ESTABLISHMENT OF GROUNDWATER PROTECTION POLICY FOR THE UNIVERSITY OF MISSISSIPPI FIELD STATION - LAFAYETTE COUNTY, MISSISSIPPI

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ABSTRACT

The University of Mississippi Field Station [UMFS] is a relatively new component of the research capabilities of The University of Mississippi, located approximately 11 miles from the main campus, in rural Lafayette County. Numerous springs and seeps, resulting from aquifer leakage, make the Field Station a natural laboratory for the study of wetlands, and interactions between groundwater, surface water, and the biota. Initial development of research laboratories and culturing facilities has recently been completed and more is planned. At this early stage of facility expansion, groundwater protection has been established to protect this source of water supply and vital component of wetlands research.

The Field Station is situated on the eastern extreme of the Meridian Sand outcrop belt and utilizes the Meridian - upper Wilcox aquifer. The Meridian Sand is an easily mapped, lithologic unit, regionally, but on a local scale may be complex. Clay lenses and fine-grained sand facies produce unusual groundwater conditions. Within the boundaries of the Field Station, for example, the aquifer is under water table conditions in upland areas while flowing artesian conditions prevail in the flood plains. Groundwater protection policy must accommodate these varying conditions and the attendant differences in contamination potential.

Of primary concern are the upland areas where the aquifer is unconfined and potential surface to subsurface contamination is greatest. A circular 500 foot well-head protection zone has been established, centered on the supply wells. Particular care is exercised in this area in the use and tracking of potential contaminants. An existing well inventory has been initiated and policy established for new well construction, well use, and final fate (continuing use or plugging). Groundwater protection will continue to be a concern as existing facilities are relocated or new ones built.

The flood plain areas contain numerous experimental ponds, so potential for contamination there is closely monitored. The flowing artesian conditions minimize the potential for groundwater contamination, but present a potential for surface-water contamination. Construction and wells in the flood plains are discouraged and additives to experimental ponds are to be carefully screened and tracked. Careful peer review by the Field Station User Committee continues to focus research and educational projects on appropriate and sustainable water uses (UMFS User Guidelines, 2002).

INTRODUCTION

Mississippi has an abundance of groundwater and this resource continues to provide potable water to most of the state's population. The abundance of the resource is, however, no reason for complacency in protecting groundwater for our continued use and the use of future generations. Protection of groundwater from surface contamination is particularly important in areas of the State where the geographic location of the groundwater withdrawal and the aquifer recharge area coincide. These areas, for example, include The University of Mississippi's main campus, the City of Oxford, and the University of Mississippi Field Station (UMFS), all of which own their own water supply systems. In these special areas, the geological conditions may allow surface-derived contaminants to infiltrate downward and contaminate the aquifer. Significant impediments to the downward flow of contaminants provided by laterally continuous clay beds is frequently absent. The results of this type of contamination can render a water supply unsuitable for human use and since the groundwater and surface water systems are frequently interconnected, contaminants are free to cross from the subsurface environment to the surface water environment.

The geological and hydrological conditions at the UMFS are as those previously described. An overall vision for development of the UMFS was achieved in 1997 with funds from the National Science Foundation (Holland et al., 1997). Construction (research and educational facilities) at the UMFS has been completed only recently. This situation provides an opportunity to investigate ways in which the resource can be protected, prior to the occurrence of actual groundwater contamination, and still allow the use of the resource for both private consumption and for research purposes. The concerns regarding groundwater protection at the UMFS have been formalized as part of a set of user guidelines, a guidance document for field station users (UMFS, 2002). Also, Swann and Lutken (2002) completed an illustrated layperson's guide to water protection at the UMFS. Groundwater investigations at the UMFS, together with other relevant information contained herein, are intended to provide an example illustrating issues that should be considered when formulating a groundwater source protection plan in other areas of the state where similar hydrogeologic conditions prevail.

AREA OF STUDY

The UMFS is located in northern Lafayette County, approximately 11 miles northeast of Oxford and The University of Mississippi main campus (Figure 1). The UMFS resides entirely within the watershed of the Little Tallahatchie River. Surface water flow is predominately to the northeast into Puskus Creek, the major fluvial component, then into the Little Tallahatchie River. The UMFS topography can be divided into flood plains associated with local fluvial components and upland areas consisting of gently rolling hills. Total topographic relief within the UMFS is approximately 140 feet. Springs and seeps are common where the valley walls intersect the flood plains and provide for development of wetlands, one essential component and focal point of UMFS research.

Geological Setting

The area contained in the UMFS was included in geological mapping conducted by Attaya in 1951. Attaya mapped the Eocene Kosciusko Formation (Claiborne Group) at the higher elevations with Meridian Sand (Claiborne Group) - Kosciusko Formation contact near the base of the valley walls. Quaternary deposits were mapped along the fluvial elements. The UMFS area was mapped recently at a 1:24,000 scale (Attaya's mapping was at a 1:62,500 relative fraction scale) in support of this project. Lithologies consistent with the Tallahatta Formation and the older Meridian Sand were identified cropping out within the confines of the UMFS. Figure 2 is the geological map reflecting the new stratigraphic interpretations for the UMFS and surrounding areas. The Meridian unconformably overlies the finer-grained sediments of the Wilcox Group and oversteps much of the Wilcox outcrop belt in areas representing Meridian-age channels.

A major departure of the more recent geological mapping from that of Attaya is the change in stratigraphic assignment of the upper unit at the UMFS from the Kosciusko Formation to the Tallahatta Formation. It is interesting to note that the unit Attaya mapped as Kosciusko closely coincides with the unit assigned to the Tallahatta in the recent mapping. The differences in contact elevations reflect the better data base from which the recent mapping derives. Of particular importance is the core obtained from the UMFS to aid in the identification of stratigraphic units as well as aquifer identification (Figure 3).

The Wilcox Group is characterized by fine-grained, clastic sediments (clay, silt, carbonaceous clays and silts), lignites, and sandy zones including those marking the base of the Nanafalia and Tuscahoma Formations. The fine-grained, low permeability, Wilcox sediments are generally considered confining units and this situation appears to be the case at the UMFS. Due to the stratigraphic overstep of the Meridian Sand, various older units can be present beneath the Meridian's lower contact. The Hatchetigbee Formation (Wilcox Group), for example, is present beneath the Meridian on The University of Mississippi main campus (Swann and others, 1999) while at the UMFS the Wilcox unit beneath the Meridian unconformity is the Tuscahoma Formation.

The Meridian Sand - Wilcox Group contact marks one of the most notable unconformities in the early Tertiary section in northern Mississippi. Often a regolith is present beneath the contact and is composed of a zone of white kaolin. Above the contact, the Meridian may consist of a fine-grained sand lithology which is often discontinuous and perhaps fills relief in the unconformable Wilcox surface. Medium- to coarse-grained, cross-bedded sands, typical lithologies of the Meridian, overly the fine-grained sands when they are present. If the fine-grained sands are not present then the medium- to coarse-grained sands extend to the base of the unit. The Meridian may contain minor clay lenses which are more common near the base of the formation.

The Tallahatta conformably overlies the older Meridian Sand. Lithologically, the Tallahatta consists of medium- to fine-grained sands with subordinate clay lenses and areas of clay laminations within a matrix of sand. The clay lenses and laminations are not laterally continuous. The Tallahatta is distinguished from the Meridian by the predominately finer sand grain size and the characteristic white, often laminated clays. In southern Lafayette County, a lithology consistent with the Basic City Shale Member of the Tallahatta Formation is present, so the Tallahatta at the UMFS represents a sand-enriched facies equivalent to the Basic City Member. The sandy facies of the Basic City Shale Member and its stratigraphic relationship to the rest of the formation was described in Brown and Adams (1943). Attaya (1951) apparently assigned the Tallahatta Formation, as mapped here, to the Kosciusko Formation. We feel the stratigraphic reassignment is justified due to the lithologic similarity of this section to the Tallahatta Formation, its apparent conformity with the Meridian Sand, its stratigraphic position and its continuity with well logs and core samples from down the dip.

Although the flood plains mapped in Figure 2 are considered to be Quaternary, it is an established fact that there has been significant modification of the flood plains at the UMFS prior to its acquisition by The University of Mississippi. Limited subsurface data from the flood plains suggest a complex set of lithologies reflecting deposition from the local fluvial components in addition to sands derived from the adjoining valley walls.

Hydrogeologic Setting

The UMFS and the surrounding area derive their groundwater supply largely from the Meridian - Upper Wilcox aquifer. Moyse and others (1997) surveyed water usage in the area surrounding the UMFS and found only minimal usage from the aquifer. Since 1997, the area has experienced continued residential development and the Meridian - Upper Wilcox aquifer continues to be the groundwater source of choice.

The groundwater at the UMFS is under flowing artesian as well as water table conditions, determined largely by geomorphic location. Limited groundwater monitoring wells indicate the highland areas of the field station are under water table conditions, whereas in the flood plains, wells constructed at shallow depths often exhibit flowing artesian conditions.

Subsurface data derived from UMFS water-supply wells demonstrate the lack of continuity of the clay lenses and clay beds. This condition has several important consequences, 1) the sand matrix surrounding the argillaceous zones does not provide significant protection from potential surface-derived contaminants moving downward into the groundwater, 2) the lenses complicate groundwater flow, and 3) the construction of water-supply wells is more complicated because stacked clay lenses reduce the amount of producible section.

The flowing artesian conditions in the flood plains result from hydraulic connections between the coarser-grained fluvial deposits and the aquifer materials from the adjoining valley wall. The top of the fluvial fining-upward sequence forms a confining bed resulting in flowing artesian wells. The artesian conditions result in an area of the UMFS that is not susceptible to surface-derived contamination because of upward groundwater flow.

Biological Setting

The UMFS is a research facility dedicated to long-term ecological research. More than 740 acres (296 hectares) of pine and mixed hardwood forest, bottomland forest, open field, wetlands (including eight constructed wetlands), ponds and springs make up this outdoor laboratory. The Field Station's 223 research ponds, five spring ponds, and 220 acres (90 ha) of associated upland habitat are among its greatest assets. Dominant overstory species include Pinus echinata, Pinus taeda, Liquidambar styraciflua, Quercus alba, Quercus falcata, Carya glabra and Carya ovalis (Smith, 2001). Wetlands present at the UMFS are ultimately dependent upon groundwater leakage.

Staff, visiting investigators, and students conduct research in disciplines as diverse as hydrology, botany, soil science, genetics, herpetology, pharmacology, toxicology, ecology, biology, and physiology. Many educational programs take place at the UMFS and are designed to increase environmental awareness and scientific knowledge. These educational programs include research training for graduates and undergraduates from several colleges and universities, various field trip opportunities for K-12 graders, several teacher workshops, and UMFS sponsored community outreach programs such as Science Day, which are held annually (Maul and Holland, 1998).

GROUNDWATER PROTECTION REGULATIONS AT THE UMFS

As the UMFS begins to expand its educational infrastructure, it is prudent to build in groundwater protection guidelines. The guidelines established in the course of this study are now part of the accepted protocol for projects at the facility. While constructed to protect the resource, the guidelines allow continuous use of groundwater for project work. Although these guidelines were designed for a specific locality, the issues addressed and the means of protection employed are intended to serve as a beginning model to be modified to suit the site-specific needs of other locations.

Guidelines to Prevent Surface To Subsurface Contamination

These guidelines, summarized in Table 1, were formulated to protect the groundwater from surface-derived contaminants or contaminants originating from ground surface activities. These regulations are designed to aid UMFS investigators by elucidating potential problems of surface-derived contamination and to encourage meticulous experimental design. Surface-derived contamination of the groundwater system is most likely to occur in the upland areas. These areas have been designated as high risk areas and are given special consideration for potential surface contamination. Logically, experiments with the potential for surface-derived contamination in this area should be carefully reviewed and kept well away from the water-supply wells, also in the upland area. Deep excavations in the flood plain could penetrate the fine-grained sediments at the surface which act as a confining unit, resulting in flowing artesian conditions, at very shallow depths (according to depth of hydraulically connected sand beds). Penetrations through these sediments could lead to flooding of the excavation, a waste of groundwater, and a conduit for contamination. The back-flow prevention guideline is intended to avert the accidental contamination of the well and groundwater source when chemicals are introduced into a flow of groundwater for an experiment.

Guidelines for Water-Supply Well Protection and Contamination Prevention

This set of guidelines provides a common sense approach to the prevention of contamination in water-supply wells and protection of the well head itself (Table 2). The approach to well-head protection includes the procedures suggested by the Mississippi Source Water Assessment Program (MDEQ, 1999). The well-head protection guideline establishes a circular protection zone, 500 feet in radius, around supply wells to prevent contamination of the water supply from the ground's surface. This guideline restricts certain materials within the 500-foot protection zone and requires particular attention to the handling of certain chemicals. The UMFS research facilities have a unique sewage disposal system that has no effluents released into the environment. This system is located down the hydraulic gradient and well away from the water-supply wells. This guideline, therefore, applies more to future development than to existing systems. The UMFS will be utilized by a variety of students and visitors, as well as faculty and staff. The well head protection guideline is suggested to provide the well head itself with some physical protection from equipment and vehicles. Brightly painted steel piping has been added around the well heads to prevent damage.

Guidelines for the Siting of New Water-Supply Wells

There are a number of considerations for siting new water-supply wells. The UMFS's location near the eastern edge of the Meridian and Tallahatta outcrop belts means these units are more variable and siting is more complex. These provisions (Table 3) are a mixture of site-specific guidelines with some that can be applied equally well elsewhere. Keeping detailed records, for example, applies to any water-supply well, domestic or public. The plugging of unused or abandoned wells is not only good common sense, but MDEQ regulations may require it (Surface Water and Groundwater Use and Protection Regulations, 1994).

Clustering supply wells causes individual cones of depression to coalesce forming a single, larger, steeper cone of depression that can cause steep drops in water levels. The well-spacing guideline is designed to minimize the coalescing cones of depression to form a more shallow cone, or perhaps several individual cones, without reinforcement. The Meridian - Upper Wilcox aquifer extends to the ground surface, so areas of higher elevations should overlie a thicker aquifer from which to establish production. At the UMFS, the aquifer is thicker on the western half of the property. A test well drilled at a potential well site provides a wealth of useful information on subsurface conditions including much that is relevant to well construction. Determination of the engineering properties as well as the geology of a well-site is good management practice as well as a good investment of time and money. These records - the more detail the better - are invaluable should problems with the well arise years after the well is drilled. With a good set of maps showing well locations, the distribution of wells, as well as the status of each, can be monitored. This guideline is, again, good management practice. Well locations should be surveyed prior to drilling activity to establish that there are no land-use conflicts that may influence the water quality of the new well. Wells should not be drilled in the flood plains as there is a potential for the well, and hence the aquifer, to become contaminated as a result of flooding. This guideline is, again, common sense management.

Many of the concerns that apply to water-supply wells apply equally well to water-monitoring wells. These wells should be constructed to industry standards to isolate the well screens from surface water traveling down the well annulus. They should be protected from damage and should be plugged when they are no longer in use or cease to function properly.

Guidelines For Water-Supply Well Construction

A water well will function only as well as the initial construction will allow. Mistakes are easy to hide underground, so, having representatives present during the well drilling and construction process is a good management practice. Wells used for public water supply fall under the guidance of the Mississippi State Board of Health, which has a set of regulations describing well construction and a useful set of recommended well design criteria (Mississippi State Department of Health, 2001). As the existing wells at the UMFS will not be used for public water supply, and thus do not fall under the jurisdiction of the Department of Health, these guidelines reflect the Health Department's guidance, but apply to all wells on the field station.

The construction guidelines are designed to prevent surface water and potential surface-derived contamination from moving downward beside the well casing, below the water table, and into the aquifer. There are several materials suitable for sealing the annular space; most are cost effective. The concrete pad provides protection from surface-derived contamination and a foundation for any surface equipment or plumbing. The wells should be constructed to accommodate access for monitoring purposes and then a program of scheduled monitoring should be formulated. Quarterly monitoring is sufficient unless there are trends (declining water levels, suspected contamination, etc.) that are of concern. In this case, more frequent water level or water chemistry measurements may be required. Table 4 is a summary of these guidelines.

Guidelines on Urbanization Effects

Although the UMFS is a special case, the effects of urbanization should be considered. With wells located in the aquifer recharge zone, paving and structures reduce the surface area available for recharge and increase surface runoff. This situation reduces the amount of water being placed back into the aquifer and changes the balance of the local fluvial components. It is prudent, therefore, to minimize those activities that impede aquifer recharge and to encourage practices that minimize the erosion often resulting from the increased runoff that accompanies urbanization. These guidelines are summarized in Table 5.

CONCLUSIONS

The UMFS is located in the outcrop belts of the Tallahatta Formation and the older Meridian Sand. These formations are hydraulically connected and form the Upper Wilcox - Meridian aquifer. The clays of the Tallahatta Formation are not continuous and are in a sand matrix, so together, the two formations comprise a single aquifer. The lack of confining beds within the sand-enriched section results in an unconfined aquifer in the upland areas. The guidelines were designed to protect this area from potential surface-derived contamination.

The flood plains (much modified by previous owners) consist of sands and an upper bed of clay or silt. The sand beds are connected with the sands that form the valley wall and can be considered part of the aquifer. The clay and silts of the top of the fluvial sequence form a confining bed which results in flowing artesian wells completed at shallow depths.

Many of the guidelines discussed herein are already in place at the UMFS and others are in the process of being implemented. The guidelines are designed to afford protection to the source aquifer while allowing the users of the field station to make continuous use of this resource. Often the guidelines are an expression of common sense, but equally often common sense ideas have not been discussed, or justified, and therefore, not always implemented. The UMFS experience is that once the educational process has been completed, users will accept the guidelines and use them. Employment of the guidelines is, of course, critical to their success as a tool. For details regarding the guidelines the reader may consult the UMFS user guide (UMFS, 2002) or Swann and Lutken's layperson's guide to water quality protection published in February of 2002.

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The authors would like to acknowledge the assistance of the Mississippi Department of Environmental Quality. Mr. Jamie Crawford, Office of Pollution Control was very helpful in providing information and guidance on well-head protection issues. The Mississippi Office of Geology drilled a stratigraphic test-well on the UMFS which was vital to working out the local stratigraphy. Mr. Steve Ingram, University of Mississippi, Department of Geology and Geological Engineering, provided insight into the stratigraphy of the Claiborne Group in northern Mississippi. The authors benefitted from these discussions and any omissions or errors in interpretation are, of course, our responsibility and not that of Mr. Ingram. The staff at the UMFS has always been helpful to all our endeavors – thanks for the patience. The illustrations were made possible through the patience and skill of Mr. Paul Mitchell, technical design specialist at the Mississippi Mineral Resources Institute.

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TABLE 1 - GUIDELINES TO PREVENT SURFACE CONTAMINATION	
Guideline	**Justification**
Designate areas of high contamination risk	Designate UMFS upland areas as high contamination risk - Design experiments accordingly
Restrict certain experiment locations to areas away from water-supply wells	Experiments with surface to subsurface contamination potential should be located away from water-supply wells
Regulate deep excavations in flood plain	Discourage deep excavations due to shallow artesian flow
Prevent Back-flow on water-supply and experimental wells	Prevent accidental introduction of chemicals into water supply

TABLE 2 - GUIDELINES FOR WATER-SUPPLY WELL PROTECTION AND CONTAMINATION PREVENTION	
Guideline	**Justification**
Establish a well-head protection zone centered on each water-supply well	A protection zone should be established to protect the area immediately surrounding the supply well
Establish inappropriate areas for sewage filter fields	Sewage filter fields should be away from supply wells and down hydraulic gradient
Physical protection should be established for all water wells	Minimize damage from passing trucks or tractors

TABLE 3 - GUIDELINES FOR THE SITING OF NEW WATER-SUPPLY WELLS	
Guideline	**Justification**
Water-supply wells should be separated, geographically, to minimize coalescence of cones of depression	Wells should be separated, geographically, to minimize individual cones of depression coalescing to form one steeper cone, resulting in a local "low" in the water table
Water-supply wells should be drilled at higher elevations	Wells drilled at the higher elevations access maximum thickness of the potential water-bearing section
The western half of the UMFS is best suited for additional wells	The Meridian-Upper Wilcox aquifer is thicker and more continuous on the western half of the UMFS
A test well should be drilled prior to the emplacement of a supply well	A test well provides geological and engineering information needed to construct a water-supply well
Test wells and unused supply wells should be plugged	Unused wells should be plugged to prevent their serving as conduits whereby contaminants may enter the aquifer
A geological and engineering report should accompany each new water-supply well	The geological and engineering (well construction) report should document all aspects of the well
Siting information on existing and new wells should be maintained	Geographic location of the well is useful to groundwater management
The area surrounding a new well location should be surveyed for potential contamination sources	Potential sources of contamination should be identified prior to well construction to ensure high-quality groundwater
Water-supply wells should not be in the flood plain	Flooding can contaminate wells, so wells should not be located within flood plains

TABLE 4 - GUIDELINES FOR WATER-SUPPLY WELL CONSTRUCTION	
Guideline	**Justification**
Water-supply wells should be constructed to prevent surface water flowing down the annular space	Filling the annular space with the appropriate sealing material will prevent surface-derived contamination reaching the groundwater
A concrete pad should be poured around the well head	The concrete pad prevents surface-derived contamination from following the casing down to the water table
Provisions should be made to allow for periodic water-level determinations and sampling for chemical analyses	Periodic measurement of the water level is important to determining the well-being of the aquifer while periodic chemical sampling is recommended to maintain aquifer health/check for contamination
Water-monitor wells should be constructed to restrict access	Water-monitor wells usually include open casing which provides an opportunity for illicit dumping of materials that may contaminate the aquifer
Water levels should be monitored at least quarterly, perhaps more if special events arise	A routine measurement program should be established to provide baseline information about the aquifer, so if a need arises to evaluate the aquifer, a reference will have already been established

TABLE 5 - GUIDELINES TO MINIMIZE THE EFFECTS OF URBANIZATION	
Guideline	**Justification**
Minimize paving for roads and construct new paths only as required	Asphalt and concrete allow for little recharge into the aquifer - use concrete and asphalt only when required
Minimize parking lot paving	Natural materials (gravel) can be used which will allow infiltration of precipitation
Use ornamental shrubs which require little water	Large amounts of water can be used for irrigation - shrubs that are drought-tolerant can save water
Preserve naturally occurring drainage networks	Channelizing streams and constructed ditches will alter the surface flow and cause stream adjustment – erosion often results
Preserve naturally occurring vegetation	The native flora has adjusted to its environment and usually survives best in the absence of exotic species

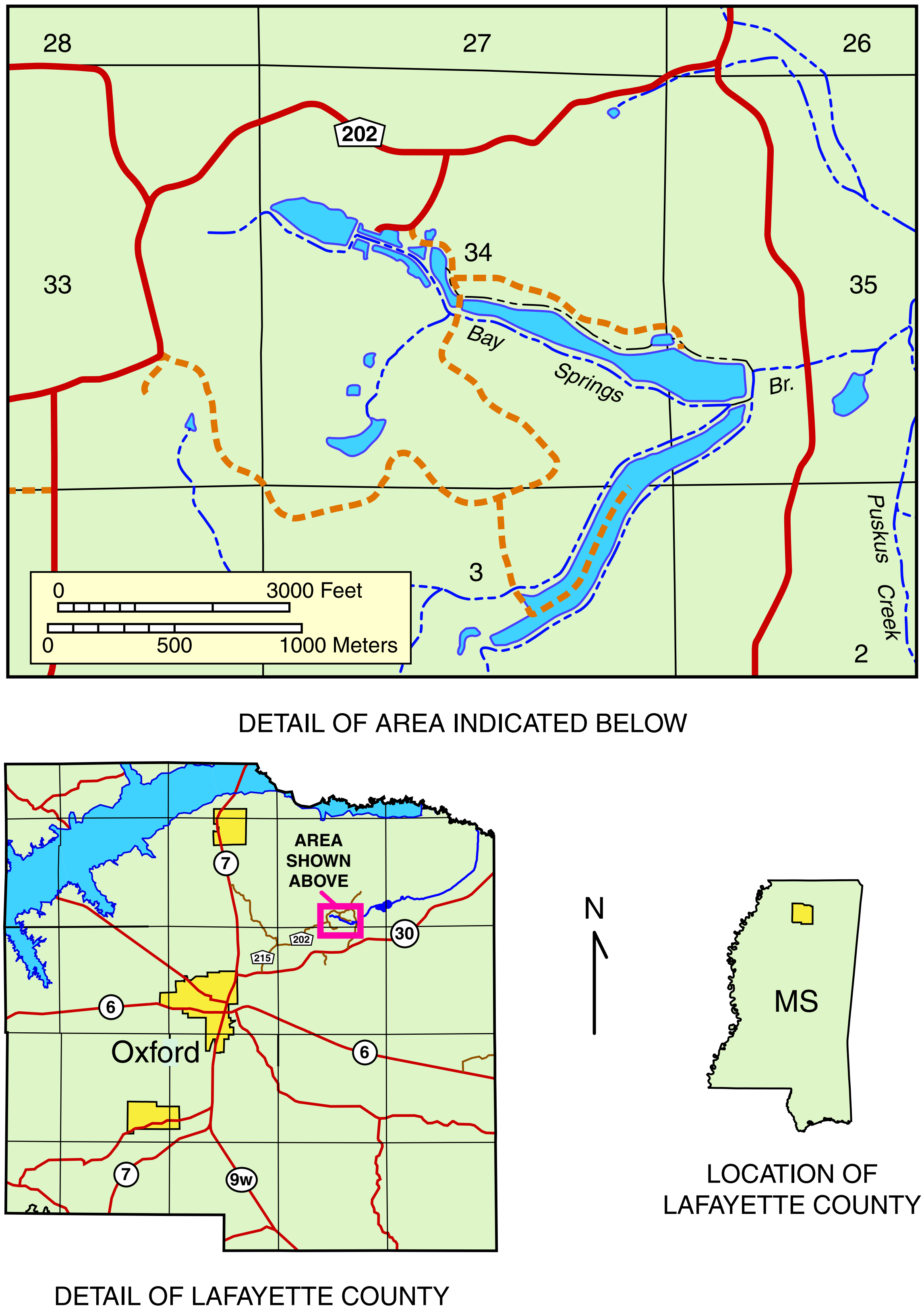

Figure 1. Location of the University of Mississippi Field Station, the City of Oxford and Lafayette County.

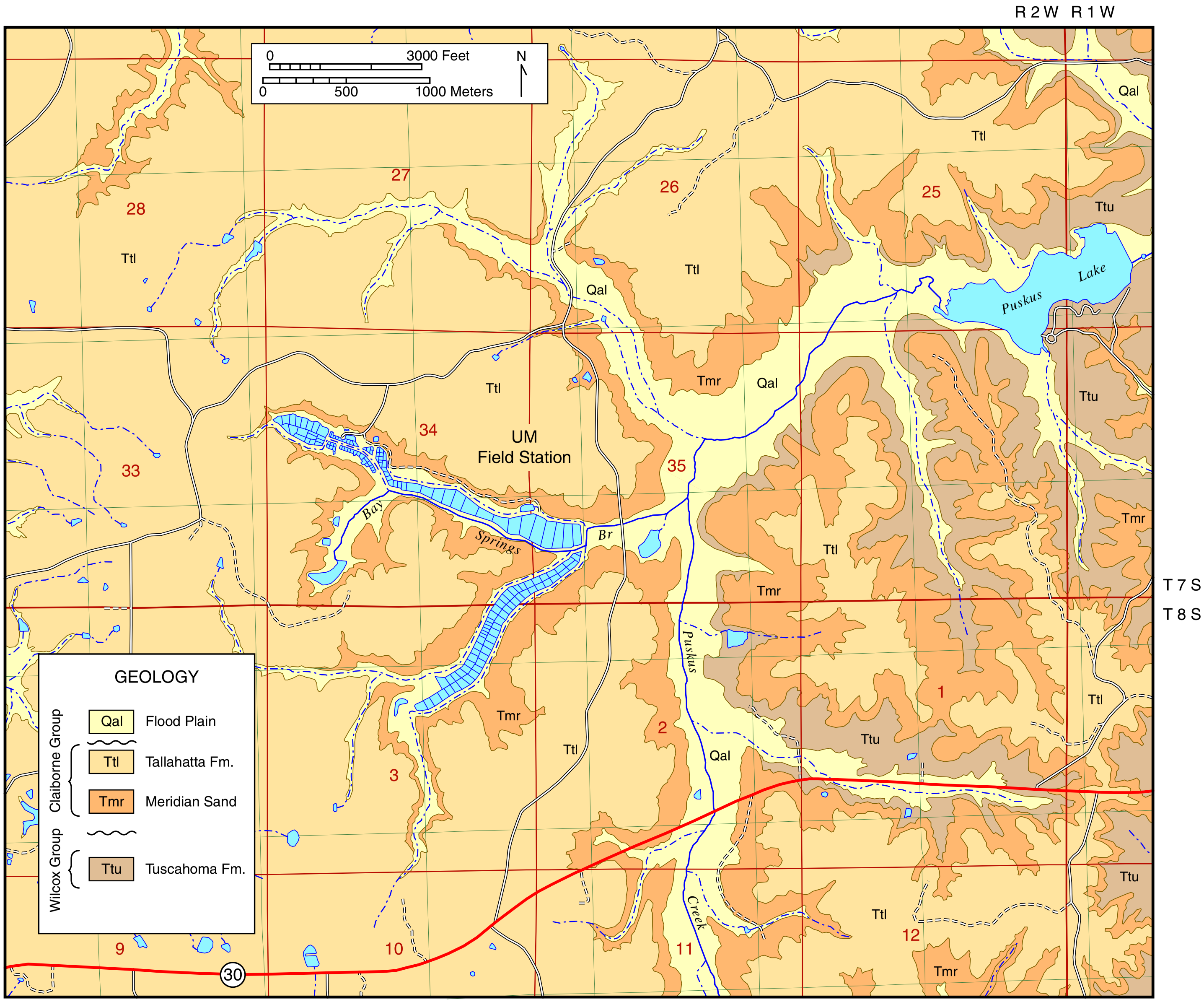

Figure 2: Geologic map of the area surrounding the UM Field Station, in Lafayette County.

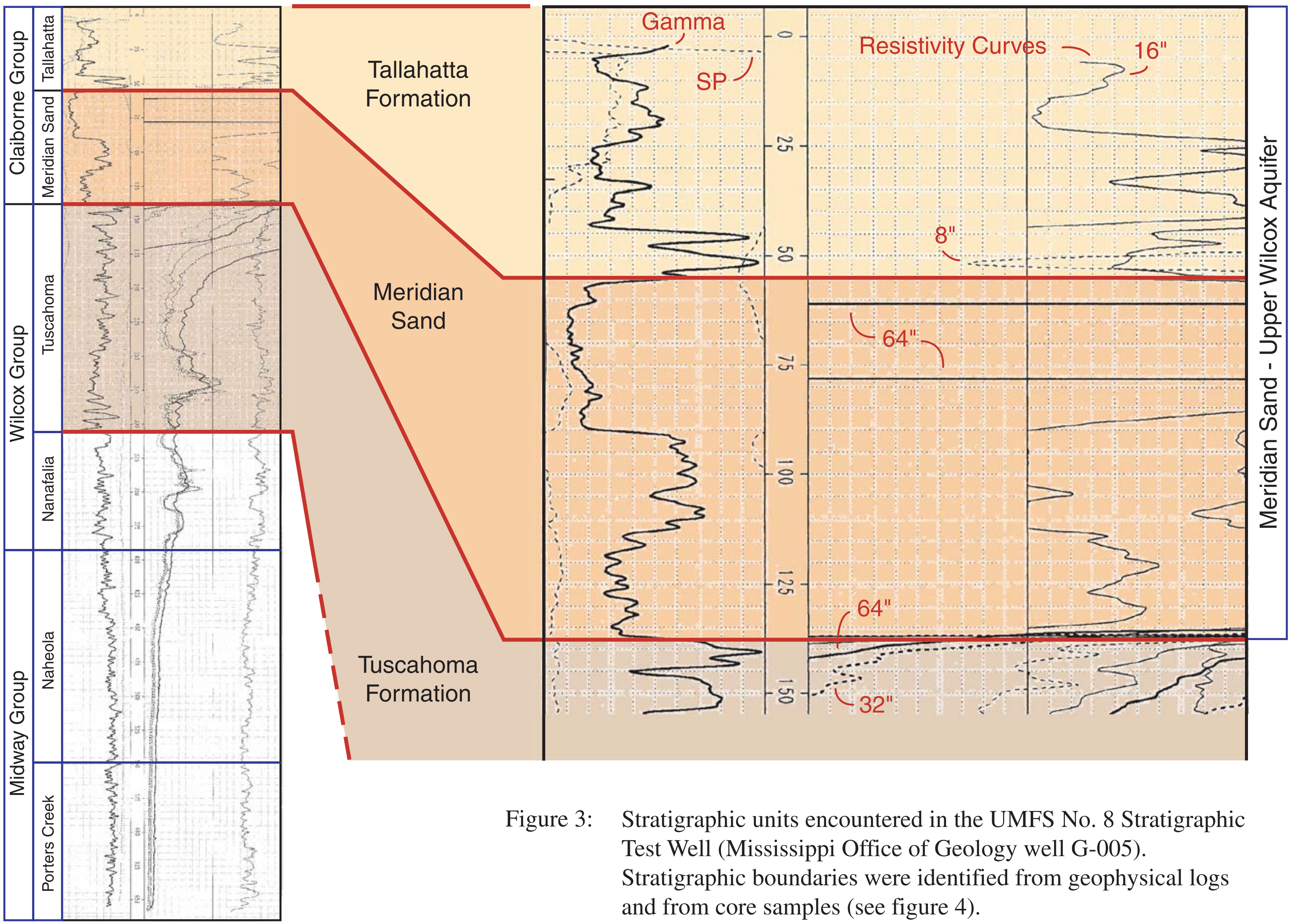

Figure 3: Stratigraphic units encountered in the UMFS No. 8 Stratigraphic Test Well (Mississippi Office of Geology well G-005). Stratigraphic boundaries were identified from geophysical logs and from core samples (see figure 4).

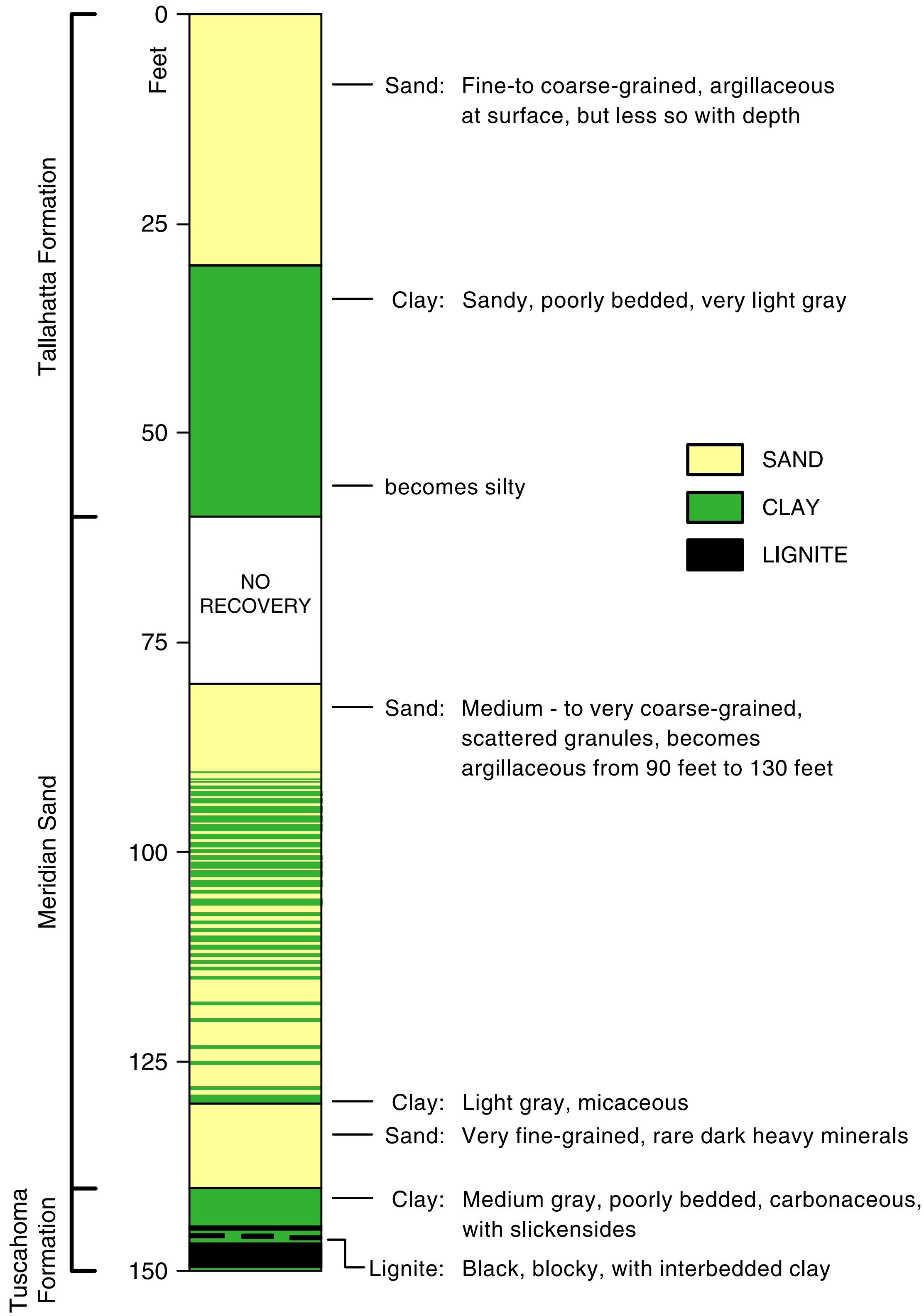

Figure 4. Detailed description of the core samples from 0 to 150 feet depth taken from the UMFS No. 8 test well. The Meridian - Upper Wilcox aquifer is assigned to the upper 140 feet of the section.

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