.050	0.078	0.001
i049	sinkhole	2185+00	8.743	100,289	0.060	0.027	0.047	3.317	10.211	52.788	0.494	6.996	54.244	0.183	0.068	16.136	0.239	0.006	0.008	0.000
i084	sinkhole	2197+50	0.426	4,888	0.442	0.306	0.516	0.000	90.636	877.321	5.864	99.741	961.930	2.735	0.000	298.197	0.000	0.082	0.131	0.001
i064	sinkhole	2209+00	0.691	7,928	0.482	0.254	0.438	0.000	87.009	594.789	4.734	72.965	632.623	1.953	0.237	192.461	0.000	0.059	0.090	0.001
i194	sinkhole	2244+00	0.857	9,832	0.370	0.199	0.343	0.000	67.448	474.949	3.720	57.839	506.711	1.551	0.151	154.454	0.000	0.047	0.072	0.001
b16	Buried Sink	1694+00	5.170	59,301	0.071	0.036	0.062	0.000	12.572	81.147	0.667	10.101	85.773	0.269	0.046	25.991	0.000	0.008	0.012	0.000
b03	Buried Sink	1652+50	3.550	40,725	0.074	0.043	0.074	0.000	14.051	110.798	0.818	13.141	119.494	0.355	0.003	36.671	0.000	0.011	0.017	0.000
b06	Buried Sink	1672+50	3.611	41,416	0.060	0.039	0.066	0.000	11.902	105.636	0.735	12.216	115.068	0.333	0.000	35.530	0.000	0.010	0.016	0.000
b10	Buried Sink	1677+00	0.976	11,200	0.209	0.139	0.234	0.000	41.925	387.027	2.644	44.406	422.869	1.214	0.000	130.811	0.000	0.036	0.058	0.000
b09	Buried Sink	1675+50	1.340	15,373	0.142	0.098	0.165	0.000	28.993	279.273	1.871	31.780	306.098	0.871	0.000	94.870	0.000	0.026	0.042	0.000
b08	Buried Sink	1675+00	1.074	12,314	0.167	0.119	0.200	0.000	34.668	346.004	2.281	39.111	380.197	1.075	0.000	118.014	0.000	0.032	0.052	0.000
b12	Buried Sink	1681+00	1.622	18,601	0.150	0.091	0.155	0.000	28.842	239.251	1.721	28.063	259.173	0.762	0.000	79.754	0.000	0.023	0.036	0.000
b15	Buried Sink	1685+00	1.290	14,796	0.154	0.104	0.175	0.000	31.062	291.795	1.977	33.365	319.235	0.913	0.000	98.831	0.000	0.027	0.044	0.000
b18	Buried Sink	1697+50	0.675	7,743	0.259	0.187	0.314	0.000	54.154	548.573	3.592	61.840	603.402	1.701	0.000	187.413	0.000	0.051	0.082	0.000
b17	Buried Sink	1695+00	1.017	11,667	0.254	0.150	0.256	0.000	48.246	385.354	2.826	45.574	416.073	1.234	0.000	127.777	0.000	0.037	0.058	0.000
b19	Buried Sink	1718+00	2.821	32,355	0.087	0.053	0.089	0.000	16.692	137.741	0.994	16.174	149.144	0.439	0.000	45.883	0.000	0.013	0.021	0.000
b20	Buried Sink	1787+00	1.835	21,048	0.111	0.074	0.125	0.000	22.276	205.881	1.406	23.617	224.967	0.646	0.000	69.596	0.000	0.019	0.031	0.000
sp021	Spring	1757+00	2.923	33,527	0.083	0.050	0.086	0.000	15.906	132.573	0.952	15.534	143.670	0.422	0.000	44.222	0.000	0.013	0.020	0.000
sp025	Spring	1583+00	4.850	55,636	0.107	0.048	0.085	5.071	18.188	94.777	0.882	12.531	97.502	0.328	0.119	29.026	0.402	0.010	0.014	0.000
sp026	Spring	1583+50	4.850	55,633	0.107	0.048	0.085	5.071	18.189	94.781	0.883	12.531	97.507	0.328	0.119	29.027	0.402	0.010	0.014	0.000
sp028	Spring	1585+00	4.852	55,657	0.107	0.048	0.085	5.069	18.181	94.742	0.882	12.526	97.466	0.328	0.119	29.015	0.402	0.010	0.014	0.000
sp032	Spring	1585+00	10.928	125,356	0.068	0.028	0.049	15.033	11.156	47.400	0.502	6.698	47.190	0.172	0.099	13.735	0.576	0.005	0.007	0.000
sp055	Spring	1791+00	16.968	194,642	0.044	0.018	0.032	9.681	7.185	30.527	0.324	4.313	30.392	0.111	0.064	8.846	0.371	0.003	0.005	0.000
sp071	Spring	1895+00	20.726	237,743	0.056	0.021	0.037	20.090	8.817	30.071	0.370	4.613	28.608	0.116	0.095	8.053	0.682	0.004	0.005	0.000
sp077	Spring	1923+00	3.017	34,610	0.124	0.062	0.108	0.000	21.960	139.762	1.157	17.462	147.495	0.465	0.084	44.649	0.000	0.014	0.021	0.000
sp083	Spring	1939+50	1.114	12,774	0.171	0.118	0.199	0.000	35.007	336.287	2.256	38.287	368.516	1.049	0.000	114.201	0.000	0.031	0.050	0.000
sp093	Spring	1965+00	1.429	16,386	0.286	0.139	0.242	0.000	50.069	301.573	2.577	38.240	316.208	1.013	0.232	95.323	0.000	0.031	0.046	0.001
sp097	Spring	1972+50	4.715	54,090	0.078	0.040	0.069	0.000	13.903	89.171	0.735	11.118	94.187	0.296	0.052	28.528	0.000	0.009	0.013	0.000

sp098	Spring	1973+50	6.559	75,239	0.067	0.032	0.055	0.000	11.547	66.792	0.584	8.565	69.683	0.226	0.060	20.938	0.052	0.007	0.010	0.000
sp099	Spring	1974+00	1.281	14,692	0.112	0.091	0.151	0.000	24.875	282.767	1.761	31.240	313.352	0.865	0.000	97.758	0.000	0.026	0.042	0.000
sp105	Spring	1982+00	0.522	5,990	0.242	0.213	0.353	0.000	56.307	685.430	4.151	74.893	762.614	2.081	0.000	238.481	0.000	0.062	0.102	0.000
sp106	Spring	1923+00	0.522	5,990	0.242	0.213	0.353	0.000	56.306	685.418	4.151	74.891	762.600	2.081	0.000	238.477	0.000	0.062	0.102	0.000
sp107	Spring	1985+00	14.565	167,069	0.015	0.010	0.016	0.000	2.983	26.243	0.183	3.040	28.566	0.083	0.000	8.817	0.000	0.002	0.004	0.000
sp110	Spring	1991+00	1.235	14,172	0.198	0.120	0.204	0.000	38.005	314.289	2.265	36.888	340.370	1.001	0.000	104.723	0.000	0.030	0.047	0.000
sp112	Spring	2110+50	1.493	17,128	0.211	0.114	0.196	0.000	38.498	272.246	2.127	33.120	290.577	0.889	0.083	88.597	0.000	0.027	0.041	0.000
sp115	Spring	2122+50	12.272	140,770	0.056	0.023	0.041	10.518	9.243	41.012	0.423	5.709	41.144	0.147	0.078	12.040	0.424	0.005	0.006	0.000
sp120	Spring	2140+00	4.583	52,570	0.089	0.043	0.076	0.000	15.607	94.002	0.803	11.920	98.563	0.316	0.072	29.712	0.000	0.010	0.014	0.000
sp121	Spring	2110+00	0.811	9,306	0.127	0.128	0.211	0.000	31.917	433.709	2.517	46.613	485.383	1.303	0.000	152.309	0.000	0.039	0.064	0.000
sp122	Spring	2141+00	10.555	121,078	0.018	0.012	0.021	0.000	3.652	35.408	0.236	4.024	38.827	0.110	0.000	12.037	0.000	0.003	0.005	0.000
sp124	Spring	2144+00	2.030	23,280	0.120	0.073	0.124	0.000	23.135	191.321	1.379	22.456	207.197	0.609	0.000	63.749	0.000	0.018	0.029	0.000
sp125	Spring	2145+00	16.716	191,747	0.034	0.015	0.026	3.425	5.749	28.315	0.273	3.809	28.889	0.099	0.042	8.552	0.178	0.003	0.004	0.000
sp127	Spring	2146+00	16.716	191,747	0.041	0.017	0.030	7.777	6.799	30.132	0.311	4.196	30.222	0.108	0.057	8.842	0.313	0.003	0.005	0.000
sp128	Spring	2148+00	16.716	191,746	0.041	0.017	0.030	7.777	6.799	30.132	0.311	4.196	30.222	0.108	0.057	8.842	0.313	0.003	0.005	0.000
sp136	Spring	2161+50	0.560	6,419	0.226	0.199	0.330	0.000	52.544	639.623	3.874	69.888	711.648	1.942	0.000	222.543	0.000	0.058	0.095	0.000
sp167	Spring	2287+00	0.393	4,509	0.322	0.283	0.469	0.000	74.798	910.525	5.514	99.487	1013.056	2.765	0.000	316.798	0.000	0.082	0.136	0.000

Acute Aquatic Criterion, AAC (Table 2, 327 IAC 2-1-6)	0.262	0.042	0.254	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	860	n/a	0.011	3.679	n/a
Chronic Aquatic Criterion, CAC (Table 2, 327 IAC 2-1-6)	0.010	0.026	0.230	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	230	n/a	0.002	0.438	n/a
Point of Water Intake Human Health (Table 1, 327 IAC 2-1-6)	0.050	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.010	n/a	n/a	n/a	0.010	170.000	0.00014
Values in shaded cells exceed one of the water quality standards	**0.010**	**0.026**	**0.230**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**0.010**	**n/a**	**230**	**n/a**	**0.002**	**0.438**	**0.00014**
Number of features exceeding water quality standards	72	62	24							72		10		72		59
Highest concentration	1.154	0.475	0.843							3.509		392.795		0.104	0.170	0.003
Highest concentration feature ID	i017	i017	i017							i182		i182		i182	i182	i017

Table #2-7: 5-Year/24-Hour Average Pollutant Concentration of Karst Features for Post-Construction (Proposed) Conditions - Preferred Alternative #8

ID	Type	Approx. Station	Runoff Area inside R/W	Runoff Volume inside R/W	*Average Concentration*															
					Lead	Copper	Zinc	TSS	VSS	TVS	TKN	TOC	COD	TN	TPO4	CL-	Fe	Cd	Cr	Hg
		(feet)	(acres)	(cf)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
i015	sinkhole	1577+50	0.825	11,740	0.236	0.144	0.245	0.000	45.491	378.722	2.720	44.387	410.383	1.205	0.000	126.309	0.000	0.036	0.057	0.000
i219	sinkhole	1557+50	0.950	13,514	0.241	0.136	0.233	0.000	44.867	338.255	2.555	40.530	363.296	1.093	0.047	111.204	0.000	0.033	0.051	0.000
i020	sinkhole	1590+00	14.658	208,577	0.037	0.015	0.027	6.603	6.118	27.473	0.281	3.809	27.616	0.098	0.051	8.093	0.271	0.003	0.004	0.000
i023	sinkhole	1597+50	2.135	30,378	0.117	0.063	0.109	0.000	21.402	152.974	1.188	18.562	163.450	0.498	0.042	49.870	0.000	0.015	0.023	0.000
i017	sinkhole	1575+00	0.615	8,752	1.048	0.419	0.747	257.849	170.056	696.684	7.565	99.712	688.942	2.549	1.565	199.562	9.577	0.078	0.107	0.002
i025	sinkhole	1599+00	2.239	31,864	0.206	0.090	0.158	20.174	34.488	170.208	1.639	22.885	173.709	0.596	0.249	51.435	1.055	0.018	0.026	0.000
i050	sinkhole	1605+00	1.345	19,133	0.159	0.093	0.158	0.000	30.052	236.085	1.746	28.024	254.528	0.758	0.009	78.094	0.000	0.023	0.035	0.000
i168	sinkhole	1588+00	17.116	243,554	0.044	0.017	0.030	12.965	7.003	26.579	0.304	3.912	25.890	0.099	0.069	7.418	0.459	0.003	0.004	0.000
i024	sinkhole	1596+00	0.488	6,948	0.595	0.303	0.526	0.000	106.084	690.458	5.646	85.763	730.496	2.286	0.371	221.489	0.000	0.069	0.104	0.001
i387	sinkhole	1580+00	0.318	4,530	0.361	0.294	0.490	0.000	80.449	916.753	5.704	101.243	1016.059	2.803	0.000	317.013	0.000	0.083	0.137	0.001
i379	sinkhole	1570+00	6.487	92,309	0.119	0.046	0.082	36.380	19.002	71.035	0.821	10.515	68.975	0.266	0.191	19.716	1.279	0.008	0.011	0.000
i412	sinkhole	1715+00	0.659	9,384	0.374	0.204	0.351	0.000	68.628	494.064	3.824	59.846	528.276	1.608	0.128	161.253	0.000	0.048	0.074	0.001
i042	sinkhole	1712+10	1.807	25,719	0.179	0.088	0.153	0.000	31.422	191.317	1.624	24.188	200.862	0.641	0.141	60.602	0.000	0.019	0.029	0.000
i040	sinkhole	1777+50	9.872	140,481	0.095	0.035	0.064	34.417	15.022	51.064	0.630	7.843	48.543	0.197	0.163	13.656	1.168	0.006	0.008	0.000
i426	sinkhole	1788+00	2.591	36,875	0.157	0.071	0.125	4.248	26.621	141.576	1.302	18.603	146.066	0.488	0.168	43.567	0.501	0.015	0.022	0.000
i044	sinkhole	1800+00	2.738	38,958	0.175	0.075	0.133	20.575	29.191	140.918	1.376	19.080	143.329	0.496	0.218	42.342	0.990	0.015	0.022	0.000
i430	sinkhole	1794+50	1.266	18,010	0.184	0.103	0.177	0.000	34.112	254.591	1.933	30.577	273.178	0.824	0.042	83.569	0.000	0.025	0.038	0.000
i182	sinkhole	1868+00	0.320	4,553	0.424	0.313	0.525	0.000	89.769	928.823	6.025	104.303	1023.126	2.872	0.000	318.051	0.000	0.086	0.139	0.001
i205	sinkhole	1869+00	0.561	7,989	0.151	0.150	0.247	0.000	37.640	505.978	2.948	54.464	565.954	1.521	0.000	177.535	0.000	0.045	0.075	0.000
i116	sinkhole	1905+00	2.353	33,477	0.241	0.099	0.176	46.896	39.509	173.570	1.800	24.244	173.825	0.624	0.336	50.804	1.866	0.019	0.027	0.001
i174	sinkhole	1936+00	1.210	17,211	0.268	0.131	0.228	0.000	46.926	285.834	2.426	36.133	300.110	0.958	0.210	90.549	0.000	0.029	0.043	0.001
i192	sinkhole	2131+00	1.705	24,260	0.231	0.106	0.185	2.231	39.443	213.425	1.942	27.901	220.720	0.732	0.240	65.938	0.631	0.022	0.032	0.000
i252	sinkhole	2129+00	0.333	4,735	0.356	0.285	0.475	0.000	78.575	879.730	5.515	97.441	973.975	2.695	0.000	303.689	0.000	0.080	0.131	0.001
i269	sinkhole	2139+00	0.337	4,793	0.409	0.299	0.502	0.000	86.101	883.809	5.753	99.390	973.019	2.736	0.000	302.378	0.000	0.081	0.132	0.001
i054	sinkhole	2155+00	4.934	70,204	0.069	0.033	0.058	0.000	11.943	70.835	0.611	9.020	74.132	0.239	0.058	22.320	0.000	0.007	0.011	0.000
i048	sinkhole	2153+00	0.658	9,368	0.262	0.169	0.287	0.000	51.902	465.789	3.225	53.745	507.822	1.467	0.000	156.884	0.000	0.044	0.070	0.000
i078	sinkhole	2149+00	3.398	48,351	0.081	0.042	0.073	0.000	14.543	98.007	0.786	12.066	104.084	0.323	0.043	31.635	0.000	0.010	0.015	0.000
i055	sinkhole	2192+50	0.760	10,812	0.318	0.175	0.301	0.000	58.589	427.137	3.284	51.584	457.282	1.387	0.096	139.691	0.000	0.042	0.064	0.001
i049	sinkhole	2185+00	8.743	124,409	0.055	0.024	0.042	6.372	9.124	44.098	0.430	5.969	44.860	0.155	0.068	13.254	0.308	0.005	0.007	0.000
i084	sinkhole	2197+50	0.426	6,064	0.391	0.258	0.436	0.000	78.200	716.115	4.911	82.296	781.955	2.249	0.000	241.802	0.000	0.067	0.107	0.001
i064	sinkhole	2209+00	0.691	9,835	0.433	0.218	0.378	0.000	76.755	490.920	4.053	61.256	518.372	1.631	0.289	156.975	0.000	0.049	0.074	0.001
i194	sinkhole	2244+00	0.857	12,196	0.332	0.171	0.295	0.000	59.405	391.578	3.179	48.480	414.863	1.294	0.196	125.900	0.000	0.039	0.059	0.001
b16	Buried Sink	1694+00	5.170	73,563	0.064	0.031	0.054	0.000	11.123	67.125	0.573	8.507	70.399	0.225	0.051	21.225	0.000	0.007	0.010	0.000
b03	Buried Sink	1652+50	3.550	50,519	0.066	0.037	0.063	0.000	12.295	90.992	0.694	10.950	97.556	0.295	0.017	29.829	0.000	0.009	0.014	0.000
b06	Buried Sink	1672+50	3.611	51,377	0.054	0.033	0.056	0.000	10.334	86.435	0.619	10.120	93.698	0.275	0.000	28.846	0.000	0.008	0.013	0.000
b10	Buried Sink	1677+00	0.976	13,893	0.185	0.117	0.198	0.000	36.300	316.323	2.222	36.719	344.063	1.000	0.000	106.142	0.000	0.030	0.047	0.000
b09	Buried Sink	1675+50	1.340	19,071	0.125	0.082	0.139	0.000	25.024	227.987	1.567	26.227	248.850	0.716	0.000	76.933	0.000	0.021	0.034	0.000
b08	Buried Sink	1675+00	1.074	15,276	0.147	0.100	0.168	0.000	29.840	282.198	1.907	32.226	308.889	0.882	0.000	95.657	0.000	0.026	0.042	0.000
b12	Buried Sink	1681+00	1.622	23,075	0.134	0.077	0.132	0.000	25.157	196.164	1.456	23.324	211.346	0.630	0.011	64.818	0.000	0.019	0.029	0.000
b15	Buried Sink	1685+00	1.290	18,354	0.136	0.087	0.148	0.000	26.861	238.373	1.660	27.567	259.655	0.752	0.000	80.173	0.000	0.022	0.036	0.000
b18	Buried Sink	1697+50	0.675	9,605	0.228	0.157	0.264	0.000	46.557	447.240	3.000	50.920	490.101	1.396	0.000	151.880	0.000	0.042	0.067	0.000
b17	Buried Sink	1695+00	1.017	14,473	0.227	0.128	0.219	0.000	42.182	316.335	2.396	37.950	339.584	1.023	0.048	103.913	0.000	0.031	0.048	0.000
b19	Buried Sink	1718+00	2.821	40,136	0.078	0.045	0.076	0.000	14.564	112.954	0.841	13.447	121.636	0.363	0.008	37.293	0.000	0.011	0.017	0.000
b20	Buried Sink	1787+00	1.835	26,110	0.098	0.062	0.106	0.000	19.286	168.264	1.181	19.528	183.038	0.532	0.000	56.470	0.000	0.016	0.025	0.000
sp021	Spring	1757+00	2.923	41,591	0.074	0.043	0.073	0.000	13.869	108.681	0.805	12.908	117.145	0.349	0.005	35.937	0.000	0.010	0.016	0.000
sp025	Spring	1583+00	4.850	69,017	0.097	0.042	0.074	10.654	16.246	79.143	0.768	10.685	80.610	0.278	0.120	23.836	0.529	0.008	0.012	0.000
sp026	Spring	1583+50	4.850	69,014	0.097	0.042	0.074	10.655	16.247	79.146	0.768	10.685	80.614	0.278	0.120	23.837	0.529	0.008	0.012	0.000
sp028	Spring	1585+00	4.852	69,042	0.097	0.042	0.074	10.650	16.240	79.113	0.768	10.681	80.580	0.278	0.120	23.828	0.529	0.008	0.012	0.000
sp032	Spring	1585+00	10.928	155,505	0.062	0.025	0.044	16.450	10.038	40.019	0.443	5.784	39.367	0.147	0.095	11.361	0.599	0.005	0.006	0.000
sp055	Spring	1791+00	16.968	241,454	0.040	0.016	0.028	10.593	6.465	25.773	0.285	3.725	25.354	0.095	0.061	7.317	0.386	0.003	0.004	0.000
sp071	Spring	1895+00	20.726	294,922	0.051	0.019	0.033	19.826	7.984	25.756	0.330	4.041	24.174	0.101	0.090	6.734	0.663	0.003	0.004	0.000
sp077	Spring	1923+00	3.017	42,934	0.112	0.054	0.094	0.000	19.443	115.677	0.995	14.718	121.109	0.389	0.094	36.473	0.000	0.012	0.018	0.000
sp083	Spring	1939+50	1.114	15,847	0.152	0.099	0.168	0.000	30.221	274.551	1.890	31.602	299.610	0.863	0.000	92.613	0.000	0.026	0.041	0.000
sp093	Spring	1965+00	1.429	20,327	0.258	0.121	0.211	0.000	44.446	250.172	2.224	32.331	260.088	0.852	0.248	77.970	0.414	0.026	0.038	0.001
sp097	Spring	1972+50	4.715	67,099	0.070	0.034	0.059	0.000	12.304	73.781	0.632	9.367	77.319	0.248	0.058	23.300	0.000	0.008	0.011	0.000

sp098	Spring	1973+50	6.559	93,334	0.060	0.028	0.048	0.648	10.269	55.504	0.505	7.258	57.393	0.190	0.063	17.144	0.166	0.006	0.008	0.000
sp099	Spring	1974+00	1.281	18,226	0.098	0.076	0.126	0.000	21.176	229.889	1.460	25.598	254.026	0.707	0.000	79.115	0.000	0.021	0.034	0.000
sp105	Spring	1982+00	0.522	7,431	0.210	0.177	0.293	0.000	47.625	556.407	3.427	61.196	617.597	1.697	0.000	192.862	0.000	0.050	0.083	0.000
sp106	Spring	1923+00	0.522	7,431	0.210	0.177	0.293	0.000	47.624	556.397	3.426	61.195	617.587	1.697	0.000	192.859	0.000	0.050	0.083	0.000
sp107	Spring	1985+00	14.565	207,251	0.013	0.008	0.014	0.000	2.591	21.478	0.155	2.520	23.265	0.068	0.000	7.159	0.000	0.002	0.003	0.000
sp110	Spring	1991+00	1.235	17,580	0.176	0.102	0.174	0.000	33.155	257.713	1.916	30.665	277.578	0.829	0.017	85.116	0.000	0.025	0.039	0.000
sp112	Spring	2110+50	1.493	21,247	0.189	0.098	0.169	0.000	33.899	224.421	1.818	27.754	237.879	0.741	0.109	72.212	0.000	0.022	0.034	0.000
sp115	Spring	2122+50	12.272	174,626	0.051	0.021	0.037	12.018	8.304	34.538	0.371	4.917	34.251	0.126	0.075	9.941	0.452	0.004	0.005	0.000
sp120	Spring	2140+00	4.583	65,214	0.081	0.038	0.066	0.000	13.854	77.980	0.693	10.078	81.071	0.265	0.077	24.304	0.129	0.008	0.012	0.000
sp121	Spring	2110+00	0.811	11,544	0.109	0.105	0.174	0.000	26.688	351.282	2.063	37.929	392.496	1.058	0.000	123.045	0.000	0.031	0.052	0.000
sp122	Spring	2141+00	10.555	150,198	0.016	0.010	0.018	0.000	3.150	28.900	0.198	3.320	31.562	0.091	0.000	9.761	0.000	0.003	0.004	0.000
sp124	Spring	2144+00	2.030	28,879	0.107	0.062	0.106	0.000	20.183	156.881	1.166	18.667	168.973	0.504	0.010	51.813	0.000	0.015	0.024	0.000
sp125	Spring	2145+00	16.716	237,864	0.031	0.013	0.023	4.883	5.146	23.711	0.238	3.259	23.938	0.084	0.041	7.036	0.209	0.003	0.004	0.000
sp127	Spring	2146+00	16.716	237,864	0.038	0.015	0.027	8.873	6.109	25.377	0.273	3.614	25.160	0.093	0.055	7.302	0.333	0.003	0.004	0.000
sp128	Spring	2148+00	16.716	237,862	0.038	0.015	0.027	8.873	6.109	25.377	0.273	3.614	25.161	0.093	0.055	7.302	0.333	0.003	0.004	0.000
sp136	Spring	2161+50	0.560	7,963	0.196	0.165	0.274	0.000	44.442	519.222	3.198	57.106	576.323	1.583	0.000	179.973	0.000	0.047	0.077	0.000
sp167	Spring	2287+00	0.393	5,594	0.280	0.235	0.390	0.000	63.265	739.131	4.552	81.293	820.416	2.254	0.000	256.198	0.000	0.067	0.110	0.000

Acute Aquatic Criterion, AAC (Table 2, 327 IAC 2-1-6)	0.262	0.042	0.254	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	860	n/a	0.011	3.679	n/a
Chronic Aquatic Criterion, CAC (Table 2, 327 IAC 2-1-6)	0.010	0.026	0.230	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	230	n/a	0.002	0.438	n/a
Point of Water Intake Human Health (Table 1, 327 IAC 2-1-6)	0.050	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.010	n/a	n/a	n/a	0.010	170.000	0.00014
Values in shaded cells exceed one of the water quality standards	**0.010**	**0.026**	**0.230**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**0.010**	**n/a**	**230**	**n/a**	**0.002**	**0.438**	**0.00014**
Number of features exceeding water quality standards	72	60	20							72		6		71		54
Highest concentration	1.048	0.419	0.747							2.872		318.051		0.086	0.139	0.002
Highest concentration feature ID	i017	i017	i017							i182		i182		i182	i182	i017

Table #2-8: 50-Year/10-Min Average Pollutant Concentration of Karst Features for Post-Construction (Proposed) Conditions - Preferred Alternative #8

ID	Type	Approx. Station	Runoff Area inside R/W	Runoff Volume inside R/W	*Average Concentration*															
					Lead	Copper	Zinc	TSS	VSS	TVS	TKN	TOC	COD	TN	TPO4	CL-	Fe	Cd	Cr	Hg
		(feet)	(acres)	(cf)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
i015	sinkhole	1577+50	0.825	3,594	1.085	0.566	0.979	0.000	195.328	1318.004	10.564	162.212	1399.913	4.337	0.572	425.520	0.000	0.131	0.199	0.002
i219	sinkhole	1557+50	0.950	4,137	1.122	0.548	0.953	0.000	196.397	1191.185	10.137	150.757	1250.038	3.996	0.892	377.035	0.000	0.121	0.180	0.002
i020	sinkhole	1590+00	14.658	63,850	0.180	0.069	0.123	57.943	28.762	104.928	1.233	15.676	101.356	0.396	0.295	28.860	2.016	0.012	0.016	0.000
i023	sinkhole	1597+50	2.135	9,299	0.547	0.259	0.452	0.000	94.572	542.382	4.768	69.720	565.248	1.839	0.504	169.721	0.571	0.056	0.082	0.001
i017	sinkhole	1575+00	0.615	2,679	5.109	1.892	3.405	1882.694	806.531	2710.153	33.730	418.206	2569.265	10.474	8.827	721.260	63.654	0.324	0.421	0.012
i025	sinkhole	1599+00	2.239	9,754	0.994	0.393	0.701	264.173	160.498	638.784	7.072	92.382	628.190	2.355	1.521	181.240	9.614	0.072	0.098	0.002
i050	sinkhole	1605+00	1.345	5,857	0.737	0.370	0.642	0.000	130.537	827.214	6.866	103.470	872.553	2.752	0.509	264.051	0.000	0.083	0.125	0.002
i168	sinkhole	1588+00	17.116	74,557	0.214	0.077	0.139	86.128	33.439	105.099	1.372	16.670	97.983	0.415	0.383	27.149	2.862	0.013	0.016	0.000
i024	sinkhole	1596+00	0.488	2,127	2.813	1.260	2.214	133.572	475.966	2479.433	23.091	327.843	2550.620	8.576	3.126	759.291	10.555	0.261	0.377	0.006
i387	sinkhole	1580+00	0.318	1,387	1.557	1.079	1.818	0.000	319.211	3092.332	20.661	351.508	3390.752	9.640	0.000	1051.164	0.000	0.287	0.462	0.003
i379	sinkhole	1570+00	6.487	28,258	0.581	0.209	0.378	238.096	90.847	281.831	3.714	44.948	261.851	1.116	1.050	72.356	7.889	0.035	0.044	0.001
i412	sinkhole	1715+00	0.659	2,873	1.750	0.830	1.449	0.000	302.882	1750.107	15.318	224.492	1825.625	5.926	1.582	548.504	1.429	0.179	0.265	0.004
i042	sinkhole	1712+10	1.807	7,873	0.852	0.369	0.651	93.256	142.383	693.724	6.734	93.654	706.604	2.435	1.049	208.946	4.630	0.074	0.106	0.002
i040	sinkhole	1777+50	9.872	43,004	0.467	0.164	0.297	208.945	72.360	207.102	2.896	34.201	188.141	0.842	0.877	51.044	6.817	0.026	0.032	0.001
i426	sinkhole	1788+00	2.591	11,288	0.752	0.306	0.544	162.431	122.803	524.497	5.541	73.976	522.660	1.899	1.079	152.223	6.259	0.058	0.080	0.002
i044	sinkhole	1800+00	2.738	11,926	0.846	0.331	0.592	236.417	136.183	530.968	5.961	77.370	520.044	1.968	1.317	149.596	8.497	0.061	0.082	0.002
i430	sinkhole	1794+50	1.266	5,513	0.857	0.416	0.723	0.000	149.589	897.688	7.686	113.943	940.831	3.017	0.702	283.536	0.000	0.091	0.136	0.002
i182	sinkhole	1868+00	0.320	1,394	1.875	1.175	1.995	0.000	366.183	3160.358	22.300	367.594	3434.824	10.006	0.000	1059.121	0.000	0.299	0.474	0.003
i205	sinkhole	1869+00	0.561	2,446	0.616	0.529	0.878	0.000	141.168	1684.374	10.284	184.626	1871.906	5.125	0.000	584.979	0.000	0.152	0.251	0.001
i116	sinkhole	1905+00	2.353	10,248	1.170	0.443	0.795	389.750	186.135	665.748	7.930	100.225	640.298	2.527	1.942	181.729	13.454	0.078	0.103	0.003
i174	sinkhole	1936+00	1.210	5,269	1.273	0.551	0.973	138.768	212.620	1036.381	10.057	139.894	1055.693	3.637	1.565	312.187	6.901	0.111	0.158	0.003
i192	sinkhole	2131+00	1.705	7,427	1.109	0.455	0.808	225.784	181.563	788.402	8.239	110.564	787.954	2.843	1.565	229.965	8.857	0.087	0.121	0.002
i252	sinkhole	2129+00	0.333	1,450	1.544	1.049	1.770	0.000	313.438	2971.992	20.054	339.220	3253.720	9.291	0.000	1007.733	0.000	0.277	0.445	0.003
i269	sinkhole	2139+00	0.337	1,467	1.809	1.124	1.911	0.000	351.972	3009.452	21.332	350.726	3268.311	9.541	0.000	1007.305	0.000	0.285	0.451	0.003
i054	sinkhole	2155+00	4.934	21,491	0.327	0.140	0.247	43.110	54.319	257.873	2.544	35.104	261.597	0.910	0.416	77.141	1.975	0.028	0.039	0.001
i048	sinkhole	2153+00	0.658	2,868	1.189	0.657	1.128	0.000	219.278	1607.630	12.323	193.891	1722.032	5.217	0.339	526.229	0.000	0.157	0.242	0.002
i078	sinkhole	2149+00	3.398	14,801	0.381	0.174	0.305	4.659	64.891	350.237	3.192	45.820	362.083	1.202	0.397	108.145	1.065	0.037	0.053	0.001
i055	sinkhole	2192+50	0.760	3,310	1.486	0.710	1.239	0.000	258.009	1510.579	13.120	193.052	1578.374	5.102	1.301	474.731	0.611	0.154	0.229	0.003
i049	sinkhole	2185+00	8.743	38,084	0.264	0.104	0.185	73.679	42.559	166.120	1.864	24.196	162.739	0.616	0.411	46.821	2.650	0.019	0.026	0.001
i084	sinkhole	2197+50	0.426	1,856	1.770	0.994	1.705	0.000	328.866	2466.334	18.681	295.880	2647.601	7.974	0.378	810.172	0.000	0.239	0.371	0.003
i064	sinkhole	2209+00	0.691	3,011	2.048	0.909	1.599	131.830	345.295	1767.287	16.638	234.942	1813.416	6.136	2.343	538.915	8.623	0.187	0.269	0.004
i194	sinkhole	2244+00	0.857	3,733	1.568	0.707	1.242	54.730	266.009	1403.648	12.970	184.877	1446.579	4.842	1.705	431.155	5.349	0.147	0.213	0.003
b16	Buried Sink	1694+00	5.170	22,519	0.303	0.131	0.230	35.453	50.466	243.724	2.379	32.996	247.911	0.857	0.377	73.240	1.707	0.026	0.037	0.001
b03	Buried Sink	1652+50	3.550	15,465	0.310	0.150	0.260	0.000	54.000	321.180	2.764	40.867	336.250	1.081	0.260	101.263	0.000	0.033	0.049	0.001
b06	Buried Sink	1672+50	3.611	15,728	0.246	0.129	0.222	0.000	44.328	300.646	2.403	36.954	319.503	0.988	0.126	97.150	0.000	0.030	0.045	0.000
b10	Buried Sink	1677+00	0.976	4,253	0.845	0.456	0.786	0.000	154.368	1095.244	8.543	133.135	1169.380	3.573	0.325	356.619	0.000	0.107	0.165	0.002
b09	Buried Sink	1675+50	1.340	5,838	0.568	0.318	0.545	0.000	105.364	785.622	5.969	94.376	842.899	2.542	0.132	257.840	0.000	0.076	0.118	0.001
b08	Buried Sink	1675+00	1.074	4,676	0.662	0.382	0.654	0.000	124.542	968.676	7.200	115.243	1043.403	3.114	0.061	319.958	0.000	0.093	0.146	0.001
b12	Buried Sink	1681+00	1.622	7,064	0.619	0.309	0.537	0.000	109.427	687.950	5.736	86.231	724.995	2.292	0.440	219.269	0.000	0.069	0.104	0.001
b15	Buried Sink	1685+00	1.290	5,619	0.619	0.339	0.583	0.000	113.769	823.713	6.356	99.641	881.248	2.678	0.200	269.090	0.000	0.081	0.124	0.001
b18	Buried Sink	1697+50	0.675	2,940	1.023	0.598	1.023	0.000	193.577	1532.770	11.289	181.624	1653.679	4.914	0.030	507.606	0.000	0.147	0.230	0.002
b17	Buried Sink	1695+00	1.017	4,431	1.057	0.514	0.895	0.000	184.821	1114.728	9.517	141.296	1169.017	3.743	0.854	352.444	0.000	0.113	0.169	0.002
b19	Buried Sink	1718+00	2.821	12,287	0.360	0.179	0.310	0.000	63.417	396.392	3.316	49.762	417.457	1.322	0.260	126.202	0.000	0.040	0.060	0.001
b20	Buried Sink	1787+00	1.835	7,993	0.449	0.243	0.418	0.000	81.993	582.524	4.540	70.787	622.039	1.900	0.171	189.715	0.000	0.057	0.088	0.001
sp021	Spring	1757+00	2.923	12,732	0.341	0.171	0.296	0.000	60.271	380.920	3.166	47.680	401.675	1.268	0.237	121.531	0.000	0.038	0.058	0.001
sp025	Spring	1583+00	4.850	21,128	0.470	0.185	0.330	128.658	75.715	297.713	3.323	43.247	292.079	1.101	0.726	84.123	4.647	0.034	0.046	0.001
sp026	Spring	1583+50	4.850	21,127	0.470	0.185	0.330	128.664	75.718	297.727	3.323	43.249	292.092	1.101	0.726	84.126	4.647	0.034	0.046	0.001
sp028	Spring	1585+00	4.852	21,135	0.470	0.185	0.330	128.610	75.687	297.603	3.322	43.231	291.971	1.101	0.726	84.091	4.645	0.034	0.046	0.001
sp032	Spring	1585+00	10.928	47,603	0.303	0.111	0.201	115.636	47.727	156.568	1.982	24.397	147.564	0.609	0.531	41.238	3.884	0.019	0.024	0.001
sp055	Spring	1791+00	16.968	73,915	0.195	0.072	0.129	74.469	30.737	100.833	1.277	15.712	95.035	0.393	0.342	26.558	2.501	0.012	0.016	0.000
sp071	Spring	1895+00	20.726	90,282	0.250	0.087	0.157	116.667	38.603	105.805	1.528	17.815	94.869	0.436	0.479	25.457	3.780	0.014	0.017	0.001
sp077	Spring	1923+00	3.017	13,143	0.531	0.228	0.402	68.702	88.389	420.917	4.145	57.242	427.206	1.485	0.674	126.020	3.173	0.045	0.064	0.001
sp083	Spring	1939+50	1.114	4,851	0.687	0.383	0.658	0.000	127.328	946.362	7.202	113.771	1015.047	3.064	0.166	310.441	0.000	0.092	0.142	0.001
sp093	Spring	1965+00	1.429	6,223	1.236	0.516	0.914	215.061	203.565	918.234	9.361	127.121	923.744	3.281	1.674	270.833	8.878	0.100	0.141	0.003
sp097	Spring	1972+50	4.715	20,541	0.335	0.144	0.255	41.134	55.875	268.148	2.628	36.376	272.486	0.944	0.421	80.446	1.942	0.029	0.041	0.001

sp098	Spring	1973+50	6.559	28,572	0.289	0.118	0.210	59.027	47.276	205.072	2.144	28.769	204.918	0.740	0.408	59.798	2.313	0.023	0.031	0.001
sp099	Spring	1974+00	1.281	5,579	0.427	0.280	0.474	0.000	85.233	778.760	5.347	89.535	850.211	2.446	0.000	262.881	0.000	0.073	0.117	0.001
sp105	Spring	1982+00	0.522	2,275	0.902	0.643	1.081	0.000	187.514	1872.859	12.341	211.674	2058.039	5.816	0.000	638.841	0.000	0.173	0.280	0.001
sp106	Spring	1923+00	0.522	2,275	0.902	0.643	1.081	0.000	187.511	1872.827	12.340	211.670	2058.004	5.816	0.000	638.830	0.000	0.173	0.280	0.001
sp107	Spring	1985+00	14.565	63,444	0.062	0.032	0.056	0.000	11.137	74.786	0.601	9.215	79.392	0.246	0.033	24.124	0.000	0.007	0.011	0.000
sp110	Spring	1991+00	1.235	5,382	0.818	0.407	0.707	0.000	144.306	904.151	7.553	113.434	952.463	3.015	0.587	287.992	0.000	0.091	0.137	0.002
sp112	Spring	2110+50	1.493	6,504	0.893	0.404	0.709	27.284	151.693	803.973	7.409	105.753	829.074	2.771	0.964	247.208	2.942	0.084	0.122	0.002
sp115	Spring	2122+50	12.272	53,457	0.249	0.093	0.166	89.836	39.331	133.940	1.651	20.558	127.381	0.516	0.426	35.847	3.050	0.016	0.021	0.001
sp120	Spring	2140+00	4.583	19,963	0.385	0.161	0.285	67.035	63.452	286.217	2.918	39.624	287.935	1.023	0.522	84.420	2.767	0.031	0.044	0.001
sp121	Spring	2110+00	0.811	3,534	0.447	0.373	0.620	0.000	100.885	1171.235	7.232	128.950	1299.555	3.574	0.000	405.733	0.000	0.106	0.175	0.001
sp122	Spring	2141+00	10.555	45,979	0.071	0.040	0.069	0.000	13.242	99.515	0.753	11.933	106.850	0.322	0.015	32.700	0.000	0.010	0.015	0.000
sp124	Spring	2144+00	2.030	8,841	0.498	0.248	0.430	0.000	87.845	550.394	4.598	69.052	579.804	1.835	0.357	175.313	0.000	0.055	0.083	0.001
sp125	Spring	2145+00	16.716	72,815	0.151	0.058	0.104	46.276	24.127	90.117	1.042	13.343	87.488	0.338	0.243	25.005	1.627	0.010	0.014	0.000
sp127	Spring	2146+00	16.716	72,815	0.183	0.068	0.122	66.203	28.935	98.436	1.214	15.115	93.593	0.379	0.314	26.333	2.247	0.012	0.015	0.000
sp128	Spring	2148+00	16.716	72,815	0.183	0.068	0.122	66.204	28.935	98.436	1.214	15.115	93.593	0.379	0.314	26.333	2.247	0.012	0.015	0.000
sp136	Spring	2161+50	0.560	2,438	0.841	0.600	1.009	0.000	174.982	1747.697	11.516	197.528	1920.501	5.428	0.000	596.148	0.000	0.162	0.261	0.001
sp167	Spring	2287+00	0.393	1,712	1.198	0.854	1.436	0.000	249.093	2487.906	16.393	281.188	2733.899	7.726	0.000	848.637	0.000	0.230	0.372	0.002

Acute Aquatic Criterion, AAC (Table 2, 327 IAC 2-1-6)	0.262	0.042	0.254	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	860	n/a	0.011	3.679	n/a
Chronic Aquatic Criterion, CAC (Table 2, 327 IAC 2-1-6)	0.010	0.026	0.230	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	230	n/a	0.002	0.438	n/a
Point of Water Intake Human Health (Table 1, 327 IAC 2-1-6)	0.050	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.010	n/a	n/a	n/a	0.010	170.000	0.00014
Values in shaded cells exceed one of the water quality standards	**0.010**	**0.026**	**0.230**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**0.010**	**n/a**	**230**	**n/a**	**0.002**	**0.438**	**0.00014**
Number of features exceeding water quality standards	72	72	58							72		34		72		70
Highest concentration	5.109	1.892	3.405							10.474		1059.121		0.324	0.474	0.012
Highest concentration feature ID	i017	i017	i017							i017		i182		i017	i182	i017

FHWA HIGHWAY RUNOFF WATER QUALITY TRAINING COURSE

SECTION 8: PREDICTION OF WATER QUALITY IMPACTS

Estimated Time for Section:

The CONTENT of this Section

This section introduces impact prediction techniques developed by FHWA and others to assess highway runoff water quality impacts. Several specific procedures will be introduced either by lecture or by case study problems. Specific methods include estimating the highway runoff impact, maintenance practice impacts, groundwater impacts, and aquatic system impacts. Also, a brief overview of water quality models which have been developed to assess the impact of nonpoint pollution on watersheds relative to highway runoff will be provided.

The GOAL of this Section

Participants will become familiar with predicting quality changes in water quality parameters associated with highway runoff water quality.

The PURPOSE of this Section

To introduce participants to different qualitative and quantita- tive techniques for predicting highway runoff water quality impacts.

Listing of Sessions — Time

Session 8.1	Impact Procedures and Data Requirements
Session 8.2	Introduction to Highway Runoff Pollutant Characteristics Predictive Procedures
Session 8.3	Prediction of Pollutant Loadings and Runoff Concentrations on Highway Surfaces - Case Study
Session 8.4	Prediction of Loading Impacts of Highway Runoff - Case Study
Session 8.5	Prediction of Maintenance Impacts
Session 8.6	Prediction of Groundwater Impacts
Session 8.7	Aquatic System Impacts
Session 8.8	Introduction to Water Quality Models for Predicting Water Quality Impacts

SECTION 8: PREDICTION OF WATER QUALITY IMPACTS

SESSION 8.1: IMPACT PROCEDURES AND DATA REQUIREMENTS

Estimated Time for Completion:

OBJECTIVES: Upon completion of this session, participants will:

- Be introduced to a procedure for the assessment of effects of stormwater runoff from operating highways on receiving waters.
- Be introduced to a general procedure for evaluating potential impacts of highway maintenance practices on water quality.
- Know what data may be required to assess impacts of highway stormwater runoff on quality.

SESSION OVERVIEW:

This session introduces general procedures for assessing potential water quality impacts of highway stormwater runoff and maintenance practices. The specific methods will be introduced in later sessions. An overview of data required to assess water quality impacts of highway stormwater runoff is also presented.

I. INTRODUCTION

Data requirements to assess the need to conduct impact analysis or the potential effects of highway operations on surface water quality are identified in Table 8.1.1. This check list may be supplemented by site-specific data requirements.

II. ASSESSMENT OF HIGHWAY STORMWATER RUNOFF IMPACTS

Determining the need to assess the impact of highway stormwater runoff and the level of analysis depends on a number of factors. Selected factors include:

- The amount of traffic anticipated or currently traveling on the highway.
- The proximity of the highway site to receiving waters and their designated uses (e.g., drinking water, recreation, etc).
- Local and state requirements for control of nonpoint and stormwater point sources.
- Climatic factors, such as frequency and intensity of rainfall.
- The ratio of impervious surface to total watershed area upstream of project site.
- Local controversy.

Figure 8.1.1, illustrates a procedure for assessment of effects of stormwater runoff from operating highways on receiving waters. The first step in the procedure involves determining the anticipated impacts and/or the degree of controversy involved. Possible criteria useful in making the determination are:

- Traffic volumes in excess of 30,000 ADT.
- The highway site located near receiving stream where low dilutive capacities exist.
- Direct discharge of highway runoff to poorly flushed areas of lakes, wetlands, or coastal embayments.

If the decision is made to conduct an analysis, then either a seasonal/annual pollutant loading analysis or an event analysis should be made.

Table 8.1.1. Data for assessing water quality impacts of highway stormwater runoff.

Highway Design Features
- Length
- Number of lanes and lane widths
- Type of access
- Access ramps or intersecting roads
- Paving material
- Type of section(s) involved (at grade, cut, fill)
- Slopes (longitudinal and side)
- Median characteristics (width, paving, barrier type)
- Shoulder characteristics (width, paving, barrier type)
- Characteristics of area outside the shoulders but within the right-of-way (dimensions, topography, vegetation)
- Total impervious surface area

Operating Conditions
- Design average daily traffic (ADT)
- Projected vehicle composition
- Expected daily, weekly and seasonal traffic patterns
- Anticipated average speeds and braking characteristics
- Summary of applicable accident and spill data (from records on similar highways

Drainage System Characteristics (to the extent available during environmental assessment)
- Channel types (closed conduit, paved open channel, bare open channel, vegetated open channel, unchanneled overland flow, etc.)
- Channel dimensions and slopes
- Soils and vegetation characteristics in flow path
- Discharge points
- Collection systems (type, dimensions and spacings of drop boxes, etc.)
- Design flow rates

Hydrologic Characteristics
- Average annual precipitation (rain and snow) and monthly distribution of precipitation
- Receiving water and ground water data --
  - Streams (base flow, annual average flow, peak flow, flood plain maps)
  - Lakes and reservoirs (surface area, mean depth, water residence time)
  - Wetlands (surface area)
  - Groundwater (locations of aquifers, recharge characteristics)
- Summary of available data on point and nonpoint source flows in the watershed

Water Quality and Aquatic Biological Data

- Summary of available receiving water and groundwater monitoring data (water quality; microflora; microfauna, aquatic plants, benthic macroinvertebrates; fish populations, migrations and spawning areas)
- Sensitive or unique habitats
- Threatened and endangered species
- Summary of available data on effluent quality of sources in the watershed
- Beneficial use classification
- Established water quality criteria

Surrounding Land Use Characteristics
- Total watershed area
- Percentage of total area in each land use category (organized as in Tables 3 and 4)

Projected Highway Maintenance Characteristics
- Sanding application (quantity, frequency, particle size description)
- Deicing agent application (type, quantity, frequency, additives used)
- Pesticide application (type, quantity, frequency, toxicity)
- Roadway maintenance (sweeping, washing)
- Right-of-way maintenance (mowing, ditch cleaning, fertilizing, irrigation)

Description of Special Features
- Construction on woodwaste fill
- Detention basins
- Oil and grease traps
- Other mitigative features

Source: Horner et al., 1982

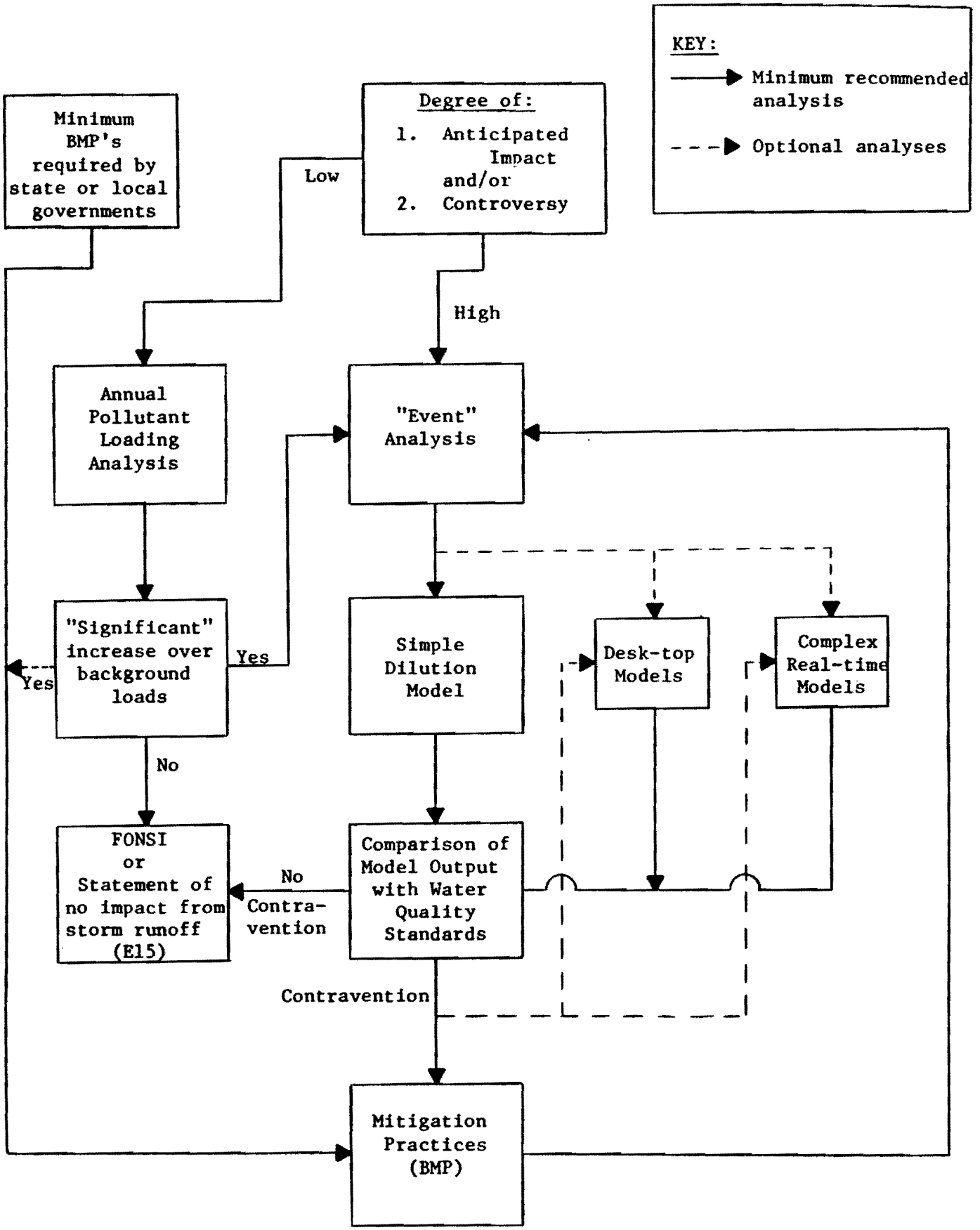


Figure 8.1.1. Simplified procedure for determining levels of analysis required to assess affects of stormwater runoff from operating highways on receiving streams.

Source: Dupuis and Kobriger, 1985.

A. SEASONAL/ANNUAL ANALYSIS

The seasonal/annual analysis determines the highway pollutant loadings relative to other loadings in the watershed. This seasonal/annual pollutant loading analysis may include either a simple determination of loadings (in pounds/yr), or the increase in stream pollutant concentration, using seasonal/annual highway pollutant input and mean flow conditions as a first cut on whether potential water quality problems may occur.

B. EVENT ANALYSIS

If the seasonal/annual analysis indicates the potential for more elaborate analysis, an event analysis may require using predictive model procedures or a simple dilution procedure. The assumption implied in dilution models are conservative, and if they show a standards exceedance, violations are not likely to appear under more exacting conditions.

If a more complex modeling effort is required, several models have been developed that provide the necessary level of analysis. In the majority of cases, these complex, real-time dynamic models would not need to be used.

Which ever approach is used, the results are compared with state water quality standards or, if standards have not been established, then the results may be compared with water quality criteria, to determine if mitigation is required.

Because of the variety of pollutants in highway stormwater runoff and the limited knowledge of the chemical, biological and physical impacts, any results may be subject to a considerable amount of uncertainty. The approaches presented in this section of the training course are intended to provide reasonable estimates of impacts based on the available information to date, and to provide highway agencies with the qualitative and quantitative procedures to make prudent planning decisions regarding highway stormwater runoff and water quality.

III. ASSESSMENT OF MAINTENANCE IMPACTS

Assessment of highway maintenance practice impacts is generally dependent on the extent and magnitude of the activity and its proximity to receiving waters. Session 2.1 provided an overview of when maintenance activity impacts should be assessed. Maintenance activities with potential impacts on water quality that need to be addressed are identified in Figure 8.1.2 with a general impact assessment method or procedure. This method is based on methods which are described in

Sessions 8.5 and 8.7. As with many procedures, it contains some subjective aspects relative to determining potentially significant impacts. It is intended to quantify, to the extent possible, selected maintenance impacts relative to the resource value of the stream, and to evaluate when mitigation measures are warranted. Specific aspects of this general method will be described in later sessions.

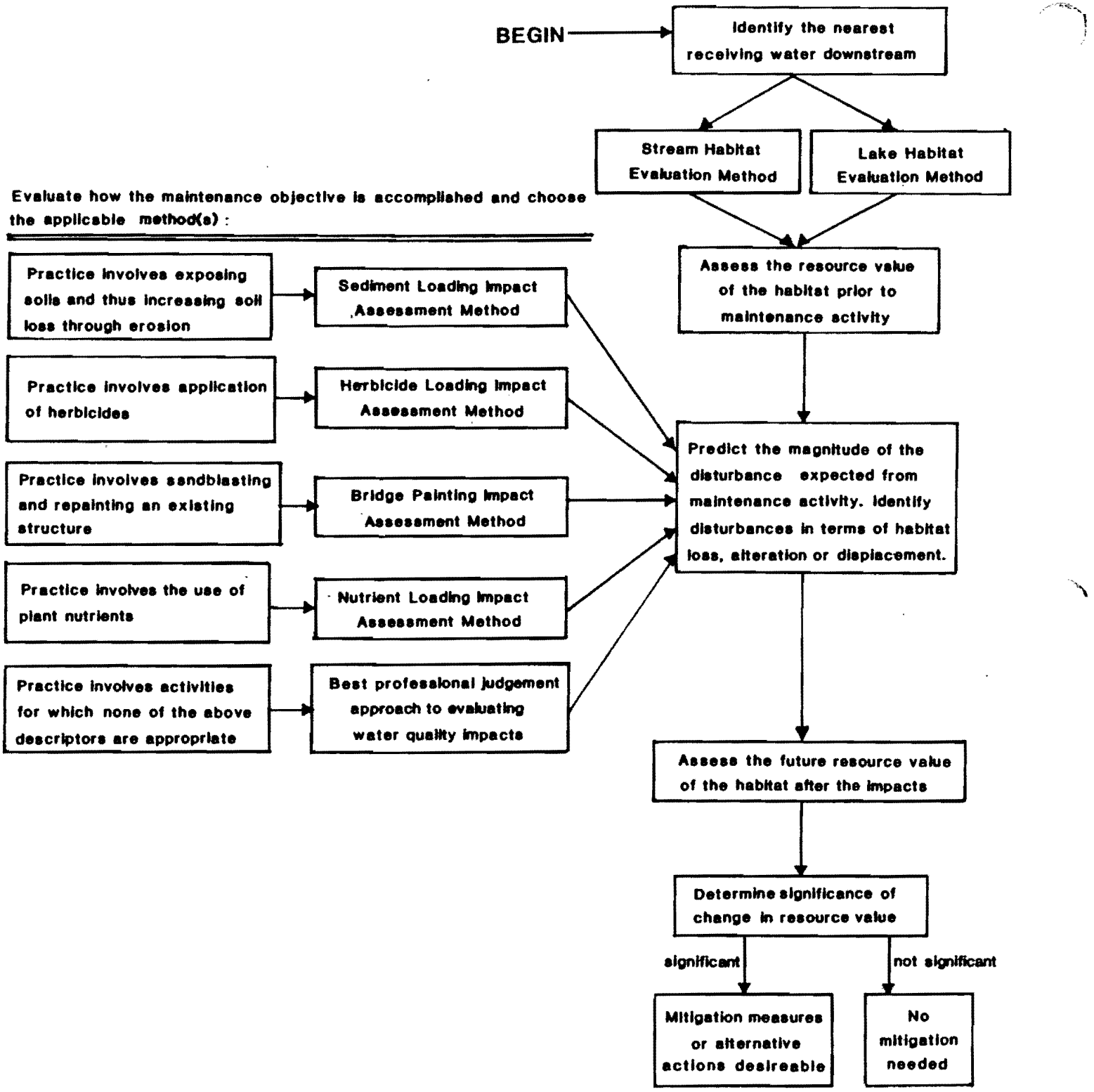


Figure 8.1.2. General impact assessment method for evaluating potential impacts to water quality from highway maintenance practices.

Source: Kramme et al., 1985

SECTION 8: PREDICTION OF WATER QUALITY IMPACTS

SESSION 8.2: INTRODUCTION TO HIGHWAY RUNOFF POLLUTANT CHARACTERISTICS PREDICTIVE PROCEDURES

Estimated Time for Completion:

OBJECTIVES: Upon completion of this session, participants will:

- Be familiar with the sections of FHWA's Predictive Procedure for Determining Pollutant Characteristics in Highway Runoff.
- Be familiar with other prediction methods developed to estimate highway runoff pollutant characteristics.
- Be knowledgeable about the limitations of the methods presented.

SESSION OVERVIEW:

A lecture will introduce the components of FHWA's Predictive Procedure not previously presented. Also, a brief overview of alternative methods will be examined to determine how they differ from FHWA's Procedure. The limitation of each method will also be discussed.

I. FHWA PREDICTIVE PROCEDURE

A. INTRODUCTION

Previous sessions presented selected components of FHWA's procedure on rainfall evaluation and highway runoff evaluation. An overview of the entire manual procedure and a detailed description of the procedure's remaining component follows. The model procedure is computerized both for mainframe and for personal computer.

The development of the procedure is based upon the monitoring program conducted in 1976 and 1977 at sites in Milwaukee, Wisconsin; Harrisburg, Pennsylvania; Nashville, Tennessee; and Denver, Colorado. Complete details of the monitoring programs can be found in Kobriger et al. (1981c).

B. PURPOSE

The predictive procedure offers highway designers and other interested parties a simplified tool to estimate the quantity and quality of storm generated highway runoff. It consists of a series of equations which can be solved manually or by computer. The procedure is composed of four components corresponding to the following functions:

- Rainfall runoff
- Pollutant build-up
- Pollutant wash-off
- Constituent loadings

The predictive procedure can be used for Environmental Impact Statements (EIS) or to determine the loadings for pollutant discharge effects of various design storms at a particular site. The predictive procedure is not meant to be an all-inclusive model which predicts hydrographs and concentrations versus time, but rather an easy-to-use method of determining the total volume of runoff and total pounds of a pollutant discharged from a highway area. The highway area under consideration is defined as the paved roadway and total nonpaved area which contribute to a particular discharge point.

In addition to EIS applications, the procedure evaluates existing highway systems. Thus, the effects of increased traffic, changes in the curb or barrier configuration, or modifications to the nonpaved area can be determined as they relate to the total pollutant loading. Design storm analyses can be conducted on an existing highway drainage area using the predictive procedure. The pollutant loadings, as predicted for these storms, can then be used to evaluate different water quality impacts through mass balance or modeling analyses. In this manner, the pounds of a pollutant discharged from a highway drainage area can be compared to other pollutant sources within the watershed.

C. GENERAL OVERVIEW

In order to use this method, the following information is required:

- Rain event data including date, total rainfall, estimated rainfall duration, and number of dry days between rainfall events
- Average Daily Traffic (ADT)
- Length of highway expressed as miles
- Drainage area above the point of discharge expressed as acres
- Estimated initial pollution levels expressed as pounds
- Total solids accumulation rate (optional, since the rate may be estimated based on ADT)

All of the above information is readily available to the highway engineer and water quality scientist.

Figure 8.2.1 provides an overview of the FHWA procedure.

1. Pollutant Accumulation Equation

The pollutant accumulation equation of the predictive model is as follows:

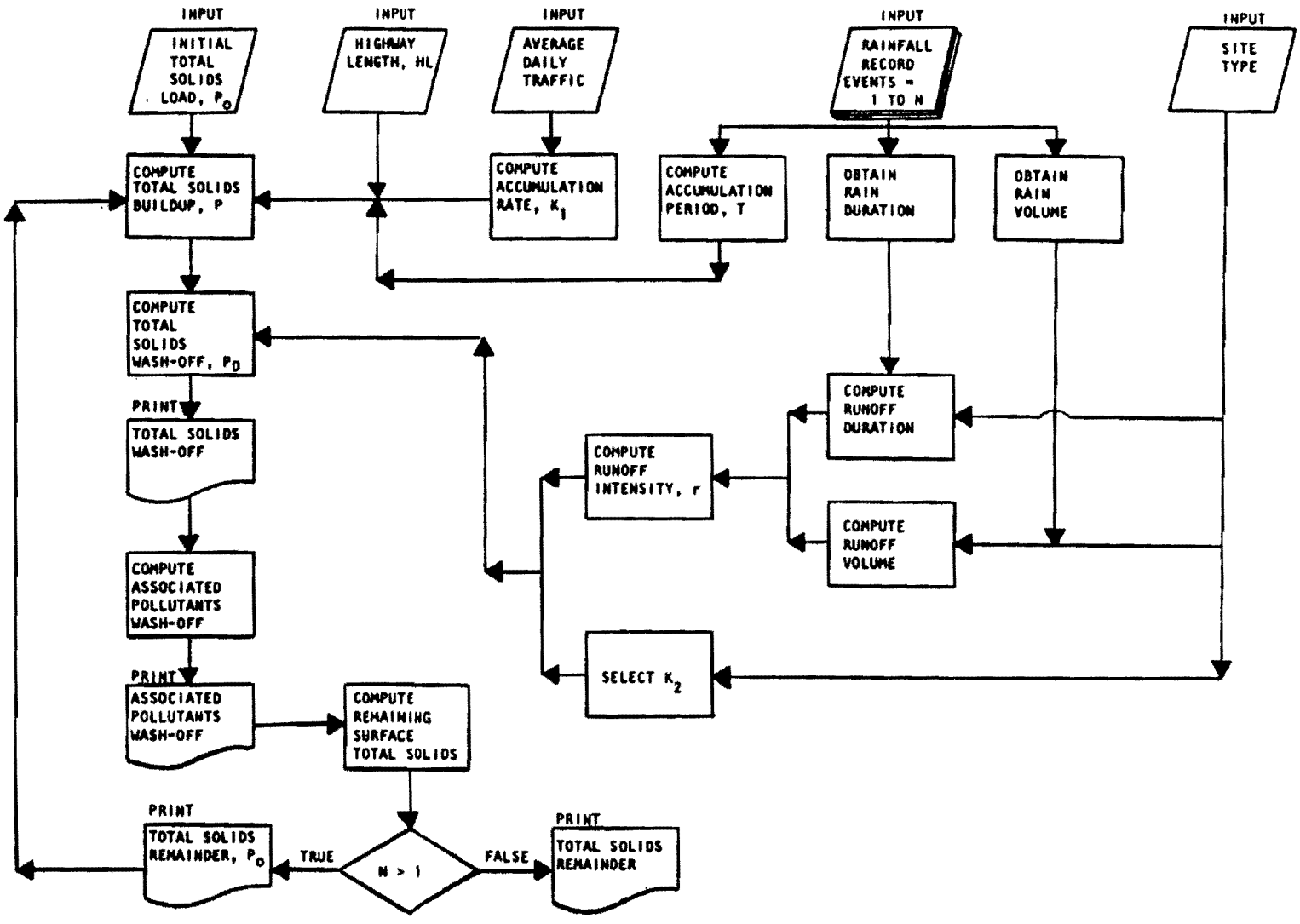
$$P = P_o + (K_1 * HL * T) \quad \text{.....(2)}$$

Where:
- P = pollutant level after build-up, lb (kg)
- P_o = initial surface pollutant load, lb (kg)
- K_1 = pollutant accumulation rate, lb/mi-day (kg/km-day)
- T = time of accumulation, days (20 day maximum)
- HL = highway length, mi (km)

This model predicts the highway surface pollutant load (P) which accumulates during a selected time period (T) at a specified rate (K_1). Surface pollutants accumulate on the surface of all-paved sites (e.g., elevated bridge sections) and on the paved and unpaved surfaces of highway sections which have right-of-way areas (e.g. gravel shoulders, grassy areas, etc.). For purposes of the predictive model, pollutant load refers to that fraction of the total highway load available for wash-off.

The monitoring data from this study were "end-of-the-pipe" wash-off data, which are not a direct measure of pollutant build-up. Therefore, monitoring data could not be used to establish whether pollutant build-up

Figure 8.2.1 Predictive flow diagram



Source: Gupta, M.K. et al., 1981c

on highways is linear, exponential, or another mathematical function. The pollutant accumulation equation assumes that pollutants build up linearly during the accumulation period. This equation is similar to that used in Storage, Treatment, Overflow, Runoff Model (STORM) from Abbott (1976), which is based on a linear pollutant build-up relationship developed from a study on urban runoff in Chicago.

The surface pollutant accumulation variable K_1 is the rate at which the carrier pollutant, total solids, accumulates in pounds per mile per day (kg/km/day). A carrier pollutant exhibits the highest degree of association with all other pollutants being considered. In many mathematical models, the predicted quantity of carrier pollutant is used to estimate the quantity of all other pollutants being modeled. This method eliminates the need for each pollutant to be predicted separately by the model, greatly reducing the number of calculations required. Total solids were chosen as the carrier pollutant for the predictive model developed in this study, because they showed the highest correlation with the other monitored quality parameters when regression analyses were performed. The term total solids (TS) refers to total suspended solids (TSS) plus total dissolved solids (TDS). Under the new nomenclature of Standard Methods, total solids as used in this study, are defined as total residue.

K_1 was developed from monitored data, and is expressed as pounds per mile - day (kg/km-day). The unit miles refers to the actual length of highway section in the contributing drainage area. This is in contrast to curb mile or lane mile, which is a multiple of the highway length. K_1 is site specific, and its value may be based upon actual monitoring data, if it exists, or estimated from average daily traffic. K_1 estimation based on average daily traffic is discussed at the end of this section.

The initial surface pollutant load (P_o) is the pounds of pollutants on the surface at the beginning of the accumulation period. The accumulation period can be intervals within an actual rainfall record, intervals within a series of design storms, or the period prior to a single design storm event.

If an accumulation period follows a large storm event, the initial surface pollutant load will be considered zero (P_o=0). The definition of a large storm is based upon that used in the Stormwater Management Model (SWMM) for the rate of pollutant removal during a storm event. For purposes of the predictive procedure, a large storm event is defined as one with greater than one inch (2.54 cm) of total rainfall, and having at least one hour in which the average intensity is 0.5 inches per hour (1.27 cm/hr). For such a storm, SWMM estimates that approximately 90 percent of the surface pollutants available for wash-off have been removed.

For succeeding rainfall events in a continuous rainfall record, P_o is the surface pollutant load remaining after wash-off from the previous rainfall event. For rainfall records which do not follow a large storm event or for design storms, the initial surface pollutant load must be estimated using a site specific K_1 value, site length, and a specified period of build-up or estimate. An analysis of monitored wash-off data and rainfall records during the subject study suggests that dry periods greater than 20 days over-estimate the surface load; therefore, any dry periods exceeding 20 days are assumed to equal 20. The initial surface pollutant load for a site with a K_1 of 80, and a site length of 5 miles would be:

$$80 \frac{\text{lbs}}{\text{mi-day}} * 5 \text{ mi.} * 20 \text{ days} = 8{,}000 \text{ lbs } (3{,}629 \text{ kg})$$

Any rainfall less than 0.05 inches (0.13 cm) is considered a trace of rain not producing runoff of sufficient volume and rate to effect pollutant wash-off. Figure 8.2.2. indicates the relationship between pollutant build-up and rainfall intensity and volume.

The minimum runoff duration that can be used in calculating average runoff intensity is 0.5 hours. Short duration flows, less than 0.5 hours, are often the result of small storms producing less than 0.1 inches (.25 cm) of flow. Using the high average runoff rates calculated from such storms gives more weight to the pollutant wash-off ability of a small storm that occurs. For this reason, all storms used in the predictive procedure were considered to have a duration of at least 0.5 hours, eliminating overestimates of total solids wash-off for short duration storms. For example, a storm producing 0.05 inches (.12 cm) of runoff in 0.17 hours (10 minutes) would have an average runoff rate calculated using an adjusted runoff duration of 0.5 inch/hr as follows:

$$\begin{aligned}\text{Average runoff rate} &= 0.05 \text{ inch of flow} \div 0.5 \text{ hours} \\ &= 0.10 \text{ inch/hr } (0.25 \text{ cm/hr})\end{aligned}$$

Otherwise, the average rate calculated from the actual runoff duration (0.17 hr) would be 0.29 inch/hr (0.73 cm/hr) and would cause a large overprediction of pollutant wash-off.

2. K_1 Variable

The total solids accumulation rate (K_1) varies from location to location. Selected K_1 previously reported in the literature are indicated in Table 8.2.1.

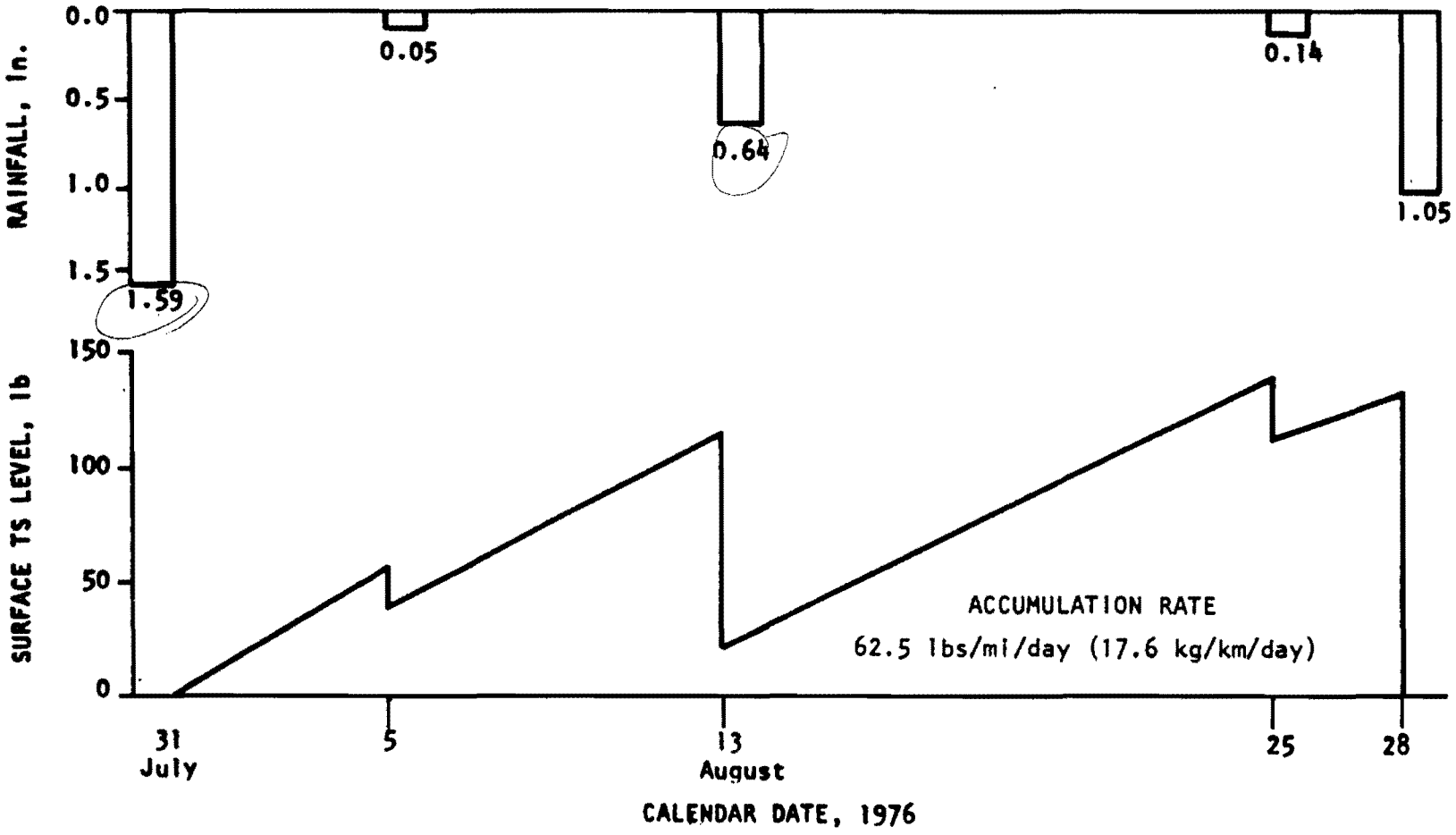


Figure 8.2.2. **Surface total solids level, Milwaukee - Hwy I-794.**

Table 8.2.1. Published K_1 values

Total solids accumulation rate, lb/mi-day	Location	Solids collection Techniques	Reference
1,580	Chicago City Sts.	Sweeping	American Public Works Association, 1969
1,180	11 U.S. City Sts.	Combined sweeping and flushing	Sartor, J.D. and G.B. Boyd, 1972
10.4	Seattle Highway	Runoff analysis	Sylvester, R.O. and F.B. DeWalle, 1972
382	Washington, D.C.	Vacuuming and	Shaheen, D.G., 1975
69.4	Seattle Highway	Runoff analysis	Municipality of Metropolitan Seattle, 1973
26.6	Seattle Highway	Runoff analysis	Municipality of Metropolitan Seattle, 1973a
236.9	Milwaukee (non-winter)	Mass balance for TS 250	Kobriger, N.P., 1984

metric units: lb x 0.454 = kg
mi x 1.609 = km

The total solids accumulation rate was correlated with ADT for the sites included in the monitoring study (Figure 8.2.3). As a result, it is possible to calculate the appropriate solids build-up rate using the following equation, when site specific rates are not available:

$$K_1 = (ADT^{0.89})\ 0.007$$

3. Wash-Off Coefficient (K_2)

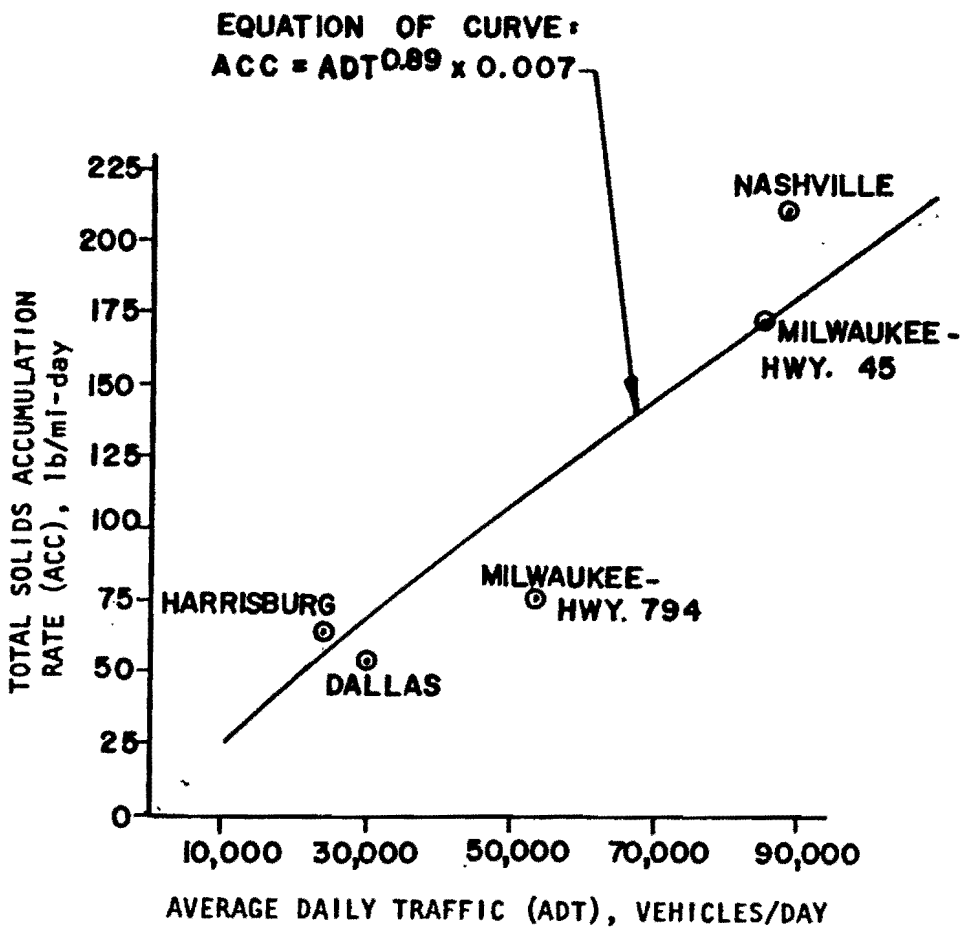
The coefficient K_2 is used in the predictive procedure to remove a portion of the carrier pollutant from the surface of the drainage area. The general wash-off equation in the Corps of Engineer STORM model and U.S. EPA Stormwater Management Model (Huber, 1975) is used as part of this procedure.

$$P_D = P\ (1-e^{-K_2 r})$$

Where: P_D = pounds (kilograms) of pollutant discharged
P = surface load at start of the runoff event.
K_2 = wash-off coefficient
r = average runoff rate, in./hr. (cm/hr)

For purposes of the predictive procedure, a single K_2 value is required for each of the three site categories. Based upon the comparison of individual K_2 values with actual monitoring data, a K_2 value of 6.5 represents sites which contain some curb or barrier, structured drainage, and grassy right-of-way (Type II). A value of 12 represents a rural, flush shouldered site (Type III) which uses grassy

Figure 8.2.3. Selected total solids accumulation rates versus average daily traffic



Source: Kobriger, N.P. et al., 1981

ditch conveyance for the surface runoff. A K_2 value of 5.0, selected for the Type I site, will be used for elevated bridge decks which are completely paved.

The Type III site requires the highest K_2 value in order to wash-off larger amounts of the pollutant load per runoff volume than other sites. This site type's flush shoulder and the nonpaved drainage conditions probably account for the high, since the grassy areas adjacent to the roadway require more pollutant wash-off per event to remove the pollutant load. The Type I site has the lowest K_2 value, indicating that pollutant wash-off is easier from a site that is all paved than a site with both paved and unpaved areas (Type II and III).

4. Constituent Loadings

The final component of the predictive procedure transforms the pounds of total solids washed off into pounds of lead, COD, suspended solids, or any other of the 16 quality constituents available in the model. The prediction of heavy metals, nutrients, solids and other parameters for individual storm events rely upon linear regression equations for predicting each parameter as a function of the total solids load for each site (Tables 8.2.2 and 8.2.3).

For example, the determination of the COD load for the Milwaukee I-794 site is as follows:

$$COD\ (lb) = 0.202\ TS + 5.47$$

where: TS = total solids in pounds

The asterisk in Tables 8.2.2 and 8.2.3 next to equations indicates significance at the 95 percent confidence limits (1). This indicates that one can be 95 percent confident that the sample was not selected from a population for which no correlation exists (i.e., that the correlation coefficient R is equal to zero). An equation may still provide good estimates even if the variables in that equation do not show a significant correlation at the 95 percent confidence level (Gupta et al., 1981c). An equation developed using regression techniques is the best fit of the data being analyzed.

The predictive procedure uses a separate constituent equation for each general site type. Individual equations account for differences between site drainage and solids retention characteristics.

D. PREDICTIVE PROCEDURE RESULTS

Table 8.2.4. summarizes the application results of the procedure to the five monitoring sites, plus a sixth site not included in the development of the procedure.

Table 8.2.2 Constituent equations developed for Type I and Type III sites.

Parameter		Type I Milwaukee I-794	Type III Harrisburg I-40
SS	=	0.53TS - 3.2*	0.32TS - 36.8*
VSS	=	0.191TS + 0.2*	0.061TS-3.3*
TVS	=	0.221TS + 13.3	0.32TS - 32.3*
TKN	=	3.3×10^{-3} TS + 0.16	3.1×10^{-3}TS+ 0.55*
BOD	=	0.023TS + 1.5*	N/A
TOC	=	0.057TS + 0.80*	0.068TS - 5.85*
COD	=	0.202TS + 5.47*	0.087TS + 0.65*
TN	=	1.37×10^{-3} TS + 0.12	1.83×10^{-3} TS+0.054*
TPO_4	=	1.0×10^{-3} TS + 3.0×10^{-4}	2.15×10^{-3}TS - 0.245
Cl^-	=	0.034TS + 2.59	0.135TS + 2.6*
Pb	=	5.6×10^{-3}TS - 0.024	4.1×10^{-4}TS - 0.029*
Zn	=	8.4×10^{-4}TS + 0.014	2.67×10^{-4}TS-0.011*
Fe	=	0.015TS + 0.59	0.014TS - 1.61*
Cu	=	2.9×10^{-4}TS+7.3×10^{-4}	7.4×10^{-5}TS+8.78×10^{-3}*
Cd	=	1.4×10^{-4}TS-1.4×10^{-3}	4.0×10^{-5}TS+0.007
Cr	=	1.6×10^{-4}TS+1.2×10^{-3}	2.3×10^{-4}TS-0.028
Hg	=	-7.6×10^{-7}TS+8.8×10^{-4}	-5.8×10^{-6}TS+0.015*

Note: TS = total solids (lb)
* - Variables correlate at the 95 percent confidence level.
metric units: lb x 0.454 = kg

Source: Gupta, M.K. et al., 1981c

Table 8.2.3 Constituent equations developed for Type II sites.

Parameter	Equation
SS	0.63TS - 188
VSS	0.152TS + 13.5
TVS	0.263TS + 243
TKN	5.46×10^{-3}TS + 1.28
BOD	3.0×10^{-2}TS + 28.3
TOC	5.6×10^{-2}TS + 25.2
COD	0.193TS + 275.3
TN	1.3×10^{-3}TS + 0.713
TPO_4	2.25×10^{-3}TS - 0.32
Cl	0.042TS + 87
Pb	1.02×10^{-3}TS + 0.04
Zn	5.84×10^{-4}TS + 0.103
Fe	1.96×10^{-2}TS - 5.0
Ni	N/A
Cu	3.16×10^{-4}TS + 0.064
Cd	4.16×10^{-5}TS + 0.021
Cr	4.3×10^{-5}TS + 0.036
Hg	2.44×10^{-6}TS + 1.006×10^{-6}

Note: TS = total solids (lb)
metric units: lb x 0.454 = kg

Source: Gupta, M.K. et al., 1981c

Table 8.2.4. Summary of Model Versus Actual Monitored Non-Winter Total Pollutant Loads Used to Develop the Predictive Procedures (except the Dallas Site)

Site Location	Total Solids, lb	Suspended Solids, lb	TPO_4, lb	COD, lb	Lead, lb[1]	Iron, lb
Milwaukee I-794						
Actual	1,862	570	1.03	271	5.17	22.94
Predicted	1,640	658	0.86	245	4.55	20.66
Predicted vs. Actual %	-11.9	+15.4	-16.5	-9.6	-12.0	-10.0
Milwaukee Hwy 45						
Actual	55,024	29,123	34.76	6,863	53.6	929.75
Predicted	63,478	36,665	137.11	17,205	65.47	1,115.14
Predicted vs. Actual %	+15.4	+25.9	+294.4	+150.7	+22.2	+24.2
Nashville I-40						
Actual	20,273	10,692	65.81	3,909	24.76	268.06
Predicted	23,325	11,369	30.62	6,294	24.53	367.97
Predicted vs. Actual %	+15.1	+6.3	-53.5	+61.0	-1.0	+37.3
Harrisburg I-81						
Actual	3,655	767	6.43	212	1.40	31.97
Predicted	3,689	835	5.64	170	1.22	36.59
Predicted vs. Actual %	+1.0	+8.9	-12.3	-19.8	-12.9	+14.5
Denver I-25						
Actual	11,016	7,263	13.66	4,338	11.99	252.43
Predicted	15,118	7,189	27.67	7,029	16.04	231.97
Predicted vs. Actual %	+37.2	-1.0	+117.2	+62.0	+33.8	-8.1
Dallas I-45						
Actual	468	204	NA	345	1.18	5.60
Predicted	626	307	NA	169	3.32	14.10
Predicted vs. Actual %	+33.8	+50.5	-	-51.0	+181.4	+151.8

[1]Caution must be used when interpreting the pollutant loadings of lead predicted by the model. The reduction in lead in gasoline has resulted in an estimated 50% reduction in lead loadings since the predictive procedure equation was developed.

As can be seen, the predicted versus the actual monitored data are within one order of magnitude for all values. Total solids and suspended solids in particular, are fairly close, although greater variation exists for other constituents. When predicted versus actual loadings on an event basis are compared, greater variation exists. Thus, the model is best suited for monthly or non-winter period evaluations.

The model is undergoing further evaluation and validation by FHWA in a study initiated in September, 1984, titled Design Procedures to Estimate Pollutant Loadings from Higher Stormwater Runoff. The study is to be completed in FY 1986.

E. MODEL LIMITATIONS

The predictive procedure is a tool for evaluating the effects of increased traffic, changes in the highway configuration, or other design aspects, on the loading of solids or other constituents to the receiving water.

Because of the complex interaction of rainfall, runoff and traffic on a highway, the prediction model has certain limitations. Users of the procedure are encouraged to further study the Predictive Procedures to ensure a full understanding of the components of the model and aid in the interpretation of the results (Kobriger, 1981c).

Specific limitations of the procedure are as follows:

- Geographic locations with low intensity, frequent rainfalls, e.g., Washington state, should not use this procedure. Research (Horner et al., 1982) demonstrates situations where ADT is not a valid variable to estimate pollutant accumulation on the roadway surface. This method will not be acceptable for use in California and states with similar climatic conditions.

- The procedure should be limited to non-winter periods. As such, the results will reflect only a portion of the total loadings that can be expected from a roadway. As shown in a more recent study (Kobriger, 1984), winter pollutant accumulation can be significant, although the dispersion is more complex and highly variable.

- The predictive procedure is better suited to continuous simulation using daily rainfall records covering periods of at least one month, since it is unable to predict surface loads prior to individual events.

- The model assumes the highway area to be uniformly characterized by the three site types that are listed. Significant variations in a site may have widely varying results.

- The predicted pounds of total solids washed off during a rainfall event are dependent upon the model prediction of the surface load at the start of the storm. If the surface load is underestimated, the pounds discharged will be low.

- The use of average runoff rate to remove surface pollutants is the quickest and easiest method. Peak runoff intensities during the runoff hydrograph may be more accurate, but are too complex for this procedure.

- Long dry periods and overlapping storms present predictive problems in determining the pre-storm surface load.

- Construction activities are difficult to simulate unless monitoring data is available to determine K_1 values.

II. FHWA PROCEDURE FOE ESTIMATING POLLUTANT LOADS

1. Determine the pollutant accumulation rate for the project site being evaluated if site specific or other accumulation values are being used:

$$K_1 = (ADT^{0.89}) * 0.007$$

where: K_1 = pollutant accumulation rate, lb/mi-day (kg/km-day)
ADT = average daily traffic, vehicles/day

Example: If the site has an ADT of 30,000 vehicles per day, the K_1 value that results would be:

$$K_1 = (30{,}000^{0.89}) * 0.007$$
$$= 67.6 \text{ lb/mi-day } (19.1 \text{ kg/km-day})$$

2. a. Using K_1, determine the pounds of total solids on the surface of the project site at the start of the storm event:

$$P = P_o + (K_1 * HL * T)$$

where: P_o = initial surface pollutant load, lb
P = pollutant level after build-up, lb
K_1 = pollutant accumulation rate, lb/mi-day (kg/km-day)
HL = highway length, mi(km)
T = time of accumulation, days (20 days maximum)

The variable P_o is a function of the amount (load) of pollutants estimated to be left on the surface after the last rainfall event. If more than one event is being evaluated, e.g., monthly or seasonal loadings are being determined, the results of P_o are carried through the calculations on an iterative basis by subtracting the pounds washed off from the previous pollutant load. The build-up rate, K_1, is then used for each dry day to add to P_o until the pollutant load at the start of the next event is determined.

The initial estimation of a P_o is made easier if the first storm to be evaluated follows a storm of average rainfall intensity greater than 0.5 inches (1.27 cm) per hour. This large storm is assumed to wash-off essentially all of the available total solids load on the surface. The succeeding dry days are then used to build up the available surface load to the start of storm conditions. Further descriptions of P_o and K_1 are included in the components description of this report.

Example: If the accumulation period is six days, the highway length is 6.5 miles, K_1 is 67.6 16/mi-day (19.1 kg/km-day) (predicted from the ADT of 30,000 vehicles/day) and P_o is zero (assume accumulation period started with a large storm). The pollutant level after build-up (P) would be:

$$
\begin{aligned}
P &= P_o + (K_1 * HL * T) \\
&= 0.0 + (67.6 \text{ lb/mi-day} * 6.5 \text{ miles} * 6 \text{ days}) \\
&= 0.0 + (2{,}636.4 \text{ lbs}) \\
&= 2{,}636.4 \text{ lbs } (1{,}196 \text{ kg}) \text{ of total solids available at the start of event number one.}
\end{aligned}
$$

b. If a large rainfall event does not occur at the beginning of the initial accumulation period of the month or period being evaluated, P_o must be estimated. One method is to evaluate local climatic data to determine the average number of dry days between rainfall events. P_o can then be estimated using the average number of dry days, K_1 and highway length.

Another approach would be to estimate the pollutant load for the first event in the period, and determine the number of dry days since the last rain event prior to the start of the event period actually being evaluated. Note: The event used to establish the accumulation period for the first event in the period or month of concern must be rainfall, not snowfall, otherwise use the first approach. Assume that $P_o = 0$. Then count the number of dry days to determine the load available for the first event for the period. This will slightly underestimate the pollutant load on the highway's surface if this previous event was less than 0.5 in./hr., since it will not account for the load left on the surface. This applies to the first approach as well.

Example (1st approach): If a large storm did not precede the initial accumulation period, and if the average number of dry days between storms was determined to be four, the estimate of P_o would be calculated as follows:

$$P_o = K_1 * HL * T$$
$$= 67.6 * 6.5 * 4$$
$$= 1{,}758 \text{ lb } (797 \text{ kg})$$

3. Calculate load wash-off using the average runoff rate (r) using the following formula:

$$P_D = P(1-e^{-K_2 r})$$

where: P_D = pollutant load discharged (total solids), lb (kg)
P = pollutant load at the storm start, lb (kg)
K_2 = wash-off coefficient r = average runoff rate - inch/hr (cm/hr)

K_2 is selected based upon site characteristics as follows:

K_2 =	Type 1	Type 2	Type 3
	5.0	6.5	12.0

Example: Assuming the site is Type II, the pounds of total solids removed would be determined as follows (P = 2,636 lbs; r = .019 in./hr, assumed here; K_2 = 6.5)

$$P_D = P(1-e^{-K_2 r})$$
$$= 2{,}636\ (1-e^{-(6.5)(0.019)})$$
$$= 306 \text{ lb of total solids discharged } (139 \text{ kg})$$

4. Calculate the surface load remaining after the storm from the above example.

$$P_o = P - P_D$$
$$= 2{,}636 \text{ lb} - 306 \text{ lbs}$$
$$= 2{,}330 \text{ lb of total solids remaining } (1{,}057 \text{ kg})$$

Thus, P_o for the next event is 2,330 lb (1,057 kg). This amount is then added to P (pollutant load after build-up that is available for washoff by next rainfall event.)

5. To calculate loadings, use the equations in Tables 8.2.2 and 8.2.3 for each pollutant of interest for each site type. The results will be expressed as pounds of pollutants discharged at the highway site for each event.

Example: From the previous example, it was determined that 306 lbs of total solids were washed off from the site. To calculate the amount of the pounds Zn washed off:

$$Zn = 5.84 * 10^{-4}TS + 0.103$$
$$= 5.84 * 10^{-4}(306) + 0.103$$
$$= .28 \text{ lbs of Zn}$$

6. Determine the average concentration of Zn in the highway runoff using the following formula (7.48 is a conversion factor to convert volume to gallons):

$$P_{conc} = (P_{Zn} * 454{,}000)/(Q_{cf} * 7.48 * 3.785)$$

Example: From the previous step, the loading of Zn was determined to be .28 lbs. Thus, the average concentration in the runoff would be (Assume Q_{cf} = 7,000):

$$P_{conc} = (P_{Zn} * 454{,}000)/(Q_{cf} * 7.48 * 3.785)$$

$$= \frac{.28 \text{ lbs} * 454{,}000 \text{ mg/lbs}}{7{,}000 \text{ cf} * 7.48 * 3.785 \text{ liters/gallon}}$$

$$= \frac{127{,}120 \text{ mg}}{198{,}182 \text{ liters}}$$

$$= .641 \text{ mg/liter of Zn in highway runoff.}$$

7. Repeat the above calculations to obtain the total solids wash-off for each event and pollutants.

III. CALIFORNIA METHOD FOR ESTIMATING

A. INTRODUCTION

Caltrans has developed a different procedure for estimating highway runoff quality (Howell et al., 1982; Kerri et al., 1985). Its method reflects the findings of studies for sites located in California:

- The number of dry days between storm events and the corresponding cumulative traffic volume before the storm were found to be not statistically significant for estimating constituent loads.

- Equations used to estimate the cumulative loads of the following pollutants were found to be statistically significant at the .05 level, on a storm event basis when:

- Correlated with vehicles during the storm: COD, Filterable Residue (Dissolved Solids), Lead (T), TKN, ZN(T).

- Correlated with total residue: COD, Nonfilterable Residue (Suspended Solids), ZN(T).

- No statistically significant correlations at the .05 level of significance were found with any of the independent variables examined: boron, cadmium, nitrate nitrogen, ammonia nitrogen, total phosphorus, dissolved orthophosphate, oil and grease. Thus, these pollutants cannot be estimated using the Caltrans procedure.

- The method is considered suitable on an event basis.

- The regression equations developed in this research can be used for calculating constituent loads from the paved travelled way and shoulder area. In order to assess the effects of the constituent load on nearby receiving waters - the load must be routed through the drainage system and ultimately to the receiving water - runoff from other sources may be encountered and must be included - highway runoff dilution factors in terms of the receiving water source must be accounted for.

B. PROCEDURE FOR USING THE REGRESSION EQUATIONS

In using the Caltran procedure the following assumptions are made:

- The vehicle fleet and fuels used are relatively the same as the years of actual data collection (1979 through 1981) to build the regression equations.

- The highway is in an urban setting.

- The drainage area of the roadway surface is between 2.00 and 3.00 acres, as this was the smallest area from which data were collected to build the equations. (HL * HW of pavement = 72<3 acres).

- The median, traveled lanes, and shoulders are 100 percent paved.

- The procedure should be used with highways having ADT exceeding 30,000 vehicles, and only when a sensitive receptor, e.g. stream, lake etc., is located adjacent to the facility.

- Runoff from the assumed drainage area is conveyed via open channels to a single point of discharge. (Runoff quantity and quality from the unpaved area adjacent to the paved area was excluded from the research.)

- The storm chosen is an annual one-day rainfall event (two-year return interval) versus actual continuous events evaluation required by FHWA procedure.

- A 24-hour storm is chosen as the storm duration, since a storm lasting 24 hours will be sufficient to wash-off the gutter load and will allow both the AM and PM peak traffic to travel through the site and contribute to the runoff load. A 24-hour storm is used because the future traffic prediction is a 24-hour value.

- A runoff coefficient of 0.90 is used to compute the cumulative runoff volume because the drainage area is completely paved.

1. Using the projected average daily traffic (ADT), compute constituent loads using the linear regression equations below which were evaluated and found to be acceptable.

   Eq.1 Pb = 14.3 + 0.00189 (ADT)
   Eq.2 Zn = 14.3 + 0.00060 (ADT)
   Eq.3 FR = 5360 + 0.140 (ADT)
   Eq.4 COD = 3590 + 0.221 (ADT)
   Eq.5 TKN = 150 + 0.00342 (ADT)

   Where: Pb, Zn, FR, COD, and TKN are the cumulative loads in grams for lead, zinc, filterable residue, chemical oxygen demand, and total Kjeldahl nitrogen, respectively, the intercepts represent initial dry loads in grams, while the slopes represent the washoff of a constituent in grams per ADT during storm.

2. To forecast an annual load, divide the depth (amount) of the total annual rainfall (2-year return interval, 365-day value) for the station by the 1-day depth. The result is the theoretical number of 1-day events per year. Multiply each of the daily loads by the number of 1-day events to arrive at an annual load.

3. The flow weighted concentration is computed by dividing the daily event load determined in Step 1 (above) by the 1-day cumulative runoff volume.

4. The following linear regression equations are used to calculate nonfilterable residue loads:

   Eq.6 Zn = 11.5 + 0.00064 (TR)
   Eq.7 COD = 3600 + 0.214 (TR)
   Eq.8 NR = -760 + 0.65 (TR)

Where: TR is total residue in grams, Zn, COD, and NR are the cumulative loads in grams for zinc, chemical oxygen demand, and nonfilterable residue, respectively. The intercepts represent the initial dry loads in grams, while the slopes represent the fraction of constituent found in the total residue load washed from the pavement during the storm. Because total residue is an independent variable for which no easy future value can be obtained, the following procedure should be executed. Substitute values of the total zinc load computed from Equation 2 and the chemical oxygen demand load computed from Equation 4 in Equations 6 and 7 and compute two values of total residue. Then use the average value of total residue to compute the nonfilterable residue load using Equation 8. Compute the flow-weighted concentration as in Step 3 (above).

5. The final step is to check the computed loads and flow-weighted concentrations to make sure that the computed values are bound by the field observations. Table 8.2.5. shows the limits of the observed concentrations and loads.

Table 8.2.5. Limits of observed concentrations and loads of single events from monitored events in California.

Constituent	Concentration (mg/l)		Load (grams)	
	Low	High	Low	High
Total lead	0.17	4.10	4.0	304
Total zinc	0.10	1.80	2.0	84
Filterable residue	16	461	428	50,167
Chemical oxygen demand	23	724	382	26,344
Total kjeldahl nitrogen	0.1	14.0	34	1,070
Nonfilterable residue	18	2,660	143	55,259

Source: Howard et al., 1982

6. Final water quality assessment must be made using the values of loads and concentrations in a receiving water analysis.

C. EXAMPLE PROBLEM USING CALTRAN PROCEDURE

The following example problem is taken directly from Howell (1982) and is reproduced here to demonstrate the use of the Caltran model.

Problem: An urban freeway has been proposed for year 2005 and will have the following dimensions:

46 feet of paved median	=	46 ft
Two 10-foot wide shoulders	=	20 ft
Four 12-foot wide lanes	=	48 ft
		114 ft width

The ADT for year 2005 is 56,800 vehicles. The project will cross a river used for recreation and fishing. Trout (Salmo gairdneri) inhabit the river. Average annual rainfall for the site is 22 inches.

Make the following assumptions:

- The paved width of 114 ft and each 750 ft of freeway length will be drained to a single discharge point.
- Runoff coefficient is 0.90; thus, .90 * rainfall volume = runoff volume.
- A 24-hour storm delivers 2.06 inches of continuous rainfall.
- The vehicle fleet (and fuel used) will be the same in 2005 as it was in 1980. The vehicles are operating normally, i.e., at speeds of 55 miles per hour with no accidents or spills.

Given the above data and assumptions compute:

- The area of the assumed catchment.
- The cumulative volume of runoff (in liters).
- The loads and flow-weighted concentrations of the constituents: lead (Pb), Zinc (Zn), filterable residue (FR), chemical oxygen demand (COD), and total Kjeldahl nitrogen (TKN), and nonfilterable residue, using equations 1 through 5.

1. Area = length (ft) * width (ft) $\left(\frac{1 \text{ acre}}{43{,}560 \text{ ft}^2}\right)$ = acres

$$= 750 * 114 * \frac{1}{43{,}560} = 1.96 \text{ acres}$$

(1.96 acres approaches the lower limit of 2.0 acres, the smallest area from which data were collected to build the equations).

2. Cumulative Runoff Volume = runoff coefficient * rainfall volume

   = [0.90] * [2.06 in] * [1.96 ac] * [3630 ft^3/ac-in] [28.32 l/ft^3]

   = 373,564 call 373,500 liters

3. First, compute the load in grams using the appropriate regression equation, then compute the flow-weighted concentration (conc.) in milligrams per liter:

$$\text{conc.(mg/l)} = \frac{\text{Load (grams)}}{\text{cumulative runoff volume (liters)}} * \frac{\text{1000 milligrams}}{\text{1 gram}}$$

Eq.1	Pb	=	14.3 + 0.00189 (56,800)	
		=	121.65	122 grams
	conc.	=	121.65/373,500 * 1,000	
		=	0.326	0.33 mg/l
Eq.2	Zn	=	14.3 + 0.00060 (56,800)	
		=	48.38	48 grams
	conc.	=	48.38/373,500 * 1,000	
		=	0.129	0.13 mg/l
Eq.3	FR	=	5,360 + 0.140 (56,800)	
		=	13,312	13,300 grams
	conc.	=	13,312/373,500 * 1,000	
		=	35.64	35.6 mg/l
Eq.4	COD	=	3,590 + 0.221 (56,800)	
		=	16,142	16,150 grams
	conc.	=	16,142/373,500 * 1,000	
		=	43.22	43.2 mg/l
Eq.5	TKN	=	150 + 0.00342 (56,800)	
		=	344.26	344 grams
	conc.	=	344.26/373,500 * 1,000	
		=	0.922	0.92 mg/l

Using the forecasted values of zinc (48 grams) and chemical oxygen demand (16,150 grams), an average value of total residue (TR) can be calculated using equations 6 and 7.

Eq.6 Zn = 11.5 + 0.000640 (TR)

Eq.7 COD = 3600 + 0.214 (TR)

Solve for total residue (TR):
Using (6) TR = 57,031 grams
Using (7) TR = 58,645 grams
Sum = 115,676 grams
Avg = 57,838 57,840 grams

Using Equation 8 and the average value of 57,840 grams for total residue (TR), solve for nonfilterable residue (NR):

Eq.8 NR = -760 + 0.65 (57,840)
= 36,836 grams 36,840 grams
conc. = 36,836/373,500 * 1000
= 98.62 98.6 mg/l

4. Check

The computed values within Table 8.2.5 to see if they are within the limits of the values recorded.

The results must be compared to established water quality criteria, and if any excessive values are found, mitigating measures (or transportation alternatives) may be needed.

IV. WASHINGTON STATE DEPARTMENT OF TRANSPORTATION PROCEDURE FOR WATER QUALITY IMPACTS

A. INTRODUCTION

The State of Washington has developed a procedure (Horner and March, 1982) to assess highway stormwater water quality, in-stream water quality and aquatic ecological impacts of operation highways. The procedure is based on a model (Chui et al., 1982) developed as part of an ongoing multi-year study, sponsored by the Washington Department of Transportation (WSDOT) and conducted by the Department of Civil Engineering of the University of Washington.

This model to estimate cumulative pollutant loadings is applicable when soils, climate, and land use are similar to those at the monitored highway sites used to develop the model. Thus, Oregon, Northern California, and Southern Idaho as well as Washington State, may find the model suitable for assessing the impact of highway stormwater runoff. The impact assessment component of the WSDOT procedure has been incorporated into the FHWA procedure (Session 8.4).

The model for estimating loadings differs in that it relies on vehicles during the storm (VDS) as the primarily independent variable to

estimate pollutant loads. Washington State experiences low intensity, long duration rainfall events unique to this portion of the country. This contrasts with other locations in the country where relatively intense but brief precipitation events occur. As has been shown in the State of Washington, the migration and transport of highway pollutants are more of a function of the kinetic energy provided by moving vehicles than by rainfall (Chui et al., 1982).

The model expresses cumulative runoff pollutant loadings as functions of highway geometry, drainage configuration, and, vehicles during the storm expressed as follows:

Eq.1 $TSS = (K)\ (VDS)\ (C)$

Eq.2 Pollutant loading i = (Kp_i) (TSS Loading)

where:
- TSS = loading of total suspended solids from runoff (lb/highway-mi)
- K = loading constant (lb/1000 VDS/highway-mi)
- VDS = vehicles during the storm (in thousands)
- C = runoff coefficient (ratio of runoff volume to precipitation volume)
- Kp_i = ratio of pollutant i to TSS

The model, in addition to its geographic considerations, is limited in suitability for long-term (monthly or annually) versus individual event projections. This is similar to FHWA's Predictive Procedure (Kobriger, 1981). Loadings in a given locale are highly variable on an event basis, but more constant in a longer time frame when normalized for traffic and using a runoff coefficient.

B. WSDOT ANNUAL POLLUTANT LOADING ASSESSMENT PROCEDURE

The following procedure is taken directly from Horner and Mar (1982) and represents only one portion of the procedure. If based on the initial annual analysis described in the procedure, a monthly evaluation is required and presented here as an example of another possible approach, given the restrictions previously described. It also illustrates the variations between highway sites.

1. Estimate the hr/yr during which the roadway is expected to be wet as equal to the hr/yr of recorded precipitation. The reported hr/yr of recorded precipitation ($\leq$0.01 inch) represents the mean of a number of years of data (1948-1964). Trace quantities are eliminated from consideration, since they generally do not produce runoff. The tabulated data are recommended as an estimate of the hr/yr of wet roadway, recognizing that two counteracting factors are operating: (1) the highway remains wet for some time after precipitation stops; however (2) precipitation does not necessary fall throughout a recorded hour.

2. Estimate the total annual vehicles passing during storms (VDS/yr) as follows:

$$\text{VDS/yr} = \text{ADT} \quad \frac{\text{wet hr/yr}}{\text{24 hr/day}}$$

where: ADT = projected average daily traffic on highway lanes draining to receiving water.

3. Estimate annual highway runoff TSS loading according to:

$$\text{TSS (lb/highway - mi/yr)} = (K) \quad \frac{\text{VDS/yr}}{1000} \; (C)$$

where: K = 6.4 lb TSS/highway-mi/1000 VDS for western Washington
K = 26 lb TSS/highway-mi/1000 VDS for eastern Washington
C = runoff coefficient for the site

The loading constants given apply to new highways and existing highways where traffic increase is anticipated. On existing highways the constants apply whether or not additional lanes are constructed, up to a maximum of four lanes in a single direction, representing the cases contributing to the data base (Little, 1982). With greater widths, pollutants deposited on innermost lanes may be transported less effectively into shoulder drainage, such that K would tend to decrease; however, there was no sampling to test this hypothesis.

Note: If the lanes in one direction only drain to the receiving water, adjust ADT accordingly.

4. Express total annual highway loading (L_H) by multiplying by number of highway-mi.

5. If a mitigation device such as a detention basin is provided, reduce the TSS loading according to the solids removal capability of the device. If highway runoff is discharged to receiving water via a vegetated drainage course, multiply the estimated TSS loading by the appropriate fraction as follows in Table 8.2.6 (after Wang, 1981). Interpolate as necessary.

6. Estimate annual highway loadings of other pollutants from:

$$\text{Loading (lb/yr)} = (K_p) \text{ (TSS Loading)}$$

where: K_p = ratio of pollutant P to TSS (Table 8.2.7.)
TSS Loading previously estimated

Table 8.2.6. Solids removal ability of vegetated drainage course.

Length of Vegetated Drainage Course (ft)	Fraction of Pollutant Remaining
≤30	1
31- 60	0.50
61- 90	0.40
91-120	0.30
121-150	0.26
151-180	0.23
≥180	0.20

Use the modified TSS loading in further calculations.

Source: Wang, 1981

Table 8.2.7 K_p (Pollutant:TSS Ratios) for Various Contaminants in Highway Runoff.

Pollutant	Abbreviation	K_p
Chemical Oxygen Demand	COD	$K_{COD} = 0.4$
Lead (Western Washington)	Pb	$K_{Pb} = 1.5 \times 10^{-4} + (8.7 \times 10^{-8})(ADT)$
(Eastern Washington)		$K_{Pb} = 5.3 \times 10^{-4} + (2.8 \times 10^{-9})(ADT)$ (Note 1)
Zinc (Western Washington)	Zn	$K_{Zn} = 1.4 \times 10^{-4} + (3.0 \times 10^{-8})(ADT)$
(Eastern Washington)		$K_{Zn} = 2.0 \times 10^{-4} + (3.2 \times 10^{-7})(ADT)$
Copper	Cu	$K_{Cu} = 7.9 \times 10^{-5} + (2.7 \times 10^{-9})(ADT)$
Nitrate + Nitrite-Nitrogen	NO_3+NO_2-N	$K_N = 2.0 \times 10^{-3}$
Total Kjeldahl Nitrogen (Western Washington)	TKN	$K_{TKN} = 2.7 \times 10^{-3}$
(Eastern Washington)		$K_{TKN} = 1.2 \times 10^{-3}$
Total Phosphorus	TP	$K_{TP} = 2.1 \times 10^{-3}$

Note: (1) Base predicted lead loading on the lead concentration in gasoline at the time in proportion to that during the years of research. During those years, the concentration was 0.13 grams/liter. That concentration is scheduled to be reduced under U.S. Environmental Protection Agency regulations, and that agency can provide information on adherence to the schedule. For estimation purposes, it should be assumed that the proportion of vehicles using leaded gasoline remains constant.

SESSION QUESTIONS:

1. Based on the different procedures, what are the major differences bewteen the predictive procedures presented?

2. What limitations restrict the use of the procedures presented?

3. In what ways may the most applicable procedure presented here be adopted to use in a particular state?

SECTION 8: PREDICTION OF WATER QUALITY IMPACTS

SESSION 8.4: PREDICTION OF LOADING IMPACTS OF HIGHWAY RUNOFF - CASE STUDY

Estimated Time for Completion:

OBJECTIVES: Upon completion of this session, participants will be able to:

- Calculate pollutant loadings from other land uses within a watershed, using the simplified method presented.
- Assess the loading impacts from the highway, relative to loadings from other land uses within the watershed.
- Recognize the problems of the method presented, and be introduced to other approaches that might be used when more sensitive analysis is required.

SESSION OVERVIEW:

One approach to assess the potential impacts of pollutant loadings from highways surfaces compares the area loadings from other land uses within the watershed to those loadings estimated from the highway right-of-way.

This session introduces a simplified procedure for conducting an impact analysis. Case Study 8.4 will be distributed and participants will complete the required analysis.

Participants will review questions at the end of the session and discuss the findings and other approaches used when more sensitive analysis is required.

8.4: PREDICTION OF LOADING IMPACTS OF HIGHWAY RUNOFF - CASE STUDY

I. DETERMINATION OF BACKGROUND LOADINGS FOR THE DRAINAGE AREA

The following procedure is adapted from Horner and Mar (1982). This simplified procedure may be used for non-winter periods to determine background loadings for a watershed area, based on typical area pollutant loadings and typical runoff concentrations data for selected land uses reported in the literature. The actual loadings and runoff concentrations vary for each location, based on site characteristics (e.g., rural or urban), soil types, and other factors, and the results should be interpreted with caution. The procedure provides a relative indication of highway loads to background loadings, and may determine whether a more detailed evaluation using more complicated procedures is required. The steps of the procedure are:

1. If the receiving water is a stream and if a comprehensive water quality record exists for the stream, proceed to Step 2. Otherwise, go to Step 3.

2. Estimate the mean monthly loading of each pollutant transported by the stream, prior to the presence of the highway (L_s, lb/mo) according to:

$$L_s = 1{,}965\ Q_s C_s$$

where: Q_s and C_s are average quantities for the month in question.

where: Q_s = average stream discharge (cfs)
C_s = average pollutant concentration (mg/l)

The loadings for each month should be aggregated for the period, if the measured flow data are available.

Q_s may be the discharge rate determined for a specific drainage area; however, then C_s must be a flow weighted average for the same flow rate.

If the stream is gaged, obtain Q_s in the U.S. Geological Survey Water Resources Data provided for the most recent water year. If the stream is not gaged, estimate Q_s from the record of a nearby stream with similar watershed characteristics, as follows:

$$Q_s = Q_s^{\ 1} \frac{A_w}{A_w^{\ 1}}$$

where: Q_s = average discharge in runoff receiving stream (cfs)

$Q_s^{\ 1}$ = average discharge in stream of record (cfs)

A_w = runoff receiving stream watershed area (any area units)

$A_w^{\ 1}$ = stream of record watershed area (any area units)

3. Determine the areas (in acres) in Central Business District, Other Commercial, Industrial, Single-Family Residential, Multiple-Family Residential, Cropland, Pasture, and Forested and Open Land used in the watershed draining to the highway runoff discharge point located farthest downstream. If it is projected by the planning agency for the location that development will modify land uses substantially in coming years, conduct the analysis for both present and ultimate land uses.

4. Determine annual area loading (lb/acre/yr) of each contaminant for each land use in the receiving water basin from local data, if they exist, or Table 8.4.1. (Note storm runoff pollutant loadings for specific land use categories.) Where a range is given, use the lower value if a conservative estimate of highway contribution to total loading is desired; otherwise, use the midpoint of the range. If pollutant loading rates are not available for a specific pollutant, then go to Step 7.

5. Approximate the proportion of each annual area loading delivered during the month or period in question according to:

   lb/acre/mo (period)=[(hr ppt during month (period)/annual hr ppt) (lb/acre/yr)] or lb/acre/mo = []

6. Multiply loadings in lb/acre/mo by the respective acres to obtain loadings for the month (period) in question for each land use (L_{Li}). Then sum over all land uses for each pollutant (summation L_{Li}). Record results on Worksheet 8.4.a.

7. From Table 8.4.1a, determine the runoff coefficient for each land use in the watershed, above the discharge point for the project.

8. Multiply the runoff coefficient for each land use by the total seasonal rainfall for the site to obtain the runoff in inches.

9. Convert the runoff in inches to runoff volume by the following equation:

$$Q_{cf} = \frac{R \quad * \quad acres}{12 \quad * \quad 43{,}560}$$

R = runoff in inches
Q_{cf} = runoff in cubic feet

10. Convert Q_{cf} to liters by multiplying by 28.31625.

$R_L = Q_{cf} * 28.31625$

R_L = Runoff in liters

11. Determine total lbs. of pollutant by using the following equation and Table 8.4.2. Record results on Worksheet 8.4.b:

$P_{pD} = R_L * P_{conc} * 2.2046 * 10^{-6}$

where: P_{pD} = total pollutant loading
R_L = runoff volume expressed as liters
P_{conc} = pollutant concentration

12. If the receiving water is a stream, proceed to Step 13. If the receiving water is a lake or wetland, go to Step 15.

13. Estimate point source loadings (L_p) of each pollutant as follows:

L_p (lb/mo) = 1,965 Q_pC_p

where: Q_p and C_p are monthly quantities for the month in question

Q_p = point source effluent flow rate (cfs) (average over year if not continuous). Obtain flow from discharge monitoring report as required by NPDES permit or develop industry typical flow.

C_p = average point source effluent pollutant concentration (mg/l). Obtain from monitoring records or from industry typical discharge concentrations available from U.S. EPA Development Document Series for the specific point source category.

14. Estimate total stream loadings prior to highway presence as:

L_s = summation $L_{Li} + L_p$

Table 8.4.1. Storm runoff pollutant loadings for specific land use categories.

Land	Loading (lb/acre/yr)							
	TSS	COD	Pb	ZN	Cu	NO_3+NO_2	TKN	TP
Central Business District	964	955	6.3	2.7	1.9	4.0	13	2.5
Other Commercial	750	906	2.7	2.9	N/A	0.6	13	2.4
Industrial	50	56	1.8-6.3	3.1-11	0.3-1.0	0.4	2-13	0.8-3.6
Single-Family Residential	15	25	0.1	0.2	0.03	0.3	1-5	0.2-1.3
Multiple-Family Residential	390	297	0.6	0.3	0.3	3.4	3-4	1.2-1.4
Cropland	402	N/A	0.004-0.005	0.03-0.07	0.01-0.05	7.0	1.5	0.3
Pasture	306	N/A	0.003-0.013	0.02-0.15	0.02-0.04	0.3	0.6	0.06
Forested	76	N/A	0.01-0.03	0.01-0.03	0.02-0.03	0.5	2.6	0.08
Open	6	1.8	N/A	N/A	N/A	0.3	1.5	0.06

NOTES:

1. Means given where available; otherwise ranges are reported.

2. N/A -- Not available. (If specific pollutant loadings are not indicated here, then, determine loadings based on mean concentration values.

SOURCE: Horner, R.R. et al., 1982.

Table 8.4.1a Values of runoff coefficients (C) for use in the runoff volume estimation.

Type of surface	Runoff coefficient (C)[a]
Rural Areas	
Concrete or sheet asphalt pavement	0.8-0.9
Asphalt macadam pavement	0.6-0.8
Gravel roadways or shoulders	0.4-0.6
Bare earth	0.2-0.9
Steep grassed areas (2:1)	0.5-0.7
Turf meadows	0.1-0.4
Forested areas	0.1-0.3
Cultivated fields	0.2-0.4
Urban Areas	
Flat residential, with about 30 percent of area impervious	0.40
Flat residential, with about 60 percent of area impervious	0.55
Moderately steep residential, with about 50 percent of area impervious	0.65
Moderately steep built up area, with about 70 percent of area impervious	0.80
Flat commercial, with about 90 percent of area impervious	0.80

Source: Searcy, 1973.

[a] For flat slopes or permeable soil, use the lower values. For steep slopes or impermeable soil, use the higher values.

Table 8.4.2. Mean urban runoff concentrations by land use (NURP) (U.S. EPA, 1983)

Pollutant	Units	Residential	Commercial	Industrial	Mixed	Open
TSS	mg/l	206.0	160.0	143.0	297.0	218.0
BOD	mg/l	12.0	12.4	9.5	12.4	2.0
TN	mg/l	3.64	2.45	2.32	2.51	1.85
TP	mg/l	0.465	0.493	0.539	0.489	0.188
FCB (winter only)	cells/100 ml	7,099.0	7,099.0	7,099.0	7,099.0	7,099.0
S/S/F	cells/ 100 ml	31,995.0	31,995.0	31,995.0	31,995.0	31,995.0
O&G[a]	mg/l	3.89	13.13	7.1	6.23	.0
Fe	mg/l	2.73	2.73	2.73	2.73	2.73
As	ug/l	4.25	4.25	4.25	4.25	4.25
Cd	ug/l	1.58	1.58	1.58	1.58	1.58
Cr	ug/l	8.51	8.51	8.51	8.51	8.51
Cu	ug/l	19.7	19.7	19.7	19.7	19.7
Pb	ug/l	72.8	72.8	72.8	72.8	72.8
Hg	ug/l	0.5	0.5	0.5	0.5	0.5
Zn	ug/l	103.7	103.7	103.7	103.7	103.7
PCBs	ug/l	2.96	2.96	2.96	2.96	2.96
CHPs	ug/l	9.07	9.07	9.07	9.07	9.07

[a]Data taken from Stenstrom et al., 1984.

15. Express the impact on stream pollutant loadings in terms of the estimated increase due to P_d highway runoff as a percentage of the original stream loadings (L_s). If the estimated increase exceeds 10 percent for any pollutant, then mitigation may be required. If the stream eventually discharges to a lake or wetland, also evaluate the impact on the body of water according to the next Steps 16 and 17.

16. If the immediate or eventual receiving water is a lake or wetland, estimate total loadings for the month in question prior to the highway presence (L_{La}) as equal to summation L_{Li} plus any point source loading (1,965 Q_pC_p).

17. If the immediate or eventual receiving water is a lake, conduct a special analysis to assess the potential impact of phosphorus loading on trophic state as follows:

    a. Convert P_d and L_{La} to kg/mo by dividing by 2.2 lb/kg.

    b. Estimate annual loadings from the monthly or seasonal loadings found previously by proportion (for both P_d and summation L_{Li} + L_B):

$$\text{kg/yr} = \frac{\text{annual hr precipitation}}{\text{hr precipitation during the month}} \text{ (kg/mo)}$$

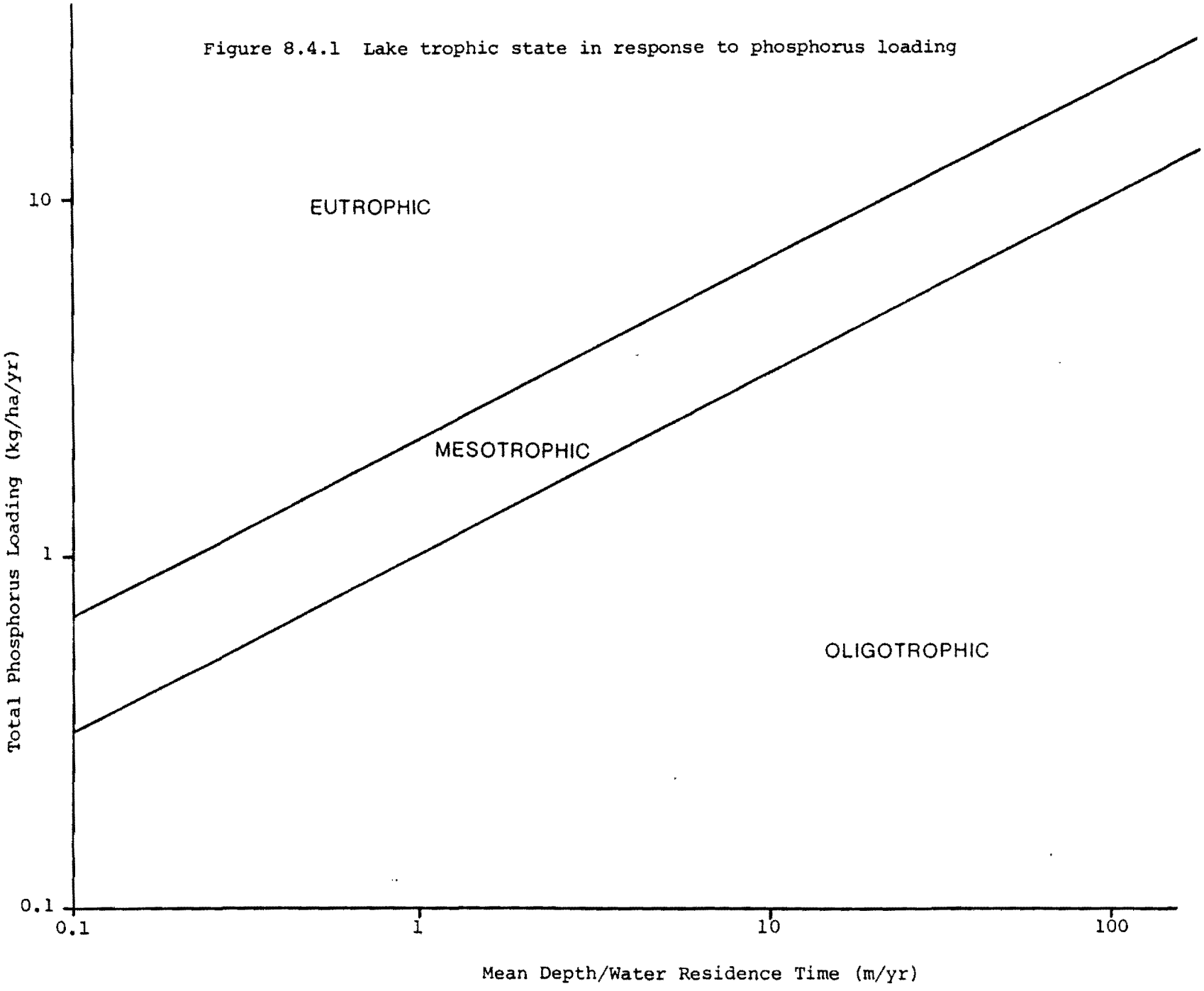
    c. Find the contributions of the highway and all other sources to the lake area total phosphorus (TP) loading (kg/ha/yr) by dividing L_H and L_{La}, respectively, by the lake surface area (A_{La}, ha). [Note: 1 hectare (ha) = 2.47 acres.]

    d. Divide lake mean depth (m) by water residence time (yr), where water residence time = lake volume (any volume units)/outflow rate (any consistent volume/yr units).

    e. Locate the lake on Figure 8.4.1, the trophic state graph (Vollenweider and Dillon, 1974), by using L_{La}/A_{La} as ordinate and the result of the previous step as abscissa.

18. If the highway loading addition does not move the status point near or into a higher trophic category, declare minimal impact on lake eutrophication and analyze impacts associated with maintenance or special problem areas. If a substantial impact on trophic state appears likely, mitigation should be further considered.

Figure 8.4.1 Lake trophic state in response to phosphorus loading



Source: Vollenweider and Dillon, 1974

Appendix M

IDNR Water Wells

REFNO	AQUELV	BAILERR	BEDROCK	PUMPRAT	BEDRO_1	SCREENL	STATIC	DEPTH		RNG	TWN	SEC	STRCOUNTY	STRTOPO	DATE
207379	0	0	0	1	0	0	37	150		1E	11N	18	MORGAN	MARTINSVILLE	9/26/1955
350554	0	0	0	80	0	3	8	63		1E	11N	18	MORGAN	MARTINSVILLE	1/15/2001
385127	0	0	0	15	0	4	8	60		1E	11N	18	MORGAN	MARTINSVILLE	8/30/2004
209574	0	0	50	0	565	0	45	77		1W	11N	26	MORGAN	HINDUSTAN	
209649	0	15	50	0	565	0	0	80		1W	11N	23	MORGAN	HINDUSTAN	9/26/1979
209604	0	12	27	0	593	0	0	75		1W	11N	26	MORGAN	HINDUSTAN	8/21/1977
209619	0	0	88	0	500	3	6	24		1W	11N	24	MORGAN	HINDUSTAN	6/28/1979
209629	0	30	28	0	572	0	0	52		1W	11N	24	MORGAN	HINDUSTAN	1/20/1965
207304	0	5	21	0	579	0	0	180		1E	11N	18	MORGAN	MARTINSVILLE	9/17/1959
207374	559	15	0	0	0	3	10	41		1E	11N	18	MORGAN	MARTINSVILLE	9/19/1971
269754	0	18	30	0	570	0	8	50		1W	11N	13	MORGAN	MARTINSVILLE	7/5/1975
269759	532	10	0	0	0	4	19	68		1W	11N	13	MORGAN	MARTINSVILLE	6/10/1966
403020	0	0	53	50	577	0	45	97		1W	11N	26	MORGAN	HINDUSTAN	7/25/2006
20888	0	0	0	60	0	60	0	145		1W	10N	28	MONROE	MODESTO	1/11/1988
213693	0	3	50	0	0	0	60	120		1W	8N	19	MONROE	CLEAR CREEK	7/20/1967
213698	0	3	70	0	0	0	31	105		1W	8N	19	MONROE	CLEAR CREEK	8/12/1971
221960	0	5	40	0	0	0	45	65		1W	9N	31	MONROE	BLOOMINGTON	10/3/1967
272239	0	0	0	0	0	0	0	0		1W	10N	33	MONROE	MODESTO	3/1/1994
310446	0	10	37	0	613	0	0	100		1W	9N	4	MONROE	MODESTO	4/26/1961
19798	0	0	12	0	718	0	0	0		1W	10N	28	MONROE	MODESTO	6/1/1991
19799	0	0	15	0	715	0	0	0		1W	10N	28	MONROE	MODESTO	7/1/1991
210630	0	2	6	0	704	0	41	160		1W	10N	33	MONROE	MODESTO	2/2/1962
213733	0	5	23	0	757	0	70	150		1W	8N	19	MONROE	CLEAR CREEK	11/5/1964
213703	0	2	7	0	753	0	41	105		1W	8N	19	MONROE	CLEAR CREEK	7/10/1964
213708	0	2	22	0	738	0	45	132		1W	8N	19	MONROE	CLEAR CREEK	4/21/1965
213713	0	5	16	0	769	0	70	140		1W	8N	19	MONROE	CLEAR CREEK	8/12/1964
213718	0	10	76	0	724	0	90	120		1W	8N	19	MONROE	CLEAR CREEK	4/23/1969
213723	0	4	27	0	763	0	75	170		1W	8N	19	MONROE	CLEAR CREEK	9/8/1964
221934	0	1	5	0	865	0	38	195		1W	9N	20	MONROE	BLOOMINGTON	7/31/1965
221939	0	4	11	0	799	0	55	120		1W	9N	20	MONROE	BLOOMINGTON	10/22/1973
222605	0	24	5	0	645	0	0	95		1W	9N	4	MONROE	BLOOMINGTON	9/10/1963
222015	0	0	0	0	0	0	0	150		1W	9N	29	MONROE	BLOOMINGTON	8/30/1960
222025	0	2	20	0	800	0	48	115		1W	9N	29	MONROE	BLOOMINGTON	10/27/1972
209578	0	0	0	0	0	405	139	410		1W	11N	35	MORGAN	HINDUSTAN	8/30/1986
338988	0	0	0	0	0	0	0	240	IN	1W	10N	21	MONROE	MODESTO	8/21/1998
209573	0	20	40	0	730	0	0	100		1W	11N	35	MORGAN	HINDUSTAN	9/1/1960
209583	0	1	26	0	675	0	28	82		1W	11N	35	MORGAN	MODESTO	5/10/1963
209584	0	5	53	0	728	0	58	100		1W	11N	26	MORGAN	HINDUSTAN	9/6/1962
211755	0	8	14	0	786	0	110	222		1W	10N	21	MONROE	MODESTO	9/4/1962
211760	0	0	17	0	773	0	140	200		1W	10N	21	MONROE	MODESTO	10/22/1960
209608	0	2	40	0	682	0	70	212		1W	11N	34	MORGAN	MODESTO	10/8/1965
211785	0	10	16	0	804	0	40	90		1W	10N	15	MONROE	MODESTO	10/30/1959
211790	0	0	12	0	808	0	0	200		1W	10N	16	MONROE	MODESTO	6/10/1960

Record of Water Well

Indiana Department of Natural Resources

Reference Number
213758

Driving directions to well

Date completed
Oct 22, 1964

Owner-Contractor | *Name* | *Address* | *Telephone*
Owner
Driller
Operator

Construction Details

Well
Use: HOME | *Drilling method:* Cable Tool | *Pump type:*
Depth: 100.0 | *Pump setting depth:* | *Water quality:*

Casing
Length: 30.0 | *Material:* | *Diameter:* 6.0

Screen
Length: | *Material:* | *Diameter:* *Slot size:*

Well Capacity Test
Type of test: | *Test rate:* gpm for hrs. | *BailTest rate:* 5.0 gpm for 1.0 hrs.
Drawdown: ft. | *Static water level:* 30.0 ft. | *Bailer Drawdown* 0.0 ft.

Grouting Information
Material: | *Depth:* from to
Installation Method: | *Number of bags used:*

Well Abandonment
Sealing material: | *Depth:* from to
Installation Method: | *Number of bags used:*

Administrative
County: Monroe | *Township:* 8N *Range:* 1W
Section: 1 | *Topo map:* Clear Creek
Grant Number:
Field located by: MT | *on:* Jul 12, 1967
Courthouse location by: | *on:*
Location accepted w/o verification by: | *on:*
Subdivision name: | *Lot number:*
Ft W of EL: 2200.0 | *Ft N of SL:* 2300.0 | *Ft E of WL:* | *Ft S of NL:*
Ground elevation: 750.0 | *Depth to bedrock:* 8.0 | *Bedrock elevation:* 742.0 | *Aquifer elevation:*
UTM Easting: | *UTM Northing:*

NAD27

Well Log

Top	Bottom	Formation
0.0	8.0	YELLOW CLAY
8.0	12.0	STONE BLUE FLINT EXTRA HARD
12.0	18.0	STONE BUFF LS HARD
18.0	39.0	STONE GRAY LS SOFT
39.0	47.0	STONE BUFF LS HARD
47.0	61.0	STONE BROWNISH LS EXTRA HARD
61.0	65.0	STONE BROWNISH LS SOFTER
65.0	70.0	STONE GRAY LS HARD
70.0	76.0	STONE GRAY LS EXTRA HARD
76.0	82.0	STONE WHITE LS HARD
82.0	93.0	STONE WHITE LS SOFT
93.0	100.0	STONE WHITE LS HARD

— = Bedrock

Comments OWNER VERIFIED

Record of Water Well

Indiana Department of Natural Resources

Reference Number	*Driving directions to well*	*Date completed*
213668		Oct 09, 1971

Owner-Contractor	*Name*	*Address*	*Telephone*
Owner			() -
Driller			() -
Operator			() -

Construction Details

Well	*Use:* HOME	*Drilling method:* Cable Tool	*Pump type:*
	Depth: 120.0	*Pump setting depth:*	*Water quality:*
Casing	*Length:* 55.0	*Material:*	*Diameter:* 6.0
Screen	*Length:*	*Material:*	*Diameter: Slot size:*

Well Capacity Test

Type of test: *Test rate:* gpm for hrs. *BailTest rate:* 2.0 gpm for hrs.
Drawdown: ft. *Static water level:* 60.0 ft. *Bailer Drawdown* 55.0 ft.

Grouting Information

Material: *Depth:* from to
Installation Method: *Number of bags used:*

Well Abandonment

Sealing material: *Depth:* from to
Installation Method: *Number of bags used:*

Administrative

County: Monroe *Township:* 8N *Range:* 1W
Section: *Topo map:* Clear Creek
Grant Number:
Field located by: JRD *on:* Jul 26, 1978
Courthouse location by: *on:*
Location accepted w/o verification by: *on:*
Subdivision name: *Lot number:*
Ft W of EL: 2000.0 *Ft N of SL:* *Ft E of WL:* *Ft S of NL:* 2550.0
Ground elevation: 770.0 *Depth to bedrock:* 50.0 *Bedrock elevation:* 720.0 *Aquifer elevation:*
UTM Easting: *UTM Northing:*

Well Log

Top	Bottom	Formation
0.0	52.0	RED CLAY OPENINGS &LIMESTONE
50.0	100.0	SLIGHT BLUE LIMESTONE HARD
100.0	120.0	WHITE LIMESTONE

Comments MC 720; OWNER VERIFIED;

Record of Water Well

Indiana Department of Natural Resources

Reference Number
213723

Driving directions to well

Date completed
Sep 08, 1964

Owner-Contractor	*Name*	*Address*	*Telephone*
Owner			() -
Driller			() -
Operator			() -

Construction Details

Well	*Use:* HOME	*Drilling method:* Rotary	*Pump type:*
	Depth: 170.0	*Pump setting depth:*	*Water quality:*
Casing	*Length:* 27.0	*Material:*	*Diameter:* 6.5
Screen	*Length:*	*Material:*	*Diameter: Slot size:*

Well Capacity Test

Type of test: *Test rate:* gpm for hrs. *BailTest rate:* 4.0 gpm for hrs.
Drawdown: ft. *Static water level:* 75.0 ft. *Bailer Drawdown* 164.0 ft.

Grouting Information

Material: *Depth:* from to
Installation Method: *Number of bags used:*

Well Abandonment

Sealing material: *Depth:* from to
Installation Method: *Number of bags used:*

Administrative

County: Monroe *Township:* 8N *Range:* 1W
Section: *Topo map:* Clear Creek
Grant Number:
Field located by: JRD *on:* Jul 26, 1978
Courthouse location by: *on:*
Location accepted w/o verification by: *on:*
Subdivision name: *Lot number:*
Ft W of EL: *Ft N of SL:* *Ft E of WL:* 1700.0 *Ft S of NL:* 2000.0
Ground elevation: 790.0 *Depth to bedrock:* 27.0 *Bedrock elevation:* 763.0 *Aquifer elevation:*
UTM Easting: *UTM Northing:*

Well Log

Top	Bottom	Formation
0.0	3.0	TOPSOIL
3.0	12.0	RED CLAY
12.0	27.0	CLAY W/ BROKEN LIME
27.0	170.0	LIMESTONE

Comments MC 763; NEIGHBOR VERIFIED;

Record of Water Well

Indiana Department of Natural Resources

Reference Number
213713

Driving directions to well

Date completed
Aug 12, 1964

Owner-Contractor	*Name*	*Address*	*Telephone*
Owner			() -
Driller			() -
Operator			() -

Construction Details

Well	*Use:* HOME	*Drilling method:* Cable Tool	*Pump type:*
	Depth: 140.0	*Pump setting depth:*	*Water quality:*
Casing	*Length:* 20.0	*Material:*	*Diameter:* 6.0
Screen	*Length:*	*Material:*	*Diameter: Slot size:*

Well Capacity Test

Type of test: *Test rate:* gpm for hrs. *BailTest rate:* 4.5 gpm for 1.0 hrs.
Drawdown: ft. *Static water level:* 70.0 ft. *Bailer Drawdown* 5.0 ft.

Grouting Information

Material: *Depth:* from to
Installation Method: *Number of bags used:*

Well Abandonment

Sealing material: *Depth:* from to
Installation Method: *Number of bags used:*

Administrative

County: Monroe *Township:* 8N *Range:* 1W
Section: *Topo map:* Clear Creek
Grant Number:
Field located by: JRD *on:* Jul 26, 1978
Courthouse location by: *on:*
Location accepted w/o verification by: *on:*
Subdivision name: *Lot number:*
Ft W of EL: *Ft N of SL:* *Ft E of WL:* 1200.0 *Ft S of NL:* 2250.0
Ground elevation: 785.0 *Depth to bedrock:* 16.0 *Bedrock elevation:* 769.0 *Aquifer elevation:*
UTM Easting: *UTM Northing:*

Well Log

Top	Bottom	Formation
0.0	6.0	YEL CLAY
6.0	12.0	RED CLAY
12.0	16.0	YEL CLAY
16.0		

Record of Water Well

Indiana Department of Natural Resources

Reference Number
213708

Driving directions to well

Date completed
Apr 21, 1965

Owner-Contractor	*Name*	*Address*	*Telephone*
Owner			() -
Driller			() -
Operator			() -

Construction Details

Well	*Use:* HOME	*Drilling method:* Rotary	*Pump type:*
	Depth: 132.0	*Pump setting depth:*	*Water quality:*
Casing	*Length:* 22.0	*Material:*	*Diameter:* 6.5
Screen	*Length:*	*Material:*	*Diameter: Slot size:*

Well Capacity Test

Type of test:
Test rate: gpm for hrs.
BailTest rate: 2.0 gpm for hrs.
Drawdown: ft.
Static water level: 45.0 ft.
Bailer Drawdown 125.0 ft.

Grouting Information

Material:
Depth: from to
Installation Method:
Number of bags used:

Well Abandonment

Sealing material:
Depth: from to
Installation Method:
Number of bags used:

Administrative

County: Monroe
Township: 8N *Range:* 1W
Section:
Topo map: Clear Creek
Grant Number:
Field located by: MT
on: Jul 12, 1967
Courthouse location by:
on:
Location accepted w/o verification by:
on:
Subdivision name:
Lot number:
Ft W of EL:
Ft N of SL:
Ft E of WL: 1000.0
Ft S of NL: 2400.0
Ground elevation: 760.0
Depth to bedrock: 22.0
Bedrock elevation: 738.0
Aquifer elevation:

Well Log

Top	Bottom	Formation
0.0	22.0	CLAY YELLOW
22.0	132.0	LIMESTONE

Comments

Record of Water Well

Indiana Department of Natural Resources

Reference Number
213718

Driving directions to well

Date completed
Apr 23, 1969

Owner-Contractor	*Name*	*Address*	*Telephone*
Owner			() -
Driller			() -
Operator			() -

Construction Details

Well	*Use:* HOME	*Drilling method:* Cable Tool	*Pump type:*
	Depth: 120.0	*Pump setting depth:*	*Water quality:*
Casing	*Length:* 77.0	*Material:*	*Diameter:* 6.0
Screen	*Length:*	*Material:*	*Diameter: Slot size:*

Well Capacity Test

Type of test: *Test rate:* gpm for hrs. *BailTest rate:* 10.0 gpm for hrs.
Drawdown: ft. *Static water level:* 90.0 ft. *Bailer Drawdown* 20.0 ft.

Grouting Information

Material: *Depth:* from to
Installation Method: *Number of bags used:*

Well Abandonment

Sealing material: *Depth:* from to
Installation Method: *Number of bags used:*

Administrative

County: Monroe *Township:* 8N *Range:* 1W
Section: *Topo map:* Clear Creek
Grant Number:
Field located by: JRD *on:* Jul 27, 1978
Courthouse location by: *on:*
Location accepted w/o verification by: *on:*
Subdivision name: *Lot number:*
Ft W of EL: *Ft N of SL:* *Ft E of WL:* 2450.0 *Ft S of NL:* 1000.0
Ground elevation: 800.0 *Depth to bedrock:* 76.0 *Bedrock elevation:* 724.0 *Aquifer elevation:*

Well Log

Top	Bottom	Formation
0.0	60.0	LAYERS STONE & CLAY
60.0	76.0	CAVE OR OPENING
76.0	120.0	BROWN LIMESTONE

Comments MC 724; OWNER VERIFIEI

Record of Water Well

Indiana Department of Natural Resources

Reference Number
222015

Driving directions to well

Date completed
Aug 30, 1960

Owner-Contractor	*Name*	*Address*	*Telephone*
Owner			() -
Driller			() -
Operator			() -

Construction Details

Well	*Use:* HOME	*Drilling method:* Cable Tool	*Pump type:*
	Depth: 150.0	*Pump setting depth:*	*Water quality:*
Casing	*Length:*	*Material:*	*Diameter:*
Screen	*Length:*	*Material:*	*Diameter: Slot size:*

Well Capacity Test

Type of test: *Test rate:* gpm for hrs. *BailTest rate:* gpm for hrs.
Drawdown: ft. *Static water level:* ft. *Bailer Drawdown* ft.

Grouting Information

Material: *Depth:* from to
Installation Method: *Number of bags used:*

Well Abandonment

Sealing material: *Depth:* from to
Installation Method: *Number of bags used:*

Administrative

County: Monroe *Township:* 9N *Range:* 1W
Section: *Topo map:* Bloomington
Grant Number:
Field located by: JMH *on:* Mar 28, 1961
Courthouse location by: JMH *on:* Mar 28, 1961
Location accepted w/o verification by: *on:*
Subdivision name: *Lot number:*
Ft W of EL: *Ft N of SL:* 1500.0 *Ft E of WL:* 1100.0 *Ft S of NL:*
Ground elevation: 840.0 *Depth to bedrock:* *Bedrock elevation:*

Record of Water Well

Indiana Department of Natural Resources

Reference Number
222025

Driving directions to well

Date completed
Oct 27, 1972

Owner-Contractor	*Name*	*Address*	*Telephone*
Owner			
Driller			
Operator			

Construction Details

Well	*Use:* HOME	*Drilling method:* Cable Tool	*Pump type:*
	Depth: 115.0	*Pump setting depth:*	*Water quality:*
Casing	*Length:* 22.0	*Material:*	*Diameter:* 5.63
Screen	*Length:*	*Material:*	*Diameter: Slot size:*

Well Capacity Test

Type of test: *Test rate:* gpm for hrs. *BailTest rate:* 1.5 gpm for hrs.
Drawdown: ft. *Static water level:* 48.0 ft. *Bailer Drawdown* ft.

Grouting Information

Material: *Depth:* from to
Installation Method: *Number of bags used:*

Well Abandonment

Sealing material: *Depth:* from to
Installation Method: *Number of bags used:*

Administrative

County: Monroe *Township:* 9N *Range:* 1W
Section: 1 *Topo map:* Bloomington
Grant Number:
Field located by: MK *on:* May 18, 1978
Courthouse location by: *on:*
Location accepted w/o verification by: *on:*
Subdivision name: *Lot number:*
Ft W of EL: *Ft N of SL:* *Ft E of WL:* 1150.0 *Ft S of NL:* 300.0
Ground elevation: 820.0 *Depth to bedrock:* 20.0 *Bedrock elevation:* 800.0 *Aquifer elevation:*

Well Log

Top	Bottom	Formation
0.0	20.0	TOPSOIL & LIMESTONE
20.0	115.0	WHITE LIMESTONE MED. HARD

Comments MC800; MC; DRY HOLE; OWNER VERIFIED - NO LONGER USED

Record of Water Well

Indiana Department of Natural Resources

Reference Number
221934

Driving directions to well

Date completed
Jul 31, 1965

Owner-Contractor	*Name*	*Address*	*Telephone*
Owner			() -
Driller			() -
Operator			() -

Construction Details

Well	*Use:* HOME	*Drilling method:* Cable Tool	*Pump type:*
	Depth: 195.0	*Pump setting depth:*	*Water quality:*
Casing	*Length:* 27.5	*Material:*	*Diameter:* 6.0
Screen	*Length:*	*Material:*	*Diameter: Slot size:*

Well Capacity Test

Type of test: *Test rate:* gpm for hrs. *BailTest rate:* 0.67 gpm for 2.0 hrs.
Drawdown: ft. *Static water level:* 38.0 ft. *Bailer Drawdown* 0.0 ft.

Grouting Information

Material: *Depth:* from to
Installation Method: *Number of bags used:*

Well Abandonment

Sealing material: *Depth:* from to
Installation Method: *Number of bags used:*

Administrative

County: Monroe *Township:* 9N *Range:* 1W
Section: *Topo map:* Bloomington
Grant Number:
Field located by: LES *on:* Jul 01, 1966
Courthouse location by: *on:*
Location accepted w/o verification by: *on:*
Subdivision name: *Lot number:*
Ft W of EL: *Ft N of SL:* 300.0 *Ft E of WL:* 300.0 *Ft S of NL:*
Ground elevation: 870.0 *Depth to bedrock:* 5.0 *Bedrock elevation:* 865.0 *Aquifer elevation:*

Well Log

Top	Bottom	Formation
0.0	5.0	YEL CLAY
5.0	22.0	GRAY LS HARD
22.0	27.0	MUD SEAM
27.0	39.0	GRAY LS HARD
39.0	73.0	LT GRAY LS HARD
73.0	95.0	RUSTIC BUFF LS SOFTER
95.0	118.0	GRAY LS HARD
118.0	124.0	DARK GRAY LS EXTRA HARD
124.0	140.0	GRAY LS HARD
140.0	160.0	LT GRAY LS EXTR HARD
160.0	166.0	LT GRAY LS SOFTER
166.0	173.0	LT GRAY LS EXTRA HARD
173.0	180.0	LT GRAY LS LITTLE SOFTER
180.0	195.0	LT GRAY LS HARD

Comments MC 865

Record of Water Well

Indiana Department of Natural Resources

Reference Number
221939

Driving directions to well

Date completed
Oct 22, 1973

Owner-Contractor	*Name*	*Address*	*Telephone*
Owner			() -
Driller			() -
Operator			() -

Construction Details

Well	*Use:* HOME	*Drilling method:* Other	*Pump type:*
	Depth: 120.0	*Pump setting depth:*	*Water quality:*
Casing	*Length:* 21.0	*Material:*	*Diameter:* 6.25
Screen	*Length:*	*Material:*	*Diameter: Slot size:*

Well Capacity Test

Type of test: *Test rate:* gpm for hrs. *BailTest rate:* 4.0 gpm for 1.0 hrs.
Drawdown: ft. *Static water level:* 55.0 ft. *Bailer Drawdown* 120.0 ft.

Grouting Information

Material: *Depth:* from to
Installation Method: *Number of bags used:*

Well Abandonment

Sealing material: *Depth:* from to
Installation Method: *Number of bags used:*

Administrative

County: Monroe *Township:* 9N *Range:* 1W
Section: *Topo map:* Bloomington
Grant Number:
Field located by: MBR *on:* May 18, 1978
Courthouse location by: *on:*
Location accepted w/o verification by: *on:*
Subdivision name: *Lot number:*
Ft W of EL: *Ft N of SL:* 500.0 *Ft E of WL:* 100.0 *Ft S of NL:*
Ground elevation: 810.0 *Depth to bedrock:* 11.0 *Bedrock elevation:* 799.0 *Aquifer elevation:*
UTM Easting: 538299.0 *UTM Northing:* 4338325.0

Well Log

Top	Bottom	Formation
0.0	8.0	YEL CLAY
8.0	11.0	RED CLAY
11.0	24.0	GRAY KLS HARD
24.0	36.0	GRAY LS EXTRA HARD
36.0	42.0	BLUE LS EXTRA HARD
42.0	65.0	GRAY LS HARD
65.0	85.0	BUFF LS HARD
85.0	100.0	GRAY LS HARD
100.0	120.0	DARK GRAY LS HARD

Comments MC 799; OWNER VER;

Record of Water Well

Indiana Department of Natural Resources

Reference Number
222451

Driving directions to well

Date completed
Oct 26, 1971

Owner-Contractor	*Name*	*Address*	*Telephone*
Owner			
Driller			
Operator			

Construction Details

Well	*Use:* HOME	*Drilling method:* Other	*Pump type:*
	Depth: 195.0	*Pump setting depth:*	*Water quality:*
Casing	*Length:* 20.0	*Material:*	*Diameter:* 6.25
Screen	*Length:*	*Material:*	*Diameter: Slot size:*

Well Capacity Test
Type of test: *Test rate:* gpm for hrs. *BailTest rate:* 7.5 gpm for hrs.
Drawdown: ft. *Static water level:* 70.0 ft. *Bailer Drawdown* 195.0 ft.

Grouting Information
Material: *Depth:* from to
Installation Method: *Number of bags used:*

Well Abandonment
Sealing material: *Depth:* from to
Installation Method: *Number of bags used:*

Administrative
County: Monroe *Township:* 9N *Range:* 1W
Section: *Topo map:* Bloomington
Grant Number:
Field located by: BEB *on:* Mar 07, 1989
Courthouse location by: *on:*
Location accepted w/o verification by: *on:*
Subdivision name: LANCASTER PARK *Lot number:*
Ft W of EL: 150.0 *Ft N of SL:* 100.0 *Ft E of WL:* *Ft S of NL:*
Ground elevation: 720.0 *Depth to bedrock:* 6.0 *Bedrock elevation:* 714.0 *Aquifer elevation:*

Well Log

Top	Bottom	Formation
0.0	2.0	YEL CLAY
2.0	6.0	RED CLAY
6.0	45.0	GRAY LS HARD
45.0	67.0	DARK GRAY LS HARD
67.0	130.0	GRAY LS HARD
130.0	146.0	WHITE LS HARD
146.0	170.0	GRAY LS HARD
170.0	195.0	BLUE SOAPSTONE HARD

Comments WELL LOCATED ON S

Record of Water Well

Indiana Department of Natural Resources

Reference Number
222610

Driving directions to well

Date completed
May 02, 1963

Owner-Contractor	*Name*	*Address*	*Telephone*
Owner			() -
Driller			() -

Construction Details

Well	*Use:* HOME	*Drilling method:* Cable Tool	*Pump type:*
	Depth: 110.0	*Pump setting depth:*	*Water quality:*
Casing	*Length:* 21.5	*Material:*	*Diameter:* 6.0
Screen	*Length:*	*Material:*	*Diameter: Slot size:*

Well Capacity Test

Type of test: PUMPING *Test rate:* gpm for 1.0 hrs. *BailTest rate:* 1.0 gpm for hrs.
Drawdown: ft. *Static water level:* 50.0 ft. *Bailer Drawdown* 50.0 ft.

Grouting Information

Material: *Depth:* from to
Installation Method: *Number of bags used:*

Well Abandonment

Sealing material: *Depth:* from to
Installation Method: *Number of bags used:*

Administrative

County: Monroe *Township:* 9N *Range:* 1W
Section: *Topo map:* Bloomington
Grant Number:
Field located by: LES *on:* Jul 01, 1966
Courthouse location by: *on:*
Location accepted w/o verification by: *on:*
Subdivision name: *Lot number:*
Ft W of EL: 2500.0 *Ft N of SL:* 3200.0 *Ft E of WL:* *Ft S of NL:*
Ground elevation: 650.0 *Depth to bedrock:* 20.0 *Bedrock elevation:* 630.0 *Aquifer elevation:*

Well Log

Top	Bottom	Formation
0.0	21.5	CLAY
21.5	110.0	STONE & SH

Comments MC 630; VERY GOOD WELL

Record of Water Well

Indiana Department of Natural Resources

Reference Number
222605

Driving directions to well

Date completed
Sep 10, 1963

Owner-Contractor	*Name*	*Address*	*Telephone*
Owner			() -
Driller			() -

Construction Details

Well	*Use:* HOME	*Drilling method:* Cable Tool	*Pump type:*
	Depth: 95.0	*Pump setting depth:*	*Water quality:*
Casing	*Length:* 6.0	*Material:*	*Diameter:* 6.0
Screen	*Length:*	*Material:*	*Diameter: Slot size:*

Well Capacity Test

Type of test: *Test rate:* gpm for hrs. *BailTest rate:* 24.0 gpm for hrs.
Drawdown: ft. *Static water level:* ft. *Bailer Drawdown* 0.0 ft.

Grouting Information

Material: *Depth:* from to
Installation Method: *Number of bags used:*

Well Abandonment

Sealing material: *Depth:* from to
Installation Method: *Number of bags used:*

Administrative

County: Monroe *Township:* 9N *Range:* 1W
Section: *Topo map:* Bloomington
Grant Number:
Field located by: LES *on:* Jul 01, 1966
Courthouse location by: *on:*
Location accepted w/o verification by: *on:*
Subdivision name: *Lot number:*
Ft W of EL: 2900.0 *Ft N of SL:* 3900.0 *Ft E of WL:* *Ft S of NL:*
Ground elevation: 650.0 *Depth to bedrock:* 5.0 *Bedrock elevation:* 645.0 *Aquifer elevation:*

Well Log

Top	Bottom	Formation
0.0	5.0	DIRT
5.0	95.0	BLUE SH

Comments MC 645

Record of Water Well

Indiana Department of Natural Resources

Reference Number
210630

Driving directions to well

Date completed
Feb 02, 1962

Owner-Contractor	*Name*	*Address*	*Telephone*
Owner			() -
Driller			() -
Operator			() -

Construction Details

Well	*Use:* HOME	*Drilling method:* Cable Tool	*Pump type:*
	Depth: 160.0	*Pump setting depth:*	*Water quality:*
Casing	*Length:* 18.5	*Material:*	*Diameter:* 6.0
Screen	*Length:*	*Material:*	*Diameter: Slot size:*

Well Capacity Test

Type of test: *Test rate:* gpm for hrs. *BailTest rate:* 1.6 gpm for 2.0 hrs.
Drawdown: ft. *Static water level:* 41.0 ft. *Bailer Drawdown* ft.

Grouting Information

Material: *Depth:* from to
Installation Method: *Number of bags used:*

Well Abandonment

Sealing material: *Depth:* from to
Installation Method: *Number of bags used:*

Administrative

County: Monroe *Township:* 10N *Range:* 1W
Section: SE1/4 of the SE1/4of the SW1/4 of Section 33 *Topo map:* Modesto
Grant Number:
Field located by: CP *on:* Aug 01, 1967
Courthouse location by: *on:*
Location accepted w/o verification by: *on:*
Subdivision name: *Lot number:*
Ft W of EL: *Ft N of SL:* 50.0 *Ft E of WL:* 2400.0 *Ft S of NL:*
Ground elevation: 710.0 *Depth to bedrock:* 6.0 *Bedrock elevation:* 704.0 *Aquifer elevation:*

Well Log

Top	Bottom	Formation
0.0	6.0	DIRT
6.0	14.0	HARD ROCK
14.0	17.0	DIRT
17.0	45.0	HARD ROCK
45.0	55.0	SH
55.0	65.0	HARD ROCK
65.0	160.0	SH

Comments MC700; NEIGHBOR VERIFIED

Record of Water Well

Indiana Department of Natural Resources

Reference Number	*Driving directions to well*	*Date completed*
19798	[illegible]	Jun 01, 1991

Owner-Contractor	*Name*	*Address*	*Telephone*
Owner			
Company			
Driller			
Operator			

Construction Details

Well	*Use:* OTHER	*Drilling method:* Rotary	*Pump type:*
	Depth:	*Pump setting depth:*	*Water quality:*
Casing	*Length:*	*Material:*	*Diameter:*
Screen	*Length:*	*Material:*	*Diameter: Slot size:*

Well Capacity Test

Type of test: *Test rate:* gpm for hrs. *BailTest rate:* gpm for hrs.
Drawdown: ft. *Static water level:* ft. *Bailer Drawdown* ft.

Grouting Information

Material: BENT *Depth:* from 4.0 to 150.0
Installation Method: PUMP *Number of bags used:* 3.0

Well Abandonment

Sealing material: *Depth:* from to
Installation Method: *Number of bags used:*

Administrative

County: Monroe *Township:* 10N *Range:* 1W
Section: *Topo map:* Modesto
Grant Number:
Field located by: JS *on:* Jul 22, 1993
Courthouse location by: *on:*
Location accepted w/o verification by: *on:*
Subdivision name: ' *Lot number:* 25
Ft W of EL: 600.0 *Ft N of SL:* *Ft E of WL:* *Ft S of NL:* 575.0
Ground elevation: 730.0 *Depth to bedrock:* 12.0 *Bedrock elevation:* 718.0 *Aquifer elevation:*

Well Log

Top	Bottom	Formation
0.0	12.0	CLAY
12.0	150.0	STONE

Comments GEOTHERMAL WELL ALL SIMILAR, VERIFIED BY ADDRESS

Record of Water Well

Indiana Department of Natural Resources

Reference Number
19799

Driving directions to well

Date completed
Jul 01, 1991

Owner-Contractor	*Name*	*Address*	*Telephone*
Owner			
Company			
Driller			
Operator			

Construction Details

Well	*Use:* OTHER	*Drilling method:* Rotary	*Pump type:*
	Depth:	*Pump setting depth:*	*Water quality:*
Casing	*Length:*	*Material:*	*Diameter:*
Screen	*Length:*	*Material:*	*Diameter: Slot size:*

Well Capacity Test

Type of test: *Test rate:* gpm for hrs. *BailTest rate:* gpm for hrs.
Drawdown: ft. *Static water level:* ft. *Bailer Drawdown* ft.

Grouting Information

Material: BENT *Depth:* from 4.0 to 150.0
Installation Method: PUMP *Number of bags used:* 4.0

Well Abandonment

Sealing material: *Depth:* from to
Installation Method: *Number of bags used:*

Administrative

County: Monroe *Township:* 10N *Range:* 1W
Section: *Topo map:* Modesto
Grant Number:
Field located by: JS *on:* Jul 20, 1993
Courthouse location by: *on:*
Location accepted w/o verification by: *on:*
Subdivision name: *Lot number:* 2
Ft W of EL: 790.0 *Ft N of SL:* *Ft E of WL:* *Ft S of NL:* 175.0
Ground elevation: 730.0 *Depth to bedrock:* 15.0 *Bedrock elevation:* 715.0 *Aquifer elevation:*

Well Log

Top	Bottom	Formation
0.0	15.0	CLAY
15.0	150.0	STONE

Comments GEOTHERMAL WELLS ALL SIMILAR,

Record of Water Well

Indiana Department of Natural Resources

Reference Number
211760

Driving directions to well

Date completed
Oct 22, 1960

Owner-Contractor | *Name* | *Address* | *Telephone*
Owner
Driller
Operator

Construction Details

Well — *Use:* HOME | *Drilling method:* Cable Tool | *Pump type:*
Depth: 200.0 | *Pump setting depth:* | *Water quality:*

Casing — *Length:* 19.0 | *Material:* | *Diameter:* 6.0
Screen — *Length:* | *Material:* | *Diameter: Slot size:*

Well Capacity Test — *Type of test:* | *Test rate:* gpm for hrs. | *BailTest rate:* gpm for 6.67 hrs.
Drawdown: ft. | *Static water level:* 140.0 ft. | *Bailer Drawdown* ft.

Grouting Information — *Material:* | *Depth:* from to
Installation Method: | *Number of bags used:*

Well Abandonment — *Sealing material:* | *Depth:* from to
Installation Method: | *Number of bags used:*

Administrative — *County:* Monroe | *Township:* 10N *Range:* 1W | *Topo map:* Modesto

Grant Number:
Field located by: JMH | *on:* Mar 27, 1961
Courthouse location by: | *on:*
Location accepted w/o verification by: | *on:*
Subdivision name: | *Lot number:*
Ft W of EL: 1200.0 | *Ft N of SL:* 600.0 | *Ft E of WL:* | *Ft S of NL:*
Ground elevation: 790.0 | *Depth to bedrock:* 17.0 | *Bedrock elevation:* 773.0 | *Aquifer elevation:*

Well Log

Top	Bottom	Formation
0.0	17.0	DIRT & CLAY
17.0	36.0	WH LS
36.0	68.0	BLUE SHALE L WATER
68.0	167.0	BLUE SHALE
167.0	170.0	SOFT SHALE & WATER
170.0	200.0	BLUE SHALE

Comments MC 775:

Record of Water Well

Indiana Department of Natural Resources

Reference Number
211790

Driving directions to well

Date completed
Jun 10, 1960

Owner-Contractor	*Name*	*Address*	*Telephone*
Owner			
Driller			
Operator			

Construction Details

Well	*Use:* HOME	*Drilling method:*	*Pump type:*
	Depth: 200.0	*Pump setting depth:*	*Water quality:*
Casing	*Length:*	*Material:*	*Diameter:*
Screen	*Length:*	*Material:*	*Diameter: Slot size:*

Well Capacity Test

Type of test: *Test rate:* gpm for hrs. *BailTest rate:* gpm for hrs.
Drawdown: ft. *Static water level:* ft. *Bailer Drawdown* ft.

Grouting Information

Material: *Depth:* from to
Installation Method: *Number of bags used:*

Well Abandonment

Sealing material: *Depth:* from to
Installation Method: *Number of bags used:*

Administrative

County: Monroe *Township:* 10N *Range:* 1W
Section: : *Topo map:* Modesto
Grant Number:
Field located by: JMH *on:* Mar 27, 1961
Courthouse location by: *on:*
Location accepted w/o verification by: *on:*
Subdivision name: *Lot number:*
Ft W of EL: 400.0 *Ft N of SL:* 600.0 *Ft E of WL:* *Ft S of NL:*
Ground elevation: 820.0 *Depth to bedrock:* 12.0 *Bedrock elevation:* 808.0 *Aquifer elevation:*

Well Log

Top	Bottom	Formation
0.0	12.0	CLAY
12.0	27.0	WH LS
27.0	154.0	BLUE SHELL
154.0	200.0	KNOB STONE

Comments MC810; NO WATER - DRY

Record of Water Well

Indiana Department of Natural Resources

Reference Number	*Driving directions to well*	*Date completed*
211785		Oct 30, 1959

Owner-Contractor	*Name*	*Address*	*Telephone*
Owner			() -
Driller			() -
Operator			() -

Construction Details

Well	*Use:* HOME	*Drilling method:*	*Pump type:*
	Depth: 90.0	*Pump setting depth:*	*Water quality:*
Casing	*Length:* 20.0	*Material:*	*Diameter:* 6.0
Screen	*Length:*	*Material:*	*Diameter: Slot size:*

Well Capacity Test

Type of test: *Test rate:* gpm for hrs. *BailTest rate:* 10.0 gpm for 2.0 hrs.
Drawdown: ft. *Static water level:* 40.0 ft. *Bailer Drawdown* ft.

Grouting Information

Material: *Depth:* from to
Installation Method: *Number of bags used:*

Well Abandonment

Sealing material: *Depth:* from to
Installation Method: *Number of bags used:*

Administrative

County: Monroe *Township:* 10N *Range:* 1W
Section: *Topo map:* Modesto
Grant Number:
Field located by: JMH *on:* Mar 27, 1961
Courthouse location by: JMH *on:* Mar 28, 1961
Location accepted w/o verification by: *on:*
Subdivision name: *Lot number:*
Ft W of EL: *Ft N of SL:* *Ft E of WL:* 800.0 *Ft S of NL:* 1500.0
Ground elevation: 820.0 *Depth to bedrock:* 16.0 *Bedrock elevation:* 804.0 *Aquifer elevation:*

Well Log

Top	Bottom	Formation
0.0	16.0	DIRT
16.0	74.0	SHALE
74.0	90.0	BLUE SHALE

Comments MC 805:

Record of Water Well

Indiana Department of Natural Resources

Reference Number
209608

Driving directions to well

Date completed
Oct 08, 1965

Owner-Contractor	*Name*	*Address*	*Telephone*
Owner			() -
Driller			() -
Operator			() -

Construction Details

Well	*Use:* HOME	*Drilling method:* Rotary	*Pump type:*
	Depth: 212.0	*Pump setting depth:*	*Water quality:*
Casing	*Length:* 47.0	*Material:*	*Diameter:* 6.5
Screen	*Length:*	*Material:*	*Diameter: Slot size:*

Well Capacity Test

Type of test: *Test rate:* gpm for hrs. *BailTest rate:* 2.0 gpm for hrs.
Drawdown: ft. *Static water level:* 70.0 ft. *Bailer Drawdown* 125.0 ft.

Grouting Information

Material: *Depth:* from to
Installation Method: *Number of bags used:*

Well Abandonment

Sealing material: *Depth:* from to
Installation Method: *Number of bags used:*

Administrative

County: Morgan *Township:* 11N *Range:* 1W
Section: *Topo map:* Modesto
Grant Number:
Field located by: WG *on:* Jun 15, 1976
Courthouse location by: *on:*
Location accepted w/o verification by: *on:*
Subdivision name: *Lot number:*
Ft W of EL: 950.0 *Ft N of SL:* *Ft E of WL:* *Ft S of NL:* 2500.0
Ground elevation: 722.0 *Depth to bedrock:* 40.0 *Bedrock elevation:* 682.0 *Aquifer elevation:*

Well Log

Top	Bottom	Formation
0.0	40.0	CLAY YELLOW
40.0	212.0	SHALE BLUE

Comments

Record of Water Well

Indiana Department of Natural Resources

Reference Number
209583

Driving directions to well

Date completed
May 10, 1963

Owner-Contractor	*Name*	*Address*	*Telephone*
Owner			() -
Driller			() -
Operator			() -

Construction Details

Well	*Use:* HOME	*Drilling method:* Cable Tool	*Pump type:*
	Depth: 82.0	*Pump setting depth:*	*Water quality:*
Casing	*Length:* 28.0	*Material:*	*Diameter:* 5.625
Screen	*Length:*	*Material:*	*Diameter: Slot size:*

Well Capacity Test

Type of test: *Test rate:* gpm for hrs. *BailTest rate:* 0.5 gpm for 3.0 hrs.
Drawdown: ft. *Static water level:* 28.0 ft. *Bailer Drawdown* ft.

Grouting Information

Material: *Depth:* from to
Installation Method: *Number of bags used:*

Well Abandonment

Sealing material: *Depth:* from to
Installation Method: *Number of bags used:*

Administrative

County: Morgan *Township:* 11N *Range:* 1W
Section: *Topo map:* Modesto
Grant Number:
Field located by: U *on:* Apr 01, 1964
Courthouse location by: *on:*
Location accepted w/o verification by: *on:*
Subdivision name: *Lot number:*
Ft W of EL: *Ft N of SL:* *Ft E of WL:* 700.0 *Ft S of NL:* 1800.0
Ground elevation: 701.0 *Depth to bedrock:* 26.0 *Bedrock elevation:* 675.0 *Aquifer elevation:*

Well Log

Top	Bottom	Formation
0.0	26.0	SOIL & BR CLAY
26.0	35.0	BR SHALE
35.0	82.0	BLUE SHALE

Comments

Record of Water Well

Indiana Department of Natural Resources

Reference Number
209584

Driving directions to well

Date completed
Sep 06, 1962

Owner-Contractor	*Name*	*Address*	*Telephone*
Owner			() -
Driller			() -
Operator			() -

Construction Details

Well	*Use:* HOME	*Drilling method:* Cable Tool	*Pump type:*
	Depth: 100.0	*Pump setting depth:*	*Water quality:*
Casing	*Length:* 57.0	*Material:*	*Diameter:* 6.0
Screen	*Length:*	*Material:*	*Diameter: Slot size:*

Well Capacity Test

Type of test: *Test rate:* gpm for hrs. *BailTest rate:* 5.0 gpm for 2.0 hrs.
Drawdown: ft. *Static water level:* 58.0 ft. *Bailer Drawdown* ft.

Grouting Information

Material: *Depth:* from to
Installation Method: *Number of bags used:*

Well Abandonment

Sealing material: *Depth:* from to
Installation Method: *Number of bags used:*

Administrative

County: Morgan *Township:* 11N *Range:* 1W
Section: *Topo map:* Hindustan
Grant Number:
Field located by: WG *on:* Jun 18, 1976
Courthouse location by: *on:*
Location accepted w/o verification by: *on:*
Subdivision name: *Lot number:*
Ft W of EL: *Ft N of SL:* *Ft E of WL:* *Ft S of NL:*
Ground elevation: 781.0 *Depth to bedrock:* 53.0 *Bedrock elevation:* 728.0 *Aquifer elevation:*

Well Log

Top	Bottom	Formation
0.0	39.0	YELLOW CLAY
39.0	53.0	BLUE CLAY
53.0	100.0	SHALE & WATER

Comments

Record of Water Well

Indiana Department of Natural Resources

Reference Number
209574

Driving directions to well

Date completed

Owner-Contractor
Owner
Driller

Name

Address

Telephone
() -
() -

Construction Details

Well
Use: HOME
Drilling method: Cable Tool
Pump type:
Depth: 77.0
Pump setting depth:
Water quality:

Casing
Length: 53.9
Material:
Diameter: 5.625

Screen
Length:
Material:
Diameter: Slot size:

Well Capacity Test
Type of test:
Test rate: gpm for hrs.
BailTest rate: gpm for hrs.
Drawdown: ft.
Static water level: 45.0 ft.
Bailer Drawdown ft.

Grouting Information
Material:
Depth: from to
Installation Method:
Number of bags used:

Well Abandonment
Sealing material:
Depth: from to
Installation Method:
Number of bags used:

Administrative
County: Morgan
Township: 11N *Range:* 1W
Section: 1
Topo map: Hindustan
Grant Number:
Field located by: U
on: Apr 01, 1964
Courthouse location by:
on:
Location accepted w/o verification by:
on:
Subdivision name:
Lot number:
Ft W of EL: 1300.0
Ft N of SL:
Ft E of WL:
Ft S of NL: 2600.0
Ground elevation: 615.0
Depth to bedrock: 50.0
Bedrock elevation: 565.0
Aquifer elevation:

Well Log

Top	Bottom	Formation
0.0	40.0	CLAY
40.0	45.0	MUD,GRAV,QCKSD,GRAV,SH,GRAV
45.0	50.0	WATERBEARING
50.0	77.0	SHALE

Comments

Record of Water Well

Indiana Department of Natural Resources

Reference Number
209604

Driving directions to well

Date completed
Aug 21, 1977

Owner-Contractor	*Name*	*Address*	*Telephone*
Owner			() -
Driller			() -

Construction Details

Well	*Use:* HOME	*Drilling method:* Cable Tool	*Pump type:*
	Depth: 75.0	*Pump setting depth:*	*Water quality:*
Casing	*Length:* 27.0	*Material:*	*Diameter:* 4.0
Screen	*Length:*	*Material:*	*Diameter: Slot size:*

Well Capacity Test

Type of test: *Test rate:* gpm for hrs. *BailTest rate:* 12.0 gpm for 2.0 hrs.
Drawdown: ft. *Static water level:* ft. *Bailer Drawdown* 75.0 ft.

Grouting Information

Material: *Depth:* from to
Installation Method: *Number of bags used:*

Well Abandonment

Sealing material: *Depth:* from to
Installation Method: *Number of bags used:*

Administrative

County: Morgan *Township:* 11N *Range:* 1W
Section: *Topo map:* Hindustan
Grant Number:
Field located by: ECM *on:* Jun 05, 1987
Courthouse location by: *on:*
Location accepted w/o verification by: *on:*
Subdivision name: *Lot number:*
Ft W of EL: 1100.0 *Ft N of SL:* *Ft E of WL:* *Ft S of NL:* 600.0
Ground elevation: 620.0 *Depth to bedrock:* 27.0 *Bedrock elevation:* 593.0 *Aquifer elevation:*

Well Log

Top	Bottom	Formation
0.0	0.5	TOP SOIL
0.5	9.0	BROWN HARDPAN
9.0	12.0	BROWN GRAVE HARDPAN
12.0	27.0	GREY HARDPAN
27.0	75.0	BLUE SHALE

Comments MC 593; NEIGHBOR VERIFICATION;

Record of Water Well

Indiana Department of Natural Resources

Reference Number
209649

Date completed
Sep 26, 1979

Owner-Contractor	*Name*	*Address*	*Telephone*
Owner			() -
Company			() -
Driller			() -
Operator			() -

Construction Details

Well	*Use:* HOME	*Drilling method:* Cable Tool	*Pump type:*
	Depth: 80.0	*Pump setting depth:*	*Water quality:*
Casing	*Length:* 50.0	*Material:*	*Diameter:* 4.0
Screen	*Length:*	*Material:*	*Diameter: Slot size:*

Well Capacity Test

Type of test: *Test rate:* gpm for hrs. *BailTest rate:* 15.0 gpm for 2.0 hrs.
Drawdown: ft. *Static water level:* ft. *Bailer Drawdown* 5.0 ft.

Grouting Information

Material: *Depth:* from to
Installation Method: *Number of bags used:*

Well Abandonment

Sealing material: *Depth:* from to
Installation Method: *Number of bags used:*

Administrative

County: Morgan *Township:* 11N *Range:* 1W
Section: *Topo map:* Hindustan
Grant Number:
Field located by: PES *on:* Jun 18, 1980
Courthouse location by: *on:*
Location accepted w/o verification by: *on:*
Subdivision name: *Lot number:*
Ft W of EL: 950.0 *Ft N of SL:* 200.0 *Ft E of WL:* *Ft S of NL:*
Ground elevation: 615.0 *Depth to bedrock:* 50.0 *Bedrock elevation:* 565.0 *Aquifer elevation:*

Well Log

Top	Bottom	Formation
0.0	0.6	TOP SOIL
0.6	10.0	BROWN HARDPAN
10.0	50.0	BLUEISH GREY MUD
50.0	80.0	GREY SHALE

Comments MC 565; VERIFIED BY NEIGHBOR; MC

Record of Water Well

Indiana Department of Natural Resources

Reference Number
209619

Driving directions to well

Date completed
Jun 28, 1979

Owner-Contractor	*Name*	*Address*	*Telephone*
Driller			() -
Operator			() -

Construction Details

Well	*Use:* OTHER	*Drilling method:* Cable Tool	*Pump type:*
	Depth: 24.0	*Pump setting depth:*	*Water quality:*
Casing	*Length:* 21.0	*Material:*	*Diameter:* 2.0
Screen	*Length:* 3.0	*Material:*	*Diameter:* 1.25 *Slot size:*

Well Capacity Test

Type of test: *Test rate:* gpm for hrs. *BailTest rate:* gpm for hrs.
Drawdown: ft. *Static water level:* 6.01 ft. *Bailer Drawdown* ft.

Grouting Information

Material: *Depth:* from to
Installation Method: *Number of bags used:*

Well Abandonment

Sealing material: *Depth:* from to
Installation Method: *Number of bags used:*

Administrative

County: Morgan *Township:* 11N *Range:* 1W
Section: *Topo map:* Hindustan
Grant Number:
Field located by: USGS *on:*
Courthouse location by: *on:*
Location accepted w/o verification by: *on:*
Subdivision name: *Lot number:*
Ft W of EL: *Ft N of SL:* *Ft E of WL:* 2550.0 *Ft S of NL:* 1000.0
Ground elevation: 587.48 *Depth to bedrock:* 88.0 *Bedrock elevation:* 500.0 *Aquifer elevation:*

Well Log

Top	Bottom	Formation
0.0	3.0	ROAD FILL BRN CLAY S&G
3.0	8.0	BRM C;AU & SILT W/ TRACE SAND
8.0	10.0	BRN GRAY SAND & CLAY MOIST
10.0	15.0	SAND & GRAVEL WET W/ CLAY
15.0	70.0	GREY WET SAND W/ TR CLAY
70.0	88.0	MED GRAVEL & SAND
88.0		BEDROCK

Comments MC 500; MC; CHEM TEST

Record of Water Well

Indiana Department of Natural Resources

Reference Number
209629

Driving directions to well

Date completed
Jan 20, 1965

Owner-Contractor
Owner
Driller

Name

Address

Telephone
() -
() -

Construction Details

Well

Use:
Depth: 52.0
Length: 28.0

Drilling method: Cable Tool
Pump setting depth:
Material:

Pump type:
Water quality:
Diameter: 6.0

Casing
Screen

Length:
Material:
Diameter: Slot size:

Well Capacity Test

Type of test:
Drawdown: ft.

Test rate: gpm for hrs.
Static water level: ft.

BailTest rate: 30.0 gpm for 0.5 hrs.
Bailer Drawdown ft.

Grouting Information

Material:
Installation Method:

Depth: from to
Number of bags used:

Well Abandonment

Sealing material:
Installation Method:

Depth: from to
Number of bags used:

Administrative

County: Morgan
Section:
Grant Number:
Field located by: CD
Courthouse location by:
Location accepted w/o verification by:
Subdivision name:
Ft W of EL:
Ground elevation: 600.0

Ft N of SL: 2650.0
Depth to bedrock: 28.0

Township: 11N *Range:* 1W
on:
on:
on:
Lot number:
Ft E of WL: 2150.0
Bedrock elevation: 572.0

Topo map: Hindustan
Ft S of NL:
Aquifer elevation:

Well Log

Top	Bottom	Formation
0.0	28.0	SOIL & CLAY
28.0	52.0	BORDEN SHALE

Comments

MC 572; OWNER VERIFIED; MC

Record of Water Well

Indiana Department of Natural Resources

Reference Number
269754

Driving directions to well

Date completed
Jul 05, 1975

Owner-Contractor	*Name*	*Address*	*Telephone*
Owner			-
Driller			-
Operator			-

Construction Details

Well	*Use:* HOME	*Drilling method:* Cable Tool	*Pump type:*
	Depth: 50.0	*Pump setting depth:*	*Water quality:*
Casing	*Length:* 31.0	*Material:*	*Diameter:* 4.0
Screen	*Length:*	*Material:*	*Diameter: Slot size:*

Well Capacity Test

Type of test: *Test rate:* gpm for hrs. *BailTest rate:* 18.0 gpm for 2.0 hrs.
Drawdown: ft. *Static water level:* 8.0 ft. *Bailer Drawdown* 20.0 ft.

Grouting Information

Material: *Depth:* from to
Installation Method: *Number of bags used:*

Well Abandonment

Sealing material: *Depth:* from to
Installation Method: *Number of bags used:*

Administrative

County: Morgan *Township:* 11N *Range:* 1W
Section: *Topo map:* Martinsville
Grant Number:
Field located by: WDH *on:* Jun 25, 1976
Courthouse location by: *on:*
Location accepted w/o verification by: *on:*
Subdivision name: *Lot number:*
Ft W of EL: 1650.0 *Ft N of SL:* 150.0 *Ft E of WL:* *Ft S of NL:*
Ground elevation: 600.0 *Depth to bedrock:* 30.0 *Bedrock elevation:* 570.0 *Aquifer elevation:*

Well Log

Top	Bottom	Formation
0.0	10.0	BR CLAY & GRAV
10.0	30.0	RED SHALE (WATER)
30.0	50.0	SHALE (WATER)

Comments

Record of Water Well

Indiana Department of Natural Resources

Reference Number
269759

Driving directions to well

Date completed
Jun 10, 1966

Owner-Contractor	*Name*	*Address*	*Telephone*
Owner			() -
Driller			() -
Operator			() -

Construction Details

Well	*Use:* HOME	*Drilling method:* Cable Tool	*Pump type:*
	Depth: 68.0	*Pump setting depth:*	*Water quality:*
Casing	*Length:* 65.0	*Material:*	*Diameter:* 4.0
Screen	*Length:* 4.0	*Material:*	*Diameter:* 3.5 *Slot size:* 6

Well Capacity Test

Type of test: *Test rate:* gpm for hrs. *BailTest rate:* 10.0 gpm for hrs.
Drawdown: ft. *Static water level:* 19.0 ft. *Bailer Drawdown* 0.0 ft.

Grouting Information

Material: *Depth:* from to
Installation Method: *Number of bags used:*

Well Abandonment

Sealing material: *Depth:* from to
Installation Method: *Number of bags used:*

Administrative

County: Morgan *Township:* 11N *Range:* 1W
Section: *Topo map:* Hindustan
Grant Number:
Field located by: CD *on:* Aug 01, 1967
Courthouse location by: *on:*
Location accepted w/o verification by: *on:*
Subdivision name: *Lot number:*
Ft W of EL: 150.0 *Ft N of SL:* 2500.0 *Ft E of WL:* *Ft S of NL:*
Ground elevation: 600.0 *Depth to bedrock:* *Bedrock elevation:* *Aquifer elevation:* 532.0

Well Log

Top	Bottom	Formation
0.0	2.0	TOPSOIL
2.0	19.0	DRY SAND
19.0	54.0	FINE SAND
54.0	61.0	YEL SAND & GRAV
61.0	62.0	BR CLAY
62.0	68.0	S&G

Comments MC 530

Record of Water Well

Indiana Department of Natural Resources

Reference Number
207374

Driving directions to well

Date completed
Sep 19, 1971

Owner-Contractor	*Name*	*Address*	*Telephone*
Owner			() -
Driller			() -
Operator			() -

Construction Details

Well	*Use:* HOME	*Drilling method:* Cable Tool	*Pump type:*
	Depth: 41.0	*Pump setting depth:*	*Water quality:*
Casing	*Length:* 39.0	*Material:*	*Diameter:* 4.0
Screen	*Length:* 3.0	*Material:*	*Diameter:* 3.0 *Slot size:* 6

Well Capacity Test

Type of test: *Test rate:* gpm for hrs. *BailTest rate:* 15.0 gpm for 1.0 hrs.
Drawdown: ft. *Static water level:* 10.0 ft. *Bailer Drawdown* 5.0 ft.

Grouting Information

Material: *Depth:* from to
Installation Method: *Number of bags used:*

Well Abandonment

Sealing material: *Depth:* from to
Installation Method: *Number of bags used:*

Administrative

County: Morgan *Township:* 11N *Range:* 1E
Section: *Topo map:* Martinsville
Grant Number:
Field located by: TMB *on:* Aug 28, 1973
Courthouse location by: *on:*
Location accepted w/o verification by: *on:*
Subdivision name: *Lot number:*
Ft W of EL: *Ft N of SL:* *Ft E of WL:* 500.0 *Ft S of NL:* 1850.0
Ground elevation: 600.0 *Depth to bedrock:* *Bedrock elevation:* *Aquifer elevation:* 559.0

Well Log

Top	Bottom	Formation
0.0	1.5	TOP SOIL'
1.5	8.0	BROWN HARDPAN
8.0	20.0	BROWN GRAVEL HARDPAN
20.0	39.0	BLUE GRAVEL HARDPAN
39.0	41.0	GREY GRAVEL

Comments MC560; OWNER VERIFIED LOCATION;

Record of Water Well

Indiana Department of Natural Resources

Reference Number
213733

Driving directions to well

Date completed
Nov 05, 1964

Owner-Contractor
Owner
Driller
Operator

Telephone

Construction Details

Well
Use: HOME
Drilling method: Cable Tool
Pump type:
Depth: 150.0
Pump setting depth:
Water quality:

Casing
Length: 27.0
Material:
Diameter: 6.0

Screen
Length:
Material:
Diameter: Slot size:

Well Capacity Test
Type of test:
Test rate: gpm for hrs.
BailTest rate: 5.0 gpm for 1.0 hrs.
Drawdown: ft.
Static water level: 70.0 ft.
Bailer Drawdown 0.0 ft.

Grouting Information
Material:
Depth: from to
Installation Method:
Number of bags used:

Well Abandonment
Sealing material:
Depth: from to
Installation Method:
Number of bags used:

Administrative
County: Monroe
Township: 8N *Range:* 1W
Topo map: Clear Creek
Section:
Grant Number:
Field located by: MT
on: Jul 12, 1967
Courthouse location by:
on:
Location accepted w/o verification by:
on:
Subdivision name:
Lot number:
Ft W of EL:
Ft N of SL:
Ft E of WL: 1300.0
Ft S of NL: 2500.0
Ground elevation: 780.0
Depth to bedrock: 23.0
Bedrock elevation: 757.0
Aquifer elevation:

Well Log

Top	Bottom	Formation
0.0	12.0	YELLOW LCAY
12.0	23.0	RED CLAY
23.0	38.0	STONE GRAY LIMESTONE HARD
38.0	40.0	STONE BLUE SHALE SOFT
40.0	44.0	STONE DARK GRAY LS HARD
44.0	50.0	STONE GRAY LS HARD
50.0	71.0	STONE GRAY LS EXTRA HARD
71.0	98.0	STONE BUFF LS SOFT
98.0	117.0	STONE GRAY LS HARD
117.0	126.0	STONE WHITE OR GRAY LS HARD
126.0	150.0	STONE GRAY LS HARD

Comments
OWNER VERIFIED

Record of Water Well

Indiana Department of Natural Resources

Reference Number
213683

Driving directions to well

Date completed
Apr 21, 1962

Owner-Contractor | *Name* | *Address* | *Telephone*
Owner
Driller
Operator

Construction Details

Well
Use: HOME
Drilling method: Cable Tool
Pump type:
Depth: 130.0
Pump setting depth:
Water quality:

Casing
Length: 7.0
Material:
Diameter:

Screen
Length:
Material:
Diameter: Slot size:

Well Capacity Test
Type of test:
Test rate: gpm for hrs.
BailTest rate: 1.0 gpm for hrs.
Drawdown: ft.
Static water level: 54.0 ft.
Bailer Drawdown 70.0 ft.

Grouting Information
Material:
Depth: from to
Installation Method:
Number of bags used:

Well Abandonment
Sealing material:
Depth: from to
Installation Method:
Number of bags used:

Administrative
County: Monroe
Township: 8N *Range:* 1W
Section:
Topo map: Clear Creek
Grant Number:
Field located by: U-S
on: Jul 01, 1963
Courthouse location by:
on:
Location accepted w/o verification by:
on:
Subdivision name:
Lot number:
Ft W of EL:
Ft N of SL:
Ft E of WL: 2200.0
Ft S of NL: 100.0
Ground elevation: 775.0
Depth to bedrock: 7.0
Bedrock elevation: 768.0
Aquifer elevation:

Well Log

Top	Bottom	Formation
0.0	7.0	CLAY
7.0	100.0	WHITE LIME
100.0	130.0	BLUE LIME

Comments

Record of Water Well

Indiana Department of Natural Resources

Reference Number
213688

Driving directions to well

Date completed
Oct 22, 1987

Owner-Contractor	***Name***	***Address***	***Telephone***
Owner			
Driller			(000) 876-1055

Construction Details

Well	***Use:*** HOME	***Drilling method:*** Rotary	***Pump type:***
	Depth: 145.0	***Pump setting depth:***	***Water quality:*** CLEAR
Casing	***Length:*** 21.0	***Material:***	***Diameter:*** 6.63
Screen	***Length:***	***Material:***	***Diameter: Slot size:***

Well Capacity Test

Type of test: ***Test rate:*** 3.0 gpm for 2.0 hrs. ***BailTest rate:*** gpm for hrs.
Drawdown: 145.0 ft. ***Static water level:*** 38.0 ft. ***Bailer Drawdown*** ft.

Grouting Information

Material: ***Depth:*** from to
Installation Method: ***Number of bags used:***

Well Abandonment

Sealing material: ***Depth:*** from to
Installation Method: ***Number of bags used:***

Administrative

County: Monroe ***Township:*** 8N ***Range:*** 1W
Section: ***Topo map:*** Clear Creek
Grant Number:
Field located by: JLL ***on:*** Nov 10, 1988
Courthouse location by: ***on:***
Location accepted w/o verification by: ***on:***
Subdivision name: ***Lot number:***
Ft W of EL: ***Ft N of SL:*** ***Ft E of WL:*** 2550.0 ***Ft S of NL:*** 450.0
Ground elevation: 770.0 ***Depth to bedrock:*** 9.0 ***Bedrock elevation:*** 761.0 ***Aquifer elevation:***

Well Log

Top	Bottom	Formation
0.0	5.0	YEL CLAY
5.0	9.0	RED CLAY
9.0	13.0	GRAY LS HARD
13.0	15.0	YEL SH SOFT
15.0	30.0	GRAY LS H.
30.0	36.0	BLUE LS H.
36.0	52.0	GRAY LS H.
52.0	76.0	BUFF LS H.
76.0	84.0	BLUE LS H.
84.0	106.0	GRAY LS H.
106.0	120.0	WHITE LS H.
120.0	132.0	GRAY LS H.
132.0	145.0	DARK GRAY LS H.

Comments

Record of Water Well

Indiana Department of Natural Resources

Reference Number
213658

Driving directions to well

Date completed
Sep 18, 1972

Owner-Contractor — ***Name*** — ***Address*** — ***Telephone***
Owner
Driller
Operator

Construction Details

Well — ***Use:*** HOME — ***Drilling method:*** Cable Tool — ***Pump type:***
Depth: 140.0 — ***Pump setting depth:*** — ***Water quality:***

Casing — ***Length:*** 12.0 — ***Material:*** — ***Diameter:*** 5.63
Screen — ***Length:*** — ***Material:*** — ***Diameter:*** ***Slot size:***

Well Capacity Test — ***Type of test:*** — ***Test rate:*** gpm for hrs. — ***BailTest rate:*** 3.5 gpm for hrs.
Drawdown: ft. — ***Static water level:*** 51.0 ft. — ***Bailer Drawdown*** ft.

Grouting Information — ***Material:*** — ***Depth:*** from to
Installation Method: — ***Number of bags used:***

Well Abandonment — ***Sealing material:*** — ***Depth:*** from to
Installation Method: — ***Number of bags used:***

Administrative

County: Monroe — ***Township:*** 8N ***Range:*** 1W
Section: — ***Topo map:*** Clear Creek
Grant Number:
Field located by: JRD — ***on:*** Jul 26, 1978
Courthouse location by: — ***on:***
Location accepted w/o verification by: — ***on:***
Subdivision name: — ***Lot number:***
Ft W of EL: 2200.0 — ***Ft N of SL:*** — ***Ft E of WL:*** — ***Ft S of NL:*** 250.0
Ground elevation: 770.0 — ***Depth to bedrock:*** 10.0 — ***Bedrock elevation:*** 760.0 — ***Aquifer elevation:***

Well Log

Top	Bottom	Formation
0.0	10.0	TOP SOIL
10.0	140.0	MEDIUM HARD WHITE LIMESTONE

Comments MC 760; NEIGHBOR VERIFIED

Record of Water Well

Indiana Department of Natural Resources

Reference Number	*Driving directions to well*	*Date completed*
213728		Nov 24, 1965

Owner-Contractor	*Name*	*Address*	*Telephone*
Owner			
Driller			
Operator			

Construction Details

Well	*Use:* HOME	*Drilling method:* Cable Tool	*Pump type:*
	Depth: 100.0	*Pump setting depth:*	*Water quality:*
Casing	*Length:* 17.5	*Material:*	*Diameter:* 6.0
Screen	*Length:*	*Material:*	*Diameter: Slot size:*

Well Capacity Test

Type of test: *Test rate:* gpm for hrs. *BailTest rate:* 5.0 gpm for hrs.
Drawdown: ft. *Static water level:* ft. *Bailer Drawdown* 65.0 ft.

Grouting Information

Material: *Depth:* from to
Installation Method: *Number of bags used:*

Well Abandonment

Sealing material: *Depth:* from to
Installation Method: *Number of bags used:*

Administrative

County: Monroe *Township:* 8N *Range:* 1W
Section: *Topo map:* Clear Creek
Grant Number:
Field located by: CES *on:* Jul 01, 1966
Courthouse location by: *on:*
Location accepted w/o verification by: *on:*
Subdivision name: *Lot number:*
Ft W of EL: *Ft N of SL:* *Ft E of WL:* 2600.0 *Ft S of NL:* 100.0
Ground elevation: 740.0 *Depth to bedrock:* 15.0 *Bedrock elevation:* 725.0 *Aquifer elevation:*

Well Log

Top	Bottom	Formation
0.0	16.0	RED CLAY
16.0	30.0	WHITE SOFT LIMESTONE
30.0	95.0	WHITE MEDIUM HARD LIMESTONE
95.0	100.0	BLUE LIMESTONE HARD

Comments MC 725

Record of Water Well

Indiana Department of Natural Resources

Reference Number
222742

Driving directions to well

Date completed
Mar 28, 1962

Owner-Contractor	***Name***	***Address***	***Telephone***
Owner			
Driller			
Operator			

Construction Details

Well	***Use:*** HOME	***Drilling method:*** Cable Tool	***Pump type:***
	Depth: 140.0	***Pump setting depth:***	***Water quality:***
Casing	***Length:*** 25.0	***Material:***	***Diameter:*** 6.0
Screen	***Length:***	***Material:***	***Diameter: Slot size:***

Well Capacity Test

Type of test: ***Test rate:*** gpm for hrs. ***BailTest rate:*** 12.0 gpm for hrs.
Drawdown: ft. ***Static water level:*** 90.0 ft. ***Bailer Drawdown*** 40.0 ft.

Grouting Information

Material: ***Depth:*** from to
Installation Method: ***Number of bags used:***

Well Abandonment

Sealing material: ***Depth:*** from to
Installation Method: ***Number of bags used:***

Administrative

County: Monroe ***Township:*** 8N ***Range:*** 2W
Section: ***Topo map:*** Clear Creek
Grant Number:
Field located by: JRD ***on:*** Jul 27, 1978
Courthouse location by: ***on:***
Location accepted w/o verification by: ***on:***
Subdivision name: ***Lot number:***
Ft W of EL: 100.0 ***Ft N of SL:*** ***Ft E of WL:*** ***Ft S of NL:*** 1350.0
Ground elevation: 785.0 ***Depth to bedrock:*** 25.0 ***Bedrock elevation:*** 760.0 ***Aquifer elevation:***

Well Log

Top	Bottom	Formation
0.0	25.0	YELLOW DIRT
25.0	127.0	GREY LIMESTONE
127.0	132.0	BUFF COLOR LIMESTONE
132.0	140.0	GREY LIMESTONE

Comments

Appendix N

Karst Mapping

Redacted for reasons related to karst.