United States Department of the Interior

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In Reply Refer To:
FWS/R2/OKES/
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November 22, 2010

Ms. Walls-Rivas
Impact Aid Program
U.S. Department of Education
400 Maryland Avenue, SW. Room 3C155
Re: Locust Grove Public School District Early Learning Center, Locust Grove, Oklahoma
Washington, DC 20201-6244

Dear Ms. Walls-Rivas:

This document transmits the U.S. Fish and Wildlife Service's (Service) biological opinion (BO) on the proposed Locust Grove Public School District Early Learning Center in Mayes County, Oklahoma and its effects on the American burying beetle (ABB) *Nicrophorus americanus* in accordance with section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 et seq.), and 50 Code of Federal Regulations [CFR] §402 of our interagency regulations governing section 7 of the ESA. Locust Grove Public School District (LGPSD) is utilizing funds provided by the U.S. Department of Education (DOEd), Impact Aid Program, for the construction of this school building. The LGPSD is proposing to build an Early Learning Center, paved roads, and parking areas. Concrete Shell Structures (CSS) is the architecture firm hired by LGPSD. The U.S. Department of Education's request for formal consultation was received by the Service on November 15, 2010 and a complete formal consultation package was received on the same day.

LGPSD evaluated the proposed project for issues relating to federally listed species identified by the Service as occurring in Mayes County. These included the American burying beetle (ABB) *Nicrophorus americanus*, gray bat *Myotis grisescens*, interior least tern *Sterna antillarum*, Ozark cavefish *Amblyopsis rosae*, piping plover *Charadrius melodus*, and the candidate species Arkansas darter *Etheostoma cragini*. LGPSD has determined that no effects will occur to the gray bat, interior least tern, Ozark cavefish, piping plover, and the Arkansas darter from the proposed school building project and the DOEd has concurred with this determination. Justification for these decisions can be found in LGPSD's biological assessment (BA), which has been approved by DOEd.

This BO is primarily based on information provided in the DOEd's November 15, 2010, BA. Additional information was obtained through telephone conversations, electronic mail, and meetings among the Service, DOEd, LGPSD, and CCS. A complete administrative record of this consultation is on file at the Service's Oklahoma Ecological Services Field Office (OFO).

Consultation History

On October 4, 2010, LGPSD sent a letter notifying the Service of the Early Learning Center construction. Their letter also provided a preliminary "may affect, not likely to adversely affect" determination for the ABB. The Service responded to LGPSD with a phone call and electronic mail on October 12, 2010 to discuss possible issues related to the ABB and request additional information. On October 18, 2010, CSS submitted additional documents to the Tulsa office of the USFWS. This preliminary information included location, project description, total property and area of disturbance information, general soils information and a full geotechnical report related to the site soils. The Service responded on October 20, 2010 and recommended that surveys be conducted to better understand the effect of the project on this species. However, a survey for the ABB was determined to not be feasible due to the schedule of construction.

In response to this, LGPSD and CSS met with the Service on October 25, 2010, to discuss the Service's requirements and recommendations for the project. Based on the habitat of the project area, the unknown status of the ABB in the project area, the life history requirements of the ABB, the scope of the project, and the timing of the project, the Service believed that take of ABBs could not likely be avoided without surveying or baiting away. The Service recommended the DOEd request formal consultation with the Service and that a BA be prepared for submission to the Service by DOEd.

Also during this meeting, the Service provided information on the threats and conservation needs of the ABB. The primary threat to ABBs is believed to be the loss, degradation, and fragmentation of suitable habitat. The Service informed the LGPSD that an ABB Conservation Fund (ABB Fund) had been established by The Nature Conservancy, Oklahoma Field Office (TNC) in coordination with the Service. The purpose of the ABB Fund is habitat conservation and recovery research. The Service indicated that our preferred conservation action for this project would be donation of funds to the ABB Fund. This conservation measure also allows the federal action agency to fulfill their Section 7(a)(1) responsibility, which stipulates that federal agencies shall utilize their authorities in furtherance of the ESA.

Previously, the Service's standard recommended conservation measures regarding the ABB included: 1) conducting surveys for the ABB, and implementing trap and relocation or baiting away measures to avoid impacts to the ABB; or 2) in lieu of surveys, assume that the ABB is present, and implement trap and relocation measures. These previous recommendations were based on the life history requirements of the ABB, the priority actions in the Recovery Plan, and the lack of specific or current survey data in a given area.

Survey data in Oklahoma has increased dramatically, especially in the last 5 years. Now that such presence/absence baseline information is available, the Service is focusing on other conservation measures identified in the ABB Recovery Plan. Specifically, we are focusing on habitat loss, degradation, and fragmentation, which are believed to be the primary limiting factors for ABBs (Service 1991). Consequently, the Service has identified priority areas for ABB habitat conservation in Oklahoma. In addition, the Service has identified priority recovery research needs for the ABB.

On November 1, 2010, the Service received a draft BA from CCS, via electronic mail. The Service provided comments in regards to the draft BA on November 8, 2010. On November 11, 2010, the Service received an updated BA from CCS, via electronic mail. On November 15, 2010, the Service received a letter from the DOEd, via electronic mail, requesting formal consultation for the Locust Grove Public School's Early Learning Center.

The November 15, 2010, BA identified the following species as potentially occurring in the project area and the DOEd's determination of the proposed actions impacts to these species:

gray bat	no effect
piping plover	no effect
Ozark cavefish	no effect
interior least tern	no effect
Arkansas darter	no effect
ABB	may affect, is likely to adversely affect

The Service concurs with DOEd's determination for the ABB. A no effect determination does not require the Service's concurrence.

BIOLOGICAL OPINION

I. Description of Proposed Action

A. Project Location

The project is located approximately 0.25 miles northwest of the intersection of Joe Koelsch Drive and State Highway 82 in the City of Locust Grove, Mayes County, Oklahoma (Appendix 1). The proposed project property is approximately 30 acres in size, with project construction on approximately 7.5 acres. The legal description of the project area is sec. 15, T. 20 N., R. 20 E.

B. Site Description

The overall 30 acre property is varied in topography and vegetation. The topography includes a localized knoll where the Early Learning Center will be located. The natural drainage on the site flows around the knoll to a pond area with a natural overflow low in the topography. There is no consistent inlet or outlet to the pond area, but rather the pond is fed and releases only in the event of heavy precipitation.

The project site is comprised primarily of pasture, prairie, and forested areas. The forested areas consist primarily of an oak/hackberry mixture. The prairie grasses on the south portion of the site have been mowed at regular intervals throughout summer 2010. Photographs of the project site are included in Appendix 2.

The soils on the property have been evaluated by a geotechnical engineer. The full geotechnical investigation report for the site is included in Appendix 3. The soils profile on the property has been characterized as follows:

- Residual soil materials formed in-place through the weathering process of the parent bedrock.
- At a depth of 0 to 2 feet above the surface soils consisted primarily of firm to hard, lean or sandy lean clay soils.
- The soils in the upper zone (0 to 2 feet) are generally very dark brown or brown.

C. Project Description

Justification

The development of the Early Learning Center is necessary because of deficient existing facilities in the district. The existing facilities have been deemed structurally inadequate by a licensed structural engineer. Additionally, the existing electrical and mechanical systems in the facilities are inadequate. The facilities are plagued with widespread mold as a result of building leaks and poor mechanical systems. The school district has been the recipient of federal grant monies in order to provide a replacement facility that will provide a quality learning environment for the young students within the district.

The proposed building design will provide a safe modern facility for the district. The facility is sized to handle current needs and anticipated growth to satisfy identified trends in the district boundaries for the coming years.

Specifics

The project includes development of a new elementary school facility with approximately 50,000 square feet of new space. The building is configured with a central building core and three classroom wings radially organized around the core. The building will be stepped to conform as much as possible to the natural grades on the site. There will be 4 distinct building pad elevations in the project with connection sections of the building providing ramped grade transitions between the main building and classrooms wings.

Building access will be provided at the front and back of the building and will include hardscape paved access roads and parking areas. The development immediately surrounding the building will be used initially for construction staging and eventually as the playground areas for the school.

The building will be located at the highest portion of the site on a knoll located towards the eastern edge of the site, approximately in the middle of the site in the north-south direction. Site drainage naturally occurs around the knoll area. Erosion control measures will be put in place around the construction site to mitigate disturbance to the undeveloped and undisturbed portions of the site. Erosion control will consist of silt fences, berms, covering and protecting stockpiled soils.

The development location for the Early Learning Center is located away from the main street frontage on the property. As a result, an access road will be developed from the south connecting to Joe Koelsch Drive. The access road will be continued to the back of the building along the east side of the property adjacent to other existing developed areas.

Utility connections for the facility will be extended from 2 distinct locations. The water, electrical, gas and phone connections will come from the south and will run adjacent to the development for the access road. Sanitary sewer connection will be made to the east at the area between the proposed building location and existing commercial development along OK State Highway 82.

Site Preparation

Existing vegetation on the site will be grubbed prior to regrading activities. Since the prairie areas have been mowed during the past several months, this grubbing will consist of scraping the top several inches of soil away to remove the organic matter. These topsoil materials will be stockpiled separately for replacement during final finish grading.

Site preparation will consist of significant regrading efforts at the specific site of the building. Regrading will include cutting and filling of existing soils to establish 4 distinct building pad elevations for the school facility. To the extent possible all native soils will either be chemically stabilized for use as structural fill or it will be stockpiled for relocation around the building as part of final rough grading for playground areas. Stockpiled soils are anticipated to be located within the construction boundaries during the construction period. After stockpiled soils are relocated under or around the building, the areas where the soils have been piled will be restored to native vegetation species.

Construction Activities

Construction activities will be limited to the approximate 7.5 acres identified within the construction boundaries for the project. During the construction period, there will be a varied range of equipment anticipated on site. All equipment will access the site using the access road from Joe Koelsch Drive. Construction equipment may likely include backhoes, trackhoes, dumptrucks, flatbed trucks, and smaller passenger grade vehicles.

The general rough grading to establish general building pad locations and elevations will be accomplished in a single phase. Refinement of the grading will likely occur in phases to allow start of construction activities for the buildings. Construction is anticipated to be phased for each individual building. The central building core will likely be started first with each of the classrooms wings following in succession and allowing an assembly line approach to completing various portions of the construction for each building.

Restoration

Areas used at the periphery of construction site boundaries are identified to receive erosion control measures and also stockpiled soils during construction activities. Toward the end of construction, stockpiled soils will be relocated around the building to blend in with natural grades. Erosion control measures will be removed toward the end of the construction phase. These distinct areas will be re-vegetated and restored to a natural state to lessen long-term impact from the construction on the otherwise undisturbed portions of the property.

Operations and Maintenance Procedures

Areas located at the periphery of the identified development boundary will be restored to a more natural state. These areas are entirely included in the 7.5 acres of land that will be disturbed during the project. As a long-term maintenance program most of these restored areas will be mowed with the exception of areas specifically marked on the construction boundaries plan (Appendix 1) for habitat restoration area. Widespread use of herbicides and pesticides is not anticipated in periphery areas, but may be necessary in areas within 20 feet of the building. The typical buffer assumed around the building footprint during development is a minimum of 20 feet, but averages over 50 feet around most of the building perimeter. Use of herbicides and/or pesticides in these areas is intended solely keep noxious vegetation and potential pest species from playground areas integral in the function of the Early Learning Center facility.

D. Conservation Measures

As part of their proposed action, the action agency has pledged the following actions to avoid, minimize, and mitigate impacts to the ABB.

The federal action agency proposes the following:

- Upon completion of construction activities, the project area will be revegetated with a mixture of native grasses, forbs, and trees.
- The Locust Grove School District will use the majority of the remaining acreage in the 30-acre property for education opportunities related to the ABB. Due to the inherent educational nature of the facility, this facility and the surrounding land will serve as a venue for focused community education related to the endangered ABB species.
- A one-time donation of $3,500 to the ABB Conservation Fund held by Oklahoma Chapter of The Nature Conservancy (TNC) and administered jointly by TNC and the Service.

II. Status of the Species

The federally listed endangered species that is likely to be present in the action area and may be adversely affected by the proposed action is the ABB. The status of the ABB is as follows:

A. Species/critical habitat description

Description

The ABB was proposed for federal listing in October of 1988 (53 FR 39617) and was designated as endangered on July 13, 1989 (54 FR 29652) and retains this status. Critical habitat as defined under the ESA has not been designated for the ABB. The Final Recovery Plan was signed on September 27, 1991. A five-year review of the ABB's listing status was completed by the Service on June 16, 2008. The review found that, based on the information available, the ABB remains endangered throughout its current range.

The ABB is the largest silphid in North America, reaching 1 to 1.8 inches (27-45 mm, Wilson 1971, Anderson 1982, Backlund and Marrone 1997). Pronotal width is highly correlated with weight (Kozol *et al.* 1988). Size (pronotal width) of ABBs ranged from 0.344 – 0.500 inches (7.83 – 12.71 mm) in a laboratory study and 0.314 – 0.497 inches (7.98 – 12.63 mm) at Block Island. They are black with orange-red markings and are sexually monomorphic. The hardened elytra are smooth, shiny black, and each elytron has two scallop shaped orange-red markings. The pronotum (hardback plate over the mid-section between the head and wings), is circular in shape with flattened margins and a raised central portion. The most diagnostic feature of the ABB is the large orange-red marking on the raised portion of the pronotum, a feature shared with no other members of the genus in North America (Service 1991). The ABB also has orange-red frons and a single orange-red marking on the clypeus, which is located on the head just above the mandibles. Antennae are large, with notable orange club-shaped tips.

Gender can be determined visually by examining the clypeus. Males have a large, rectangular, red marking and females have a smaller, triangular, red marking. Beetles are aged by visual examination. The markings of teneral ABBs are brighter and appear more uniform in color while the exoskeleton is softer and in general more translucent. The pronotum of a mature, second season adult tends to be darker than the markings on its elytra, with the former appearing dark orange to red and the latter appearing orange. The senescent ABB has pale elytral markings, seemingly lacking pigment compared to other age classes. In addition, senescent ABBs are more scarred, often with pieces missing from the margin of the pronotum or elytra, have cracks in the exoskeleton, and/or are missing appendages (e.g., tarsi, legs, or antennae).

B. Distribution and Abundance

Historically, the geographic range of the ABB encompassed over 150 counties in 35 states, covering most of temperate eastern North America and the southern borders of three eastern Canadian provinces (Appendix 4, Service 1991; Peck and Kalbars 1987). Historic records from Texas (single record c. 1935) in the south, north to Montana (single record in 1913) and the southern fringes of Ontario, Quebec, and as far east as Nova Scotia and Florida are known (Appendix 4). Documentation is not uniform throughout this broad historical range. More records exist from the Midwest into Canada and in the northeastern United States than from the southern Atlantic and Gulf of Mexico region (Service 1991). During the 20th century, the ABB disappeared from over 90 percent of its historical range (Ratcliffe 1995). The last ABB specimens along the mainland of the Atlantic seaboard, from New England to Florida, were collected in the 1940's (Service 1991). At the time of listing, known populations were limited to one on Block Island and one in Latimer County, Oklahoma. In 1991 when the Recovery Plan was completed, Creighton *et al.* (1993) reported the discovery of a previously unknown population on Cherokee Wildlife Management Area, adjacent to Camp Gruber in Muskogee and Cherokee counties, Oklahoma. They also reported the rediscovery of a single ABB specimen on private land in Sequoyah County.

Currently, the ABB is known to occur in only eight states: on Block Island off the coast of Rhode Island, Nantucket Island off the coast of Massachusetts, eastern Oklahoma (Appendix 5), western Arkansas (Carlton and Rothwein 1998), Loess Hills in south-central and Sand Hills in north-central Nebraska (Ratcliffe 1996, Bedick *et al.* 1999), Chautauqua Hills region of southeastern Kansas (Sikes and Raithel 2002), south central South Dakota (Backlund and Marrone 1995, 1997; Ratcliffe 1996), and northeast Texas (Godwin 2003,

Appendix 4). Most existing populations are located on private land. Populations known to exist on public land include: Ouachita National Forest, Arkansas / Oklahoma; Cherokee WMA, Oklahoma; Camp Gruber, Oklahoma; Fort Chaffee, Arkansas; Sequoyah National Wildlife Refuge, Oklahoma; Block Island National Wildlife Refuge, Rhode Island; Valentine National Wildlife Refuge, Nebraska; and Camp Maxey, Texas.

Abundance

Lomolino and Creighton (1996) found at Camp Gruber that in comparison to the ABB, *N. orbicollis*, *N. tomentosus*, and *N. marginatus* were nearly 20, five, and two times as abundant, respectively. Kozol (1989) demonstrated that *N. orbicollis* was about eight times more abundant than ABBs on Block Island, Rhode Island while Walker (1957) collected 19 times more *N. orbicollis* (175) than ABBs (9) in the single trapping array where the latter species was encountered in Tennessee.

C. Habitat

Feeding Habitat

ABBs are considered feeding habitat generalists and have been successfully live-trapped in several vegetation types including native grasslands, grazed pasture, riparian zones, coniferous forests, mature forest, and oak-hickory forest, as well as a variety of soil types (Creighton *et al.* 1993; Lomolino and Creighton 1996; Lomolino *et al.* 1995; Service 1991). Ecosystems supporting ABB populations are diverse and include primary forest, scrub forest, forest edge, grassland prairie, riparian areas, mountain slopes, and maritime scrub communities (Ratcliffe 1996; Service 1991). The ABB readily moves between differing habitats (Creighton and Schnell 1998, Lomolino et al. 1995).

Lomonlino *et al.* (1995) examined the niche breadth of *Nicrophorus* species at Fort Chaffe and Camp Gruber. Habitat was evaluated in terms of forest development and shrub cover. They found the niche breadth of ABBs ranged from 0.844-0.925, at Fort Chaffe and Camp Gruber, respectively. Although not as high as the ABB, *N. tomentosus* exhibited a high niche breadth of 0.903. In comparison, *N. marginatus*, and *N. orbicollis*, exhibited 0.402, and 0.512-0.707, respectively (*N. orbicollis* was found at both sites). They did not find significant differences in habitat affinities between ABB sexes during this study.
Lomolino and Creighton (1996) evaluated niche breadth of *Nicrophorus* species at east central and southeast Oklahoma (regional level) and at the Tiak Ranger District (local level) of the Ouachita National Forest in southeast Oklahoma. At the regional level, they found ABBs in sites characterized with moderate to well-developed forest with moderate to deep soils and an understory with moderate cover of small shrubs. They also found that *N. tomentosus* has the largest niche breadth, 0.89, followed by the ABB, 0.78. However, this may be a result of *N. tomemtosus* having the tendency to bury carcasses just beneath the litter, but not under the soil. The niche breadth for *N. marginatus*, *N. orbicollis*, and *N. pustulatus* was 0.36, 0.71, and 0.53, respectively.

In contrast to the results of the regional study, ABBs at the Tiak Ranger District had the most restrictive niche breadth, at 0.53, whereas *N. tomentosus* and *N. orbicollis* were 0.80 and 0.84. However, the local and regional studies evaluated different habitat types. The local Tiak District study analyzed mature forests, second-growth forests, and clearcuts. Results from this study indicated that ABBs avoided clear-cuts and preferred mature forests. The results of this study provide insight into underlying mechanisms of how deforestation, or fragmentation in general, could contribute to the decline of this species. Interpretation of these study results is limited because baited pitfall traps were utilized. This study may only illustrate where ABBs feed, but not necessarily where they will be able to successfully reproduce. The ABB likely will not be able to reproduce successfully in such a broad range of habitat conditions.

Walker (1957) captured nine ABBs in a deciduous forest located on the floodplain of a small creek in Tennessee. The site was described as being "park-like" with little undergrowth. This is not unlike the understory conditions found in Oklahoma and Arkansas upland forests. Our bottomland sites, by contrast, tended to have fairly dense undergrowth of small trees and shrubs. Studies by Creighton *et al.* (1993) at the Cherokee WMA in eastern Oklahoma found relatively more ABBs in oak-hickory forest than grasslands or bottomland forests.

The oak-hickory habitats preferred by ABBs in Oklahoma contrast sharply with the type of habitat in which they are found in Rhode Island. Kozol *et al.* (1988) reported that ABBs are broadly distributed across available habitats on Block Island, Rhode Island (shrub thickets to grazed fields). However, ABBs are most common in areas with deep soil and light agricultural activity. These habitats are not natural. The natural vegetation of Block Island has been altered during the past 200 years from hardwood forest to post-agricultural maritime scrub, mowed fields, and grazed pastures (Service 1991). The apparent generalist nature of ABBs on Block Island may be an artifact of this insular environment (Crowell 1983). Because of the low diversity of predators and competitors on islands, insular populations often exhibit ecological release, occurring in a broad variety of habitats considered atypical for populations on the mainland (Crowell 1983, Grant 1971, Case 1975, Cox and Ricklefs 1977, and Lomolino 1984).

Holloway and Schnell (1997), utilizing baited pitfall traps, found significant correlation between the number of ABBs captured and the biomass of mammals (0-200 g), and birds at Fort Chaffee. The geographic distribution of ABBs and the biomass of mammals exhibited notable concordance, except for the far northwest section of Fort Chaffee where ABB numbers were lower. This lower number of ABBs could be a result of this section of Fort Chaffee being a peninsula extending from the main portion of the installation, thereby having increased edge effect.

Reproductive Habitat

While studies indicate that the ABB is a habitat generalist in terms of feeding, it is likely more stenotopic when selecting burial sites for breeding. Anderson (1982) postulated that paired ABBs placed on carcasses will be more reproductively successful in forested habitats due to the rich, loose soils conducive to digging. Lomolino and Creighton (1996) found reproductive success to be higher in forest verses grassland habitat, because more carcasses were buried in the forested habitat than the grassland. They theorize that carcasses are more difficult to secure in grassland due to the near absence of a litter layer and that they are more difficult to bury due to the tendency of grassland soils to be more compact than those in forest. However, of the carcasses buried, habitat characteristics did not significantly influence brood size. Holloway and Schnell (1997) found significant correlations between the numbers of ABBs caught in traps and the biomass of mammals and birds, irrespective of the predominant vegetation.

Soil conditions for suitable ABB habitat must be conducive to excavation by ABBs (Anderson 1982; Lomolino and Creighton 1996). In Arkansas and Oklahoma, ABBs are found within a mixture of vegetation types from oak-hickory and coniferous forests on lowlands, slopes, and ridgetops to deciduous riparian corridors and pasturelands in the valleys (Service 1991; Creighton *et al.* 1993). Soils in the vicinity of captures are all well drained and include sandy loam and silt loam, with a clay component noted at most sites. Level topography and a well-formed detritus layer at the ground surface are common (Service 1991). In 1996, more than 300 specimens were captured in Nebraska habitats consisting of grassland prairie, forest edge, and scrubland (Ratcliffe 1996). These surveys have found certain soil types such as very xeric (dry), saturated, or loose, sandy soils to be unsuitable for carcass burial and thus are unlikely habitats.

D. Life history

The life history of the ABB is similar to that of other *Nicrophorus* species (Kozol *et al.* 1988; Pukowski 1933; Scott and Traniello 1987; Wilson and Fudge 1984). The ABB is an annual species, nocturnal, active in the summer months, inactive during the winter months, and typically only reproduce once in their lifetime. They bury themselves in the soil for the duration of the winter. The young of the year overwinter as adults and comprise the breeding population the following summer (Kozol 1990b). Both adults and larvae are dependent on carrion for food and reproduction. They must compete with other invertebrate species, as well as vertebrate species, for carrion. Even though ABBs are considered feeding habitat generalists, they have still disappeared from over 90 percent of their historic range. Habitat loss, alteration, and fragmentation, which creates edge habitat, leads to a reduced carrion prey base and an increase in vertebrate scavengers, which works against the ABB (Service 1991).

Winter Inactive Period

During the winter months, when the nighttime ambient temperature is consistently below 60°F (15.5°C), ABBs bury themselves into the soil and become inactive (Service 1991). In Oklahoma, this typically occurs in late September and lasts until mid-May, approximately 8 months. However, the length of the inactive period can fluctuate depending on temperature. Recent studies indicate that ABBs bury to depths ranging from 0 to 6 inches (0 to 20 cm), with an average depth of 2.4 inches (6 cm, Schnell *et al.* 2007). Habitat structure (*i.e.*, woodland vs. grassland) does not appear to be an influencing factor.

Preliminary data suggest that overwintering results in significant mortality (Bedick *et al.* 1999, Schnell *et al.* 2007). However, winter mortality has only recently begun to be investigated. Winter mortality may range from 25 percent to about 70 percent depending on year, location, and availability of carrion in the fall (Schnell *et al.* 2007; Raithel 1996-2002 unpubl. data). Overwintering ABBs with access to a whole vertebrate carcass in the fall had a survival rate of 77 percent versus 45 percent for those ABBs not provisioned with a carcasses.

Summer Active Period

The ABB is a nocturnal species, active in the summer months, emerging from their winter inactive period around mid-May. Nightly activity is most predominant from 2 to 4 hours after sunset, with no captures recorded immediately after dawn (Walker and Hoback 2007, Bedick *et al.* 1999). During the daytime, ABBs are believed to bury under the vegetation litter. Brood rearing occurs soon after emergence from overwintering. During late May and early June, ABBs secure a mate and carcass for reproduction. The reproductive process takes approximately 48-69 days.

Kozol *et al.* (1994) on Block Island, found ABBs were caught only on nights where the temperature was above 59°F (15°C), but were captured when the temperature was as low as 60°F. In Nebraska, Bedick *et al.* (1999) found that ABB activity was highest when temperatures were between 59°F (15°C) and 68°F (20°C). ABB activity exhibited a weakly negative relationship with temperature. Other *Nicrophorus* species were captured at 55°F (12.7°C), but activity was reduced when temperatures were below 59°F (15°C). In Oklahoma, ABBs are typically active from mid-May to late-September when nighttime ambient temperatures are consistently above 60°F. In Nebraska, ABBs become active in mid-May (Bedick *et al.* 1999). Peyton (1996) captured ABBs on May 20 in Nebraska. Capture rates for ABBs are highest from mid-June to mid-July and again in mid-August (Kozol *et al.* 1988, Bedick *et al.* 2004, Service 1991) with a decrease in pitfall captures in late July (Kozol *et al.* 1988). The Service (1991) reported that during late July ABBs were easy to attract to carrion bait but were difficult to capture in pitfall traps. Weather, such as rain and strong winds, result in reduced ABB activity (Bedick *et al.* 1999). However, on Block Island, Rhode Island, *Nicrophorus* were trapped repeatedly and successfully on both rainy and windy nights provided the temperature was above 59°F (15°C, Kozol *et al.* 1988). The ABB may delay nocturnal activity when temperatures are very warm, greater than 75°F (24°C).

Much of the long-term information concerning the life history of the ABB has come from studies at Fort Chaffee in Arkansas, Camp Gruber in Oklahoma, and Block Island, Rhode Island. Block Island has a relatively stable land use pattern. The insular condition of the population, lack of predators, and supplemental carrion provision does not lend itself to comparability to inland populations. While the land use at Fort Chaffee, AR; and Camp Gruber, OK differs, each installation maintains a relatively consistent land use pattern of its own through time. However, Schnell *et al.* (1997-2006) and Schnell *et al.* (1997-2005) reported the number of ABBs captured and the location of high-density ABB concentrations varies annually at each site. This observation indicates ABBs are annually cyclic, where there may be high numbers and abundance in one year, followed by a decline in numbers the succeeding year. In addition, each year they reported that areas of high concentration appeared to shift annually throughout the sites. Further, the ABB is an annual species (living for only one year) and the following year's numbers are dependent upon the reproductive success of the previous year.

Standard transects on Camp Gruber that resulted in ABB captures in one year failed to capture ABBs in another year. Surveys conducted in a given area have resulted in ABB captures during one survey effort but surveys conducted in the same given area within the same active season have resulted in negative ABB captures. During a 10 – 12 night period in the summer, ABBs were not recaptured after 6 nights. This indicates a relatively rapid turnover rate in the trappable ABB population due to factors such as natural mortality, dispersal, and burrowing underground and attending carrion/broods (Creighton and Schnell 1998).

Movement

Nightly movement of ABBs ranges from 0.101 to 1.03 miles (0.16 – 1.66 km). Creighton and Schnell (1998) conducted a study on movement patterns of ABBs at Camp Gruber and Fort Chaffee in 1992 and 1993. They recaptured 68 ABBs over a 12 night period, of those 68, 23 (29.5 percent) were recaptured at a site different than the original site of capture. The mean distance moved of the 23 recaptured ABBs over the 12 night sampling period was 1.21 miles (1.95 km) [0.101 miles (0.16 km) per night]. The minimum and maximum distance moved by an individual recaptured ABB was 0.16 mile (0.25 km) in 1 night and 4.3 miles (6.5 km) in 5 nights [0.8 miles (1.29 km) per night], respectively. Six ABBs were recaptured two or three times. The mean movement for these six ABBs was 6.2 miles (10 km) over 6 nights [1.03 miles (1.66 km) per night] over the entire sampling period. The maximum distance moved by one of these six was 0.76 mile (1.23 km) in one night.

Bedick *et al* (2004) reported average nightly movements of 0.62 mile (1.0 km) with 85 percent of recaptures moving distances of 0.31 miles per night. Schnell *et al.* (1997-2003) annually determined the average nightly movements of the ABB to be 0.62 miles (1.0 km), using marked individuals over a nine-year period at Camp Gruber. The smallest average nightly movement for any given active season over that same period was 0.52 miles (0.84 km). Schnell *et al.* (1997-2006) reported a one-day movement of 2.6 miles (4.25 km); previously the greatest distance moved was 1.78 miles (239 km, Creighton and Schnell 1998). While this data could be interpreted to imply that an ABB could move 95 miles [153 km, 0.62 (mean nightly movement) times 154 days (May 20 – September 20)] during the active season, the Service does not believe this is an accurate interpretation. Mark and recapture studies at Camp Gruber and Fort Chaffee have yet to find any ABBs that have moved between these installations, a distance of about 54 miles (87 km, Schnell *et al.* 1997-2003, and Schnell et al. 1997-2005). Even if ABBs moved such long distances, the Service assumes it is unlikely ABBs move in such a consistently linear direction.

Feeding

When not involved with brood rearing, carrion selection by adults for food sources can include an array of available carrion types and sizes (Trumbo 1992), as well as capture and consumption of live insects. *Nicrophorus* species are capable of finding a carcass between one and 48 hours after death at a distance up to 2 miles (3.22 km, Ratcliffe 1996). Success in finding carrion depends upon many factors including availability of optimal habitats for small vertebrates (Lomolino and Creighton 1996), density of competing invertebrate and vertebrate scavengers, individual searching ability, reproductive condition, and temperature (Ratcliffe 1996). No significant difference was found in the ABBs preference for avian verses mammalian carcasses (Kozol *et al.* 1988). At Fort Chaffee, Holloway and Schnell (1997) found that ABB numbers were higher in areas with high densities of small mammals.

Reproduction

Reproductive activity commences in mid-May and is completed in mid-August in Oklahoma and Arkansas. In Nebraska, breeding has been recorded as beginning on June 4, and completed in a minimum of 60 days. Parental care in this genus is elaborate and unique because both parents participate in the rearing of young (Bartlett 1987, Fetherston *et al.* 1990, Scott 1990, and Trumbo 1990), with care by at least one parent, usually the female, being critical for larval survival (Ratcliffe 1996). This is a rare and highly developed behavior in insects, previously known only among bees, ants, wasps, termites, and a few scarab beetle species. In Nebraska, Bedick et al (1999) found that ABBs are univoltine. However, in a laboratory setting, Lomonlino and Creighton (1996) found that five of eight ABB pairs succeeded in producing a second brood.

Immediately upon emergence from their inactive period, ABBs begin searching for a proper carcass for reproduction. American burying beetles are able to locate carcasses using chemoreceptors on their antennae. Once a carcass has been found, interspecific as well as intraspecific competition occurs until usually only a single dominant male and female burying beetle remain (Scott and Traniello 1989). Bedick *et al.* (1999) commonly found *Nicrophorus* species with multiple appendages missing, a likely indicator of fighting. Kozol (1991) reported that the ABB typically out-competes other *Nicrophorus* species because of its larger size. However, they do not evaluate the competition between the ABB and *N. marginatus*, which is diurnal (Bedick *et al.* 1999).

Male and female ABBs typically cooperatively bury a carcass, but individuals of either sex are capable of burying a carcass alone (Kozol *et al.* 1988). Once underground, both parents shave off the fur or feathers, roll the carcass into a ball, and treat it with anal and oral secretions that retard the growth of mold and bacteria. The female lays eggs in the soil near the carcass. Brood sizes for ABBs can sometimes exceed 35 larvae, but 12-18 is more typical (Kozol 1990a). Altricial, lightly sclerotized larvae hatch in about 12-14 days and the parents move the altricial, first instar larvae to the carcass. The developing larvae solicit feeding by stroking the mandibles of the parents. Both male and female parents regurgitated meat to the larvae. The larvae are soon capable of feeding directly from the carcass. In about 10-14 days large, third instar larvae burrow a short distance from the now-diminished carcass and form pupation cells. One or both of the parents may remain with the pupae for several days and at least one parent, usually the female, may remain with the pupae until they pupate (Kozol 1991). Therefore, for approximately 22-28 days, adult ABBs are present with their brood. New adults eclose in about 26-51 days. The reproductive process from carcass burial to eclosure is about 48 to 79 days (Ratcliffe 1996, Kozol 1991, Bedick *et al.* 1999). Females are reproductively capable immediately upon eclosure. The young of the year overwinter as adults, comprising the breeding population the following summer (Kozol 1990b).

While the ABB has life history requirements similar to other carrion beetles, it is the largest *Nicrophorus* in North America and requires a larger carrion item to realize its maximum reproductive potential (*i.e.*, to raise a maximum number of offspring) than the other *Nicrophorus* (Service 1991, Kozol *et al.* 1988, Trumbo 1992). Preferred carrion sources are dead birds and mammals weighing from 1.7-10.5 oz (48.19 – 297.67 g), with an optimum weight of 3.5-7.0 oz (99.22 – 198.45 g, Service 1991). Other *Nicrophorus* species are able to utilize much smaller carrion, ranging from 0.11 - 0.18 oz (3-5 g, Trumbo 1992). Kozol *et al.* (1988) found that to maximize fecundity a carcass of 3.53 – 7.05 oz (100-200 g) was preferred by ABBs. Kozol *et al.* (1988) found on Block Island, that *N. orbicollis* primarily buried carcasses ranging from 0.71 – 0.88 oz (20-25 g), and *N.*

marginatus and ABBs buried carcasses ranging from 2.82 – 3.52 oz (80-100 g). However, the ABB was recorded as burying carcasses between 7.05 – 10.58 oz (200-300 g).

Kozol *et al.* (1988) demonstrated that there is a positive relationship between carcass weight (100-200 grams is ideal) and brood weight. In addition, they found a significant positive correlation between the number of tenerals eclosed and carcass weight. Trumbo and Wilson (1993) found this true for other *Nicrophorus* as well. Lomonlino and Creighton (1996) found no relationship between carcass size and number of young raised in ABBs, but they speculated this may have been due to poor egg or larva survivorship in some broods. No significant correlation was found between carcass weight and mean weight of tenerals or mean pronotal width of tenerals (Kozol *et al.* 1988). The significant correlation between the number of adult's eclosed per brood and their average weight suggest that ABB individuals rearing broods may make a tradeoff between a large number of small offspring or a small number of large offspring. The outcome of this tradeoff may depend on carcass size, prior reproductive history of the parents, and possibly a prediction of future reproductive opportunities for the offspring.

E. Population Dynamics

Most standard techniques used to estimate population size assume that marked and unmarked individuals are equally likely to be captured, and that a substantial number of the animals remain in the trappable population from one trapping period to the next. The high turnover of trappable individuals observed in ABBs strongly suggest that the latter portion of this overall assumption is not valid for ABBs, and that conventional methods of estimating population numbers may not be applicable. This may be less of a problem for the insular population on Block Island, Rhode Island where, because of the relatively small size of the island [6,459 miles (2,614 ha)], a significant proportion of the population can be monitored. Elsewhere, however, accurate estimates of absolute or even relative densities remain a challenge.

Populations

It is likely that ABBs from Camp Gruber and Fort Chaffee are components of functionally the same biological population, given the distance between the two sites [53 miles (85 km)], and the distances ABBs were observed moving [up to 6.2 miles (10 km) over a 6-night period], (Service 1991).

F. Reasons for Listing/Threats to Survival

Data show that species in the family Silphidae are generally widely distributed and occur in many habitat types (Peck and Kaulbars 1987). Even though ABBs are considered feeding habitat generalists, they still have disappeared from over 90 percent of their historic range. The Recovery Plan identifies the following issues as potential threats to the ABB: disease/pathogens, DDT, direct habitat loss and alteration, interspecific competition, increase in competition for prey, increase in edge habitat, decrease in abundance of prey, loss of genetic diversity in isolated populations, and agricultural and grazing practices. None of these theories alone adequately explain why the ABB declined while congeneric species are still relatively common rangewide [there are eight sympatric congeners, which are not in peril (Sikes and Raithel 2002)]. There is little doubt that habitat loss and alteration affect this species at local or even regional levels, and could account for the extirpation of populations once they become isolated from others (Kozol 1995, Ratcliffe 1996, Amaral *et al.* 1997, Bedick *et al.* 1999). The prevailing theory regarding the ABBs' decline is habitat fragmentation (Service 1991) which reduced the carrion prey base and increased the vertebrate scavenger competition for this prey (Kozol 1995, Ratcliffe 1996, Amaral *et al.* 1997, Bedick *et al.* 1999).

Habitat is the place in which an organism lives, characterized by its physical features or by the dominant plant types (Oxford Dictionary of Biology 2000). Fragmentation is the breakup of extensive habitats into small, isolated patches that are too limited to maintain their species' stocks into the indefinite future and reduction of the total amount of habitat available (MacArthur and Wilson 1967, Williamson 1981). There is not a size limitation of disturbed area, which would constitute fragmentation. The limiting factor of fragmentation is not only the loss of habitat but also the inability to move between undisturbed areas, the quality of the disturbed area species move around in and through, the spatial structure of the undisturbed habitat and disturbed areas, and the ratio of edge habitat created from fragmentation to the amount of contiguous undisturbed area. Fragmentation of natural habitat that historically supported high densities of indigenous (native) species (made more severe by direct taking, ca. 1900, of birds and other vertebrates) may have been a contributing factor in the decline of ABBs.

Initial fragmentation may have minimal affects on vegetation, and species composition and abundance patterns. However, as gaps increase in size and quantity, these gaps become the dominant habitat type in a landscape. Ecosystem functions are more likely to be disrupted at finer scales of fragmentation, although the organisms affected are smaller and the overall process is less noticeable to human observers. Probably some of the strongest effects of fragmentation on ecological processes will turn out to involve the invertebrate community (Didham *et al.* 1996). Invertebrates are critically important in decomposition, nutrient cycling, disturbance regimes, and other natural processes in ecosystems, and they appear to be quite sensitive to disruption of microclimate and other effects of fragmentation. Increased use of land for urbanization and commercial agriculture and forestry has had a demonstrative negative impact on numerous insect species (Pyle *et al.* 1981). Pipelines, roads, well pads, utility corridors, *etc.* are all actions that result in fragmentation of habitat type, creating edge habitat.

Direct Habitat Loss and Alteration

Anderson (1982) attributed the decline of *N. americanus* to the coincident pattern of deforestation in North America resulting in habitat loss and fragmentation. He based this conclusion on the assumption that *N. americanus* is similar in habitat requirements to *N. germanicus* of Europe and *N. concolor* of Japan and China. Each of these species is the largest member of their guild and requires relatively large carcasses [1.76 to 10.58 oz (50 to 300 g) Kozol *et al.* 1988]. Anderson (1982) held that the dependence on larger carcasses for breeding restricts these species to mature forest with open understories and deep, loose soils.

Creighton *et al.* (2007) reported similar findings in the Tiak District of the Ouachita National Forest in southeastern Oklahoma. The habitat is dominated by mature oak-pine forest with moderate undergrowth and sandy soil. They found a significant decline in the densities of ABBs in seed tree timber harvested areas. In addition, *N. orbicollis* and *N. tomentosus* were affected negatively by timber harvesting. Bedick *et al.* (1999) also found few ABBs in disturbed and fragmented habitats. Lomolino and Creighton (1996) evaluated habitat parameters at a regional and local level. At a local scale, the Tiak Ranger District, *Nicrophorus* exhibited highly significant avoidance of clearcuts. It is important to recognize that although a feeding generalist, ABBs avoided utilizing clear cuts even for feeding. At a regional level, encompassing east-central and southeastern Oklahoma, all *Nicrophorus* species exhibited significant habitat selectivity (i.e. their niche breadths were significantly less than the maximum value of 1.0), and ABBs were found in sites characterized with moderate to well-developed forest with moderate to deep soils and an understory with moderate cover of small shrubs. The ABB exhibited the most restrictive niche breadth, at 0.53, whereas *N. tomentosus* and *N. orbicollis* were 0.80 and 0.84. The local and regional studies evaluated different habitat types. The local study evaluated mature forest, second-growth forest, and clear-cut; whereas the regional studies evaluated forest development, soil depth, and understory woody cover. Also during this study, reproductive success was found to be higher in forest verses grasslands. Again as stated above Kozol *et al.* (1988) reported that *N. americanus* is broadly distributed across available habitats on Block Island, Rhode Island (shrub thickets to grazed fields). The apparent generalist nature of *N. americanus* on Block Island, however, may be an artifact of this insular environment (Crowell 1983).

Conversely, studies by Creighton *et al.* (1993) suggested that ABBs in Oklahoma occur in both upland forests and grassland, and they tend to avoid bottomland forests, but preference was shown for upland forest over grasslands. Holloway and Schnell (1997) found significant correlations between the numbers of ABBs caught in traps and the biomass of mammals and birds, irrespective of the predominant vegetation.

Dispersal is more likely to maintain metapopulations in naturally patchy landscapes than in formerly continuous landscapes fragmented by human activity (den Boer 1970). Natural patchy landscapes have less contrast between adjacent patches, whereas anthropogenic fragmentation creates intense, sudden contrast between patches. This edge habitat is a zone where the light, wind, microclimate, and moisture are altered. The affects from these changes extend into different forest types at distances of 450, 656 to 1,640 feet. Climate edge effects may explain why dung and carrion beetle communities in 2.5 and 25-acre forest fragments in Brazil contain fewer species, sparser populations, and smaller beetles than do comparable areas within intact forest (Klein 1989). The drier conditions in small fragments, which are largely edge habitat, may lead to increased fatal desiccation of beetle larvae in the soil.

There is evidence to support a direct correlation between edge, or fragment size, and vertebrate scavenger pressure, with much of this work involving nesting bird populations (Paton 1994; Yahner and Mahan 1996; Suarez *et al.* 1997). Trumbo and Bloch (2000) found that *Nicrophorus* species had significantly greater success in larger woodland plots and attributed this in part to lower vertebrate scavenger success in those areas. Sikes (1996), working with *N. nigrita*, found that most transects laid more than 328 feet from a trail or road had 10 percent or fewer carcasses taken by vertebrates, whereas transects near trails or roads had an average of 85 percent of the carcasses taken by vertebrate scavengers. Schnell *et al.* (1997-2005) found higher numbers and abundances of ABBs within Fort Chaffe and Camp Gruber boundaries than outside.

Although some mobile species can integrate into a number of habitat patches this does not appear to be the case with the ABB. Schnell *et al.* (1997-2006) found that ABBs avoided clear-cut areas in southeast Oklahoma. Such fragmentation is comparable to pipelines, roads, well pads, utility corridors, commercial and residential development and quarries. The effect of competition, which should be strongly linked to habitat conditions, is likely to be a scale-dependent phenomenon. Tillman *et al.* (1994) suggest that even moderate levels of habitat destruction and fragmentation can 'cause time delayed, but deterministic extinction' of 'dominant competitors in remnant patches'.

The eclectic occurrences and extinction vulnerability of ABBs is likely due to the species having specialized habitat or resource requirements and carrion being a finite resource widely scattered in space and time (Karr 1982, Pimm *et al.*, 1988, Peck and Kaulbars 1987). Data available for the ABB on Block Island supports the contention that the primary mechanism for the species' rangewide declines lies in its dependence on carrion of a larger size class relative to that utilized by all other North American *Nicrophorus* species, and that the optimum-sized carrion resource base has been reduced throughout the species' range over time (Service 1991). Further, when resources fluctuate seasonally or annually, species dependent on those resources fluctuate. This population variability predisposes species to extinction. The higher level of fluctuation the greater the chance of extinction. Habitat fragmentation affects these types of species by reducing the number of sites that contain critical resources, and by isolating suitable sites and making them harder to find.

Since the middle of the 19th century, certain faunal species in the favored weight range for ABBs have either been eliminated from North America or significantly reduced over their historic range (Service 1991), including the passenger pigeon *Ectopistes migratorius,* greater prairie chicken *Tympanchus cupido* and wild turkey *Meleagris gallopavo*. The passenger pigeon was estimated at one time to have been the most common bird in the world, numbering 3 to 5 billion (Ellsworth and McComb 2003). There were once as many passenger pigeons within the approximate historic range of the ABB as there are numbers of birds of all species overwintering in the U.S. today. Wild turkeys, for example, occurred throughout the range of the ABB, and until recently, were extirpated from much of their former range. Black-tailed prairie dogs *Cynomys* *ludovicianus*, which occur in the northern portion of the ABB's range, have drastically declined (Miller *et al.* 1990), and such dense populations of mammals may have supported ABBs.

Simultaneously, the removal of top-level carnivores such as the grey wolf *Canis lupis* and eastern cougar *Puma concolor*, as well as land use changes that fragmented native forest and grasslands, creating more edge habitats, resulted in meso-carnivores becoming abundant. These mid-sized carnivores prey on small mammals and birds and directly compete with beetles by scavenging for carrion. Fragmentation of habitats may increase species richness, but the species composition results in the decrease of indigenous species and changes to species that thrive in areas disturbed by humans such as: American crow *Corvus brachyrhynchos*, raccoon *Procyon lotor*, red fox *Vulpus fulva*, opossum *Didelphis virginiana*, striped skunk *Mephitis mephitis*, rats *Neotoma spp.* and *Sigmodon spp.*, squirrels *Sciuridae spp.*, coyotes *Canis latrans,* feral cats, and other opportunistic predators (Wilcove *et al.* 1986). In this way, historically large expanses of natural habitat that once supported high densities of indigenous species are now habitat fragments that not only support fewer or lower densities of indigenous species that supported ABB populations, but also facilitated increased competition for limited carrion resources among the "new" predator/scavenger community. A number of these species, especially the raccoon and striped skunk, have undergone dramatic population increases over the last century (Garrott *et al.* 1993), and the coyote and opossum have expanded their range. These scavengers may extend hundreds of feet from edges into forest in eastern North America. Matthews (1995) experimentally placed 64 carcasses in various habitats in Oklahoma where ABBs and *N. orbicollis* had been previously documented, then tracked the organisms that scavenged them. Of the carcasses 83 percent were claimed by ants, flies, and vertebrate scavengers; about 11percent were claimed by *N. orbicollis*, and only one was claimed by ABBs.

Although much of the evidence suggesting the reduction of carrion resources as a primary mechanism of decline is circumstantial, this hypothesis fits the temporal and geographical pattern of the disappearance of ABBs, and is sufficient to explain why ABBs declined while congeneric species did not. ABBs are the largest species of *Nicrophorus* in the New World and require carcasses of 3.5 to 7.0 ounces (99.22 to 198.45 g, Kozol *et al.* 1988) to maximize fecundity, whereas all other *Nicrophorus* species can breed abundantly on much smaller carcasses, with the smaller species using carcasses of 0.11 to 0.18 ounces (3.12 to 5.10 g, Trumbo 1992). In a fragmented ecosystem, larger species have been shown to be negatively affected before smaller species, a phenomenon which has been well documented with carrion and dung beetles in South America (Klein 1989).

Wide-ranging animals, like the ABB, are typically among the species most threatened by habitat fragmentation, in part because small areas fail to provide enough prey, but also because these animals are more likely to be killed by humans or their vehicles (Karr 1982, Pimm *et al.* 1988, Mladenoff *et al.* 1994, Noss *et al.* 1996). Large mobile species that roam over large areas daily must attempt to move through the fragmented habitat. Moving relatively long distances among different habitat types increases the ABB's chance of encountering appropriate-sized carcasses, but also increases the potential for encountering natural and unnatural mortality, such as predation, insecticides, insect traps (*i.e.* bug zappers), and nocturnal light pollution (Mladenoff *et al.* 1994, Noss *et al.* 1996). The probability of individual ABBs being subjected to these types of hazards also increases as areas become more developed (Lomolino and Creighton 1996). A study in southeastern Ontario and Quebec found that several species of small mammals rarely ventured onto road surfaces when the road exceeded 65 feet (19.8 m, Oxley *et al.* 1974). Studies elsewhere report similar findings. These studies reveal potential indirect affects to the ABB by limiting its food and reproductive resources. These findings may explain, in part, why the highest densities of ABBs are in relatively large military installations with little agricultural, commercial or residential development.

Bedick *et al.* (1999) found in Nebraska and South Dakota that ABBs were observed in areas with low human population densities, minimal nighttime artificial lights, and are primarily used for grazing of beef cattle and some agriculture. In Kansas, much of the area occupied by the ABB is privately owned native grass pasture and scattered woodlands of blackjack oak *Quercus marilandica* (Miller and MacDonald 1997). In Texas, the ABB has only been found on Camp Maxey and The Nature Conservancy's Lennox Woods in Red River County.

Species Size

For most guilds, larger species tend to feed on larger prey, occupy a greater diversity of habitats, dominate in interference competition, and maintain larger homeranges, but may suffer from exploitative competition from smaller species (Ashmole 1968, Gittleman 1985, Hespenheide 1971, Rosenzweig 1968, Schoener and Gorman 1968, Werner 1974, Wilson 1975, and Zaret 1980). Because larger prey is less abundant than smaller prey (Peters 1983, Brown and Maurer 1987, Damuth 1991, and Lawton 1990), larger guild members require larger home ranges. In addition, larger carcasses are harder to bury than smaller ones (Creighton *et al.* 2007). While large size alone does not necessarily confer endangerment, within trophic or guilds rarity and extinctions tend to be higher for the larger species (Diamond 1984; Martin and Klein 1984; Vrba 1984; Owen-Smith 1988; and Stevens 1992). At less than 2 grams, the ABB is the largest member of a guild that specializes on rare and unpredictable resources, vertebrate carcasses. In contrast to other guild members, the ABB must range over a larger area and a greater diversity of habitats to find suitable carcasses.

Trumbo and Thomas (1998) investigated *Nicrophorus* species composition on several small islands in New England (lacking ABBs) and found that smaller islands were not able to support viable populations of large-bodied *Nicrophorus* species. They suggested that larger species required more carrion resources and were therefore more prone to local extinctions. The extant population of ABBs on Block Island seems to be relatively free of competitive pressures; not only are there unusually large populations of ground-nesting birds, but there are few mammal predators or scavengers and supplemental carrion provisioning is provided annually (Amaral *et al.* 1997). This hypothesis is among those most well supported by the available evidence. However, more studies on response of silphid communities to habitat fragmentation are needed, especially those that will contrast historic and current habitats, or compare multiple extant sites of ABBs.

Disease/Pathogens

The ABB disappeared from its core range and persists only on the very periphery of its historic range. A pathogen hypothesis readily accounts for such a geographic pattern of decline. Any pathogen that could be transmitted among adult burying beetles, and was non-fatal to congeners of ABBs, will eliminate all contiguous ABB populations, leaving only peripheral isolates untouched. In addition, symbiotic mites and nematodes of the ABB could also contribute to the spread of disease. Service (1991) suggested this hypothesis but pointed out that no evidence of a disease or pathogen has been found. However, no known rigid investigation has been conducted to test this hypothesis. Peck and Anderson (1985) determined that ABBs are phenotypical and presumably evolutionary distant from other *Nicrophorus* species in North America. Therefore, ABBs could be physiologically unique and vulnerable to a pathogen to which its congeners are immune. Channel and Lomolino (2000) investigated the geographic pattern of decline in 245 endangered species. Their analysis showed that the remaining populations of many endangered species (98 percent of their sample), including birds, mammals, fish, mollusks, arthropods, and plants, are in the peripheries of their former range. Therefore, while this hypothesis cannot be eliminated as a possible reason of decline, such consistent spatial remnant populations of endangered species indicate that other factors are likely the contributors to such declines.

DDT/Pesticide Use

Hoffman *et al.* (1949) showed, in a controlled study, that DDT spraying eliminated populations of three *Nicrophorus* species (*N. orbicollis*, *N. sayi*, and *N. defodiens*). Kozol (1995) and the Service (1991) concluded that given the apparent timing and pattern of decline exhibited by ABBs, particularly in the Northeast, DDT could not have been responsible for most extirpations, since populations were largely gone a full 25 years before organochlorine compounds were broadly applied as pesticides. In addition, some populations persisted following DDT spraying in Oklahoma, Nebraska, and Missouri, while other unsprayed areas within the ABB's historical range no longer support the species. In the Midwest however, several ABB populations disappeared during or right after the general period from 1940 to 1972, when DDT was actively applied as a pesticide. Although this hypothesis is rejected as the primary explanation, some ABBs may have been extirpated by DDT use.

Intraspecific and Interspecific Competition

Intrasexual competition occurs until usually only one male and female remain. Size appears to be the most important determinant of success in competition for securing carrion; the largest individuals displace smaller *Nicrophorus* (Kozol *et al.* 1988). Even after burial of a carcass, ABBs have been recorded as commandeering a carcass buried by another *Nicrophorus* species. However, factors other than size might affect the outcome of competition (i.e. temperature or activity patterns). Trumbo (1992) showed that the potential for *Nicrophorus* congener competition for carrion increased with carcass size and Scott *et al.* (1987) found the same results with carrion-feeding flies. Congener competition extends from the increase in vertebrate scavenger pressure, exacerbated by habitat fragmentation, and a decrease in carrion of the ideal weight size. Due to extinction and population declines, the competition between ABBs and sympatric congeners for sub-optimally sized carcasses will be expected to increase.

The ABB's most similar congener is *N. orbicollis*, based on historical geographic range, presumably the ecological tolerances (diel periodicity, breeding season, etc.), and phylogenetic information indicating these species may be each other's closest surviving relatives (Szalanski *et al.* 2000). Being so similar, they likely are each other's greatest congeneric competitors (Sikes and Raithel 2002). Interspecific competition may affect populations at the local level. Typically, surveys for ABBs result in 10 or more times more *N. orbicollis* than ABBs (Lomolino and Creighton 1996, Amaral *et al.* 1997, Carlton and Rothwein 1998). Kozol (1989) demonstrated that *N. orbicollis* was about eight times more abundant than ABBs on Block Island, Rhode Island while Walker (1957) collected 19 times more *N. orbicollis* (175) than ABBs (9) in the single trapping array where the latter species was encountered in Tennessee. While the ABB is more successful than *N. orbicollis* in utilizing carcasses greater than 100 g, these data suggest that this congeneric species may pose formidable competitors for the ABB (Sikes and Raithel 2002) and may have actually increased (been "released") in those areas where ABBs disappeared (Service 1991). In addition, *N. marginatus* may be a formidable competitor to ABBs. *N. marginatus* is on average slightly larger and utilizes larger carcasses than *N. orbicollis* and in Nebraska and South Dakota is typically more abundant (Backlund and Marrone 1997 and Bedick *et al.* 1999). Another, threat to ABB reproductive success is the oviposition by other *Nicrophorus* species near an ABB buried carcass, allowing brood parasitism (Müller *et al.* 1998, Trumbo 1994). Trumbo (1992) found that mixed *Nicrophorus* broods were more common on larger carcasses.

The imported fire ant *Solenopsis invicta* has become a formidable competitor for carrion and a potential source of mortality for Nicrophorus beetles when they co-occur at a food source (Warriner 2004, Godwin and Minich 2005). Scott *et al.* (1987) concluded that the inability of *N. carolinus* to successfully bury carrion provided experimentally in Florida was due to interference by imported fire ants. Only 5 of 48 carcasses were successfully exploited by *N. carolinus*, despite pitfall trapping that demonstrated that *N. carolinus* was locally abundant. Collins and Scheffrahn (2005) noted that fire ants may reduce ground-nesting populations of rodents and birds, and in some instances, may completely eliminate ground-nesting species from a given area. Fire ant infestations are not evenly distributed; rather, they tend to be more numerous in open, disturbed habitats (Carlton pers. comm. 1996). Fire ants now infest all or parts of Alabama, Arkansas, California, Florida, Georgia, Louisiana, Mississippi, New Mexico, North Carolina, Oklahoma, Puerto Rico, South Carolina, Tennessee, and Texas (USDA 2003).

Loss of Genetic Diversity in Isolated Populations

Kozol *et al.* (1994) examined ABB genetic variation within and between the Block Island and the eastern Oklahoma and western Arkansas population. Both populations have low levels of genetic variation, and most of the variation occurs within a single population. There were no unique diagnostic bands within either population, but they found the OK/AR population to be somewhat more diverse. This reduced genetic variation is often a result of founder effect, genetic drift, and inbreeding. They suggest that multiple bottleneck events, small population size, and high levels of inbreeding may be factors contributing to the pattern of diversity in ABBs.

Szalanski *et al.* (2000) expanded on Kozol *et al.*'s study and examined ABBs from five populations: Block Island, Arkansas, South Dakota, Oklahoma, and Nebraska. The authors found little evidence that the five populations have maintained unique genetic variation and no evidence to suggest that these five populations should be treated as separate, genetically independent conservation segments.

G. Recovery Efforts

Reintroduction

Establishing new populations with introductions may be made more difficult because of the dilution effects of dispersal. For example, individuals released at a site may move out of the area, making it difficult to establish a stable population. The probability of successful reintroductions of ABBs can be enhanced by sequestering released pairs of adults on carrion (Amaral *et al.* 1997). Furthermore, dispersal of teneral adults (progeny of released animals) can be lowered by providing carrion at or near the release site at the time when new adults are likely to emerge (48-65 days after carcass burial; Kozol *et al.* 1988).

The first reintroduction of the American burying beetle occurred on Penikese Island, Massachusetts from 1990- 1993 using captive-raised and wild beetles translocated from Block Island. However, this population became extirpated 9 years after the last release of ABBs (Amaral and Mostello 2007). A second long-term reintroduction effort on Nantucket Island, Massachusetts, is still being evaluated. In Ohio, a multi-year reintroduction effort has been implemented. However, to date no ABBs have been captured in post-release years. Reintroduction efforts have yet to demonstrate that an extirpated population can become successfully re-established.

H. Analysis of the species/critical habitat likely to be affected

The ABB may potentially be affected by the implementation of this school and associated facilities. Various types of disturbance associated with typical construction activities can result in impacts to the ABB. No critical habitat has been designated for the ABB; therefore, none will be affected.

III. Environmental Baseline

The environmental baseline is an analysis of the effects of all federal, state, or private past and present actions, as well as all natural actions leading to the current status of the species, its habitat, and ecosystem, within the project area. The environmental baseline is a "snapshot" of the status of the ABB at the time this document was prepared.

A. Status of the species within the action area

The ABB has been documented in the Mayes County since 2009. Two surveys, one within approximately 11 miles of the project area, had positive identifications of ABBs in July 2009. Further, suitable habitat exists throughout this general area.

B. Factors affecting species environment within the action area

Adequately evaluating the effects of this proposed project on the ABB requires that the Service not only consider the impacts from the proposed activities, but must also consider other, separate effects currently ongoing and likely to occur in the foreseeable future that also could have adverse impacts to the ABB within the action area.

1. Consultation

During fiscal years 2006, 2007, 2008, and 2009 (October 1 to September 30), the Service consulted on approximately 203, 215, 306, and 171 proposed actions, respectively, potentially affecting the ABB in Oklahoma. The decrease in the number of consultations from 2008 to 2009 is likely the result of the OFO modifying and streamlining our consultation procedures rather than an actual decrease in federal projects. Project types evaluated included pipelines, roads, quarries, communication towers, residential housing development, bridges, mining, petroleum production, commercial development, recreational development, transmission lines, and water and wastewater treatment facilities. Impacts from these activities varied in size and duration, with projects such as quarries being hundreds of acres and having permanent impacts, to water treatment facilities of a few acres with both permanent and temporary impacts.

There are currently four biological opinions with incidental take statements issued and still in effect. One biological opinion authorizes the take of 76 acres within the ABB's range in Osage County for the construction of a botanical preserve. The second biological opinion authorizes take of 35 ABBs per year throughout the Camp Gruber. The third is a programmatic biological opinion for the Federal Highway Administration within the ABB's range in Oklahoma authorizing take of 5,998.98 acres of ABB habitat. The fourth biological opinion is with the Ouachita National Forest authorizing take of 12,191 acres of ABB habitat within Oklahoma and Arkansas.

2. Scientific research

Currently, 25 entities or individuals possess section 10 permits for the ABB in Oklahoma. Eighteen are section 10(a)(1)(A) scientific research permits to enhance the survival of the species and one is an incidental take permit issued in conjunction with a Habitat Conservation Plan (HCP). Although 25 permits are enhancement of survival permits, some authorized take of ABBs can occur. The permitted research must further conservation efforts for the species, but the loss of some individual ABBs over the short-term from research is allowed as long as the survival of the ABB is not jeopardized. The Service requires that every available precaution be implemented to reduce and/or eliminate authorized take associated with research activities.

In addition, the Service may recommend that ABBs be trapped and relocated in certain instances to avoid or minimize take. While these activities can have adverse impacts, the existing recovery permits allow for take. The extent of take is usually unknown prior to implementation of this type of activity. However, all accidental deaths are required to be reported to the Service. Between 1997 to 2008, annual ABB incidental deaths in Oklahoma ranged from approximately 5 to 29 individuals.

The Weyerhaeuser HCP is valid for 35 years and does not estimate a number of ABBs that could potentially be taken. The HCP stipulates the following as foreseeable activities implemented by Weyerhaeuser over 35 years: 28,000 acres (average of 800 acres per year) of forest will potentially be harvested; 16 ponds constructed; ten or fewer food plots planted; EPA approved application of pesticides for control of pales weevil damage to planted pine seedlings; ROW vegetation control; two miles of road construction; 20 acres of mineral, oil, or gas exploration; and no more than 600 acres of cattle grazing. Take, in the form of acres, has not been exceeded to our knowledge. From 1997 to 2000 about 10,710 acres of Weyerhaeuser lands were surveyed for the ABB annually and from 2001 to 2003 about 14,382 acres were surveyed. From 1997 to 2005 the following numbers of ABBs were captured: 106, 64, 26, 41, 16, 25, 85, 0, and 0, respectively.

IV. Effects of the Action

Factors to be considered

The ABB spends anywhere from 26 to 51 days in the soil during the breeding season and approximately 7 to 8 months in the soil during their inactive period, so all phases (construction, operation, and maintenance) of the school building could potentially expose the ABB to adverse effects and potential take through soil disturbance.

Construction of the Early Learning Center will affect a total of 7.5 acres.

The operational footprint of the project will occupy approximately all of the 7.5 acres. This habitat will be permanently lost to wildlife and will contribute to edge habitat. This, as described above, is a detriment to ABBs.

A. Analysis for effects of the action

Direct effects

Potential impacts to ABB from the school construction are clearing, grading, ROW restoration, soil compaction, vegetation alteration, habitat fragmentation and loss, temporary soil displacement, erosion, soil contamination from spills and leaks, and rutting. Vegetation clearing, grading, and vehicle and equipment traffic could result in the direct killing of ABB adults, larvae, and eggs by crushing and exposure to adverse conditions if displaced during soil excavation. Direct mortality to eggs and larvae could occur via adults abandoning active broods in occupied habitat because of disturbance, habitat degradation, and/or fragmentation. Reduced foraging success due to habitat degradation and/or fragmentation, which can lead to an increase in vertebrate competition for carrion can also result in the direct mortality through starvation.

Indirect effects

Indirect effects are those project related effects, which are reasonably certain to occur, but later in time.

The potential indirect impacts to ABB from the school construction, operation, and maintenance are clearing, grading, restoration, soil compaction, erosion, contamination from spills and leaks, rutting, ROW maintenance, and vegetation maintenance. All of these actions can result in the displacement or avoidance of ABBs from suitable habitat within the project area from the construction period through the lifetime of the school.

Clearing, grading, and vegetation maintenance will result in long-term (20 -50 years) and permanent loss, fragmentation, and/or alteration of suitable ABB habitat. Anticipated ABB response to the proposed construction, operation, and maintenance activities may include harm, harassment, and eventual mortality through abandonment of the occupied habitat, limitation or reduction in available carrion for feeding and reproduction, and increased competition for carrion. Such responses can result in reduced foraging success, reduced fecundity and/or reduced overwintering survival.

Beneficial effects

The Service has identified priority ABB habitat conservation areas in Oklahoma based on known ABB concentrations and proximity of these concentrations to large tracts of land held in perpetuity for natural resource conservation purposes. The Oklahoma Chapter of TNC has established an ABB Conservation Fund in cooperation with the Service. This fund is to be used exclusively for the purchase of ABB habitat in the identified priority areas and for conducting priority research associated with the recovery of ABB.

The DoEd will make a onetime donation of $3,500 to the ABB Fund for the purchase of ABB habitat to be protected and managed in perpetuity and/or for conducting research. This conservation measure will provide overall long-term benefits for the ABB in terms of habitat replacement or research that will lead to improved conservation of the ABB.

V. Cumulative Effects

Cumulative effects include the effects of future State, tribal, local or private actions that are reasonably certain to occur within the action area considered in this BO. Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

There are no known nonfederal actions at this time or within the foreseeable future. However, since the last census in 2000, the population has grown 5.6 percent. This increase in population and potential continued increase in population could result in additional expansions or upgrades to utility systems and other infrastructure.

VI. Conclusion

After reviewing the current status of the ABB, the environmental baseline for the action area, the effects of the proposed Early Learning Center, and the cumulative effects, it is the Service's biological opinion that the action as proposed is not likely to jeopardize the continued existence of the ABB. No critical habitat, as defined in the ESA, has been designated for the ABB; therefore, none will be affected.

The Service finds that the proposed action is not likely to jeopardize the ABB for the following reasons:

1. The ABB occurs in several other areas within Oklahoma.
2. There are at least two self-sustaining populations or metapopulations of ABB in Oklahoma.
3. There are multiple populations or metapopulations of ABBs in at least six other states.
4. Capture rates at a representative portion of these other populations or metapopulations indicated stable levels of ABBs.
5. Five of these self-sustaining populations are under the ownership of the federal or state government or a natural resource conservation organization, thereby ensuring their protection.

The conclusions of this BO are based on full implementation of the project as described in the "Description of the Proposed Action" section of this document, including any Conservation Measures that were incorporated into the project design.

INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass is defined by the Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited under the ESA, provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are non-discretionary and must be undertaken by USDA, so that they become binding conditions for any action, grant, or permit issued to WFEC, as appropriate, for the exemption in section 7(o)(2) to apply. The USDA has a continuing duty to regulate the activity covered by this incidental take statement. If USDA (1) fails to assume and implement the terms and conditions or (2) fails to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, USDA must report the progress of the action and its impact on the species to the Service as specified in the Incidental Take Statement. [50 CFR §402.14(i)(3)].

Amount or Extent of Take Anticipated

The Service anticipates 7.5 acres will be taken as a result of this proposed action. The incidental take is expected to be in the form of killing, harming, and/or harassment.

The Service anticipates incidental take of ABBs will be difficult to detect for the following reasons: 1) the ABB has a small body size making it hard to locate, which makes encountering dead or injured individuals unlikely; 2) ABB losses may be masked by annual fluctuations in numbers and highly concentrated movements; and 3) ABBs spend a substantial portion of their lifespan underground.

However, the following level of take of this species can be anticipated by loss of acres of reproductive, foraging, and overwintering habitat. Because the ABB has been documented near the project area, all 7.5 acres are reasonably likely to provide foraging, reproductive, and/or overwintering habitat for the ABB based on habitat assessment results.

Effect of the take

In the accompanying biological opinion, the Service determined that the level of anticipated take is not likely to result in jeopardy to the ABB.

REASONABLE AND PRUDENT MEASURES

Pursuant to section 7(b)(4) of the ESA, the following non-discretionary reasonable and prudent measures are necessary and appropriate to minimize the amount of incidental take of the ABB.

1. Avoid using plants listed as invasive by the USDA or the state of Oklahoma to revegetate areas, so the loss of native habitats is minimized.

2. Minimize project footprint to reduce impacts to the ABB and habitat.
3. Monitor the level of disturbance to ensure compliance with the incidental take statement of this BO.
4. Monitor implementation of project description to ensure compliance with the BO.

TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the ESA, USDA must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outline the required reporting/monitoring requirements. These terms and conditions are non-discretionary and must also be a condition of any federal permits, contracts, or grants issued.

1. All plants listed on the USDA's and the state of Oklahoma's invasive species list shall not be planted.
2. Restore disturbed areas with native seeds/vegetation.
3. Provide a report to the Service's OFO annually and at the conclusion of the project. The report shall summarize the amount (acres) of forest habitat cleared prior to the project and summarize total acreage of the area disturbed by the project.
4. Provide documentation to the Service's OFO of contribution to the ABB Conservation Fund (*i.e.*, carbon copy of letter to The Nature Conservancy).

The Service believes that no more than 7.5 acres of ABB habitat will be incidentally taken because of the proposed action. The reasonable and prudent measures, with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. If, during the course of the action, this level of incidental take is exceeded, such incidental take represents new information, requiring reinitiation of consultation and review of the reasonable and prudent measures provided. The federal agency must immediately provide an explanation of the causes of the taking and review with the Service the need for possible modification of the reasonable and prudent measures.

Conservation Recommendations

Section 7(a)(1) of the ESA directs federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities designed to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information needed to conserve the species.

1 Conduct ABB related research at project site in coordination with the Service. This might include an analysis of small mammal and avian populations pre- and post-project.
2 Avoid use of chemicals, especially from mid-May to late September.

In order for the Service to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

Reinitiation Notice

This concludes formal consultation on the proposed development of the LGPSD's Early Learning Center outlined in the BA. As provided in 50 CFR § 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

The Service appreciates the cooperation extended by the DOEd, LGPSD, and CSS during this consultation. If further assistance or information is required, please contact Angela Burgess or me at the above address or telephone (918) 581-7458.

Sincerely,

Kenneth D. Frazier

for Dixie Bounds, Ph.D.
Field Supervisor

cc: Regional Director, FWS, Albuquerque, NM

AGB:rmh:2011-F-0018 Locust Grove Schools BO

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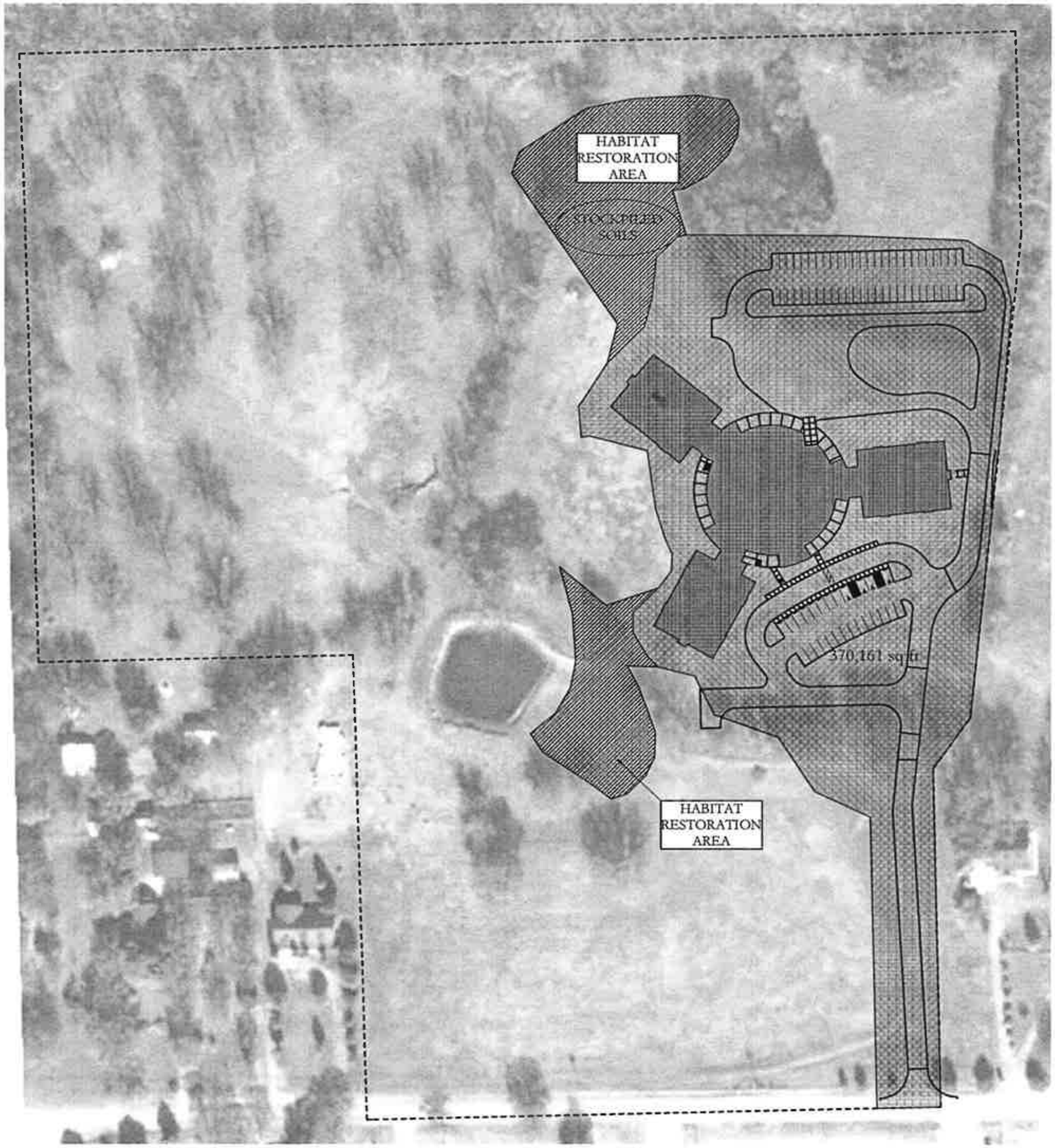
Appendix 1. Vicinity Aerial Map, Construction Boundary Plan, and Site Photo Map.

LGELC_VICINTY AERIAL

LOCUST GROVE EARLY LEARNING CENTER
BIOLOGICAL ASSESMENT, 11/3/2010

SHELLS Concrete Shell Structures
4943 NORTH 29TH EAST, STE A
IDAHO FALLS, IDAHO 83401
Phone: (208) 552-9874
Fax: (208) 552-9302



CONSTRUCTION BOUNDARY PLAN

LOCUST GROVE EARLY LEARNING CENTER
BIOLOGICAL ASSESMENT, 11/3/2010

CSHELLS Concrete Shell Structures
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SITE PHOTO MAP

LOCUST GROVE EARLY LEARNING CENTER
BIOLOGICAL ASSESMENT, 11/3/2010

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Appendix 2. Photographs of the proposed Early Learning Center construction.

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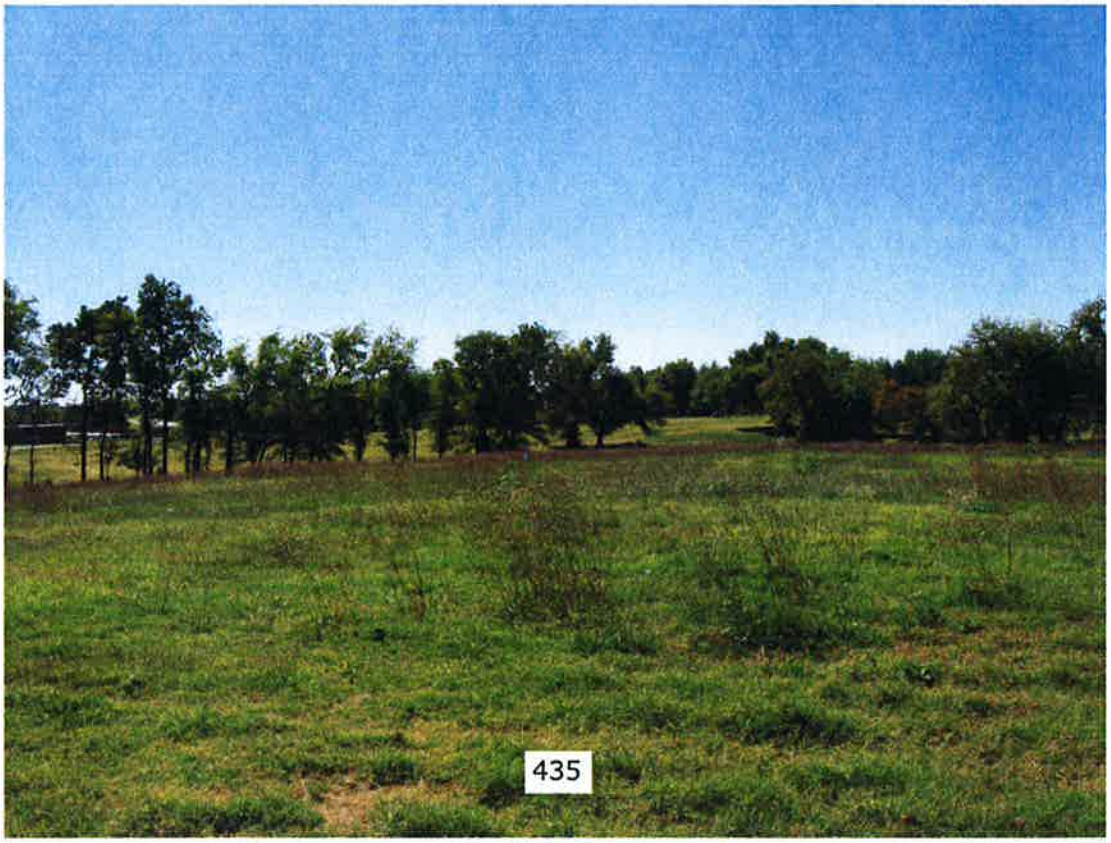

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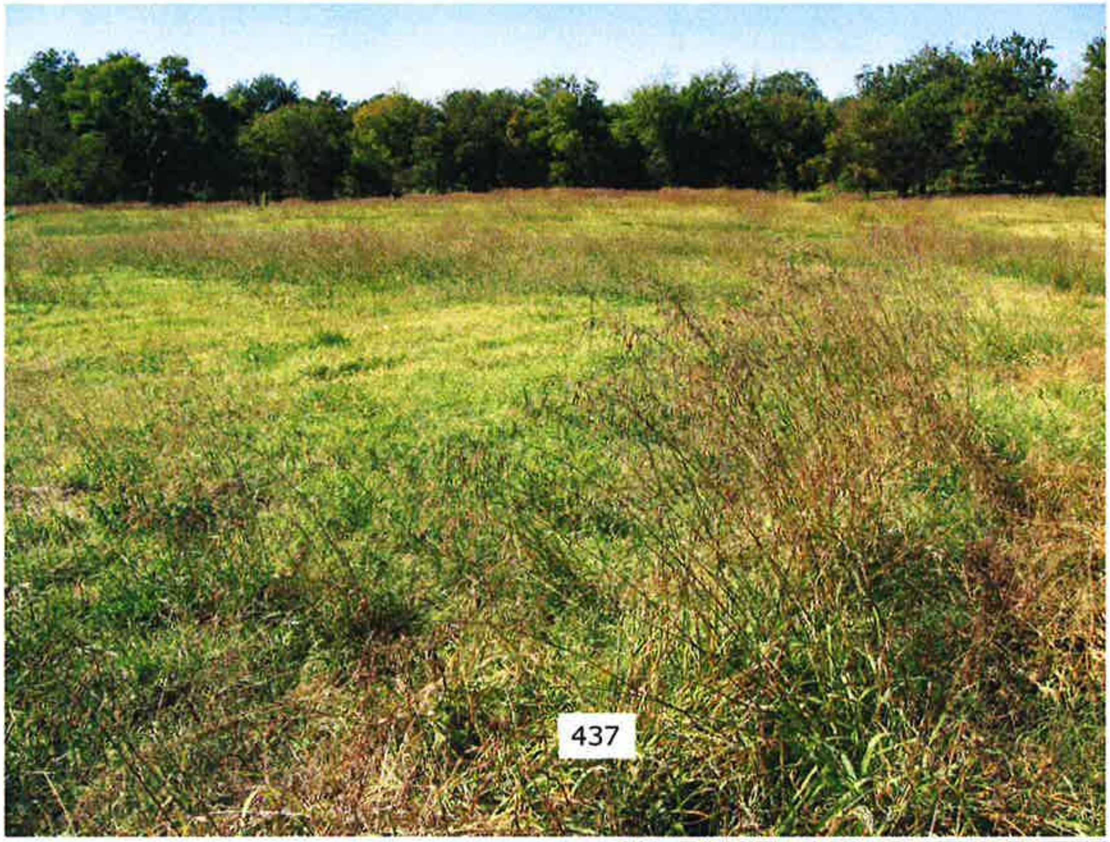

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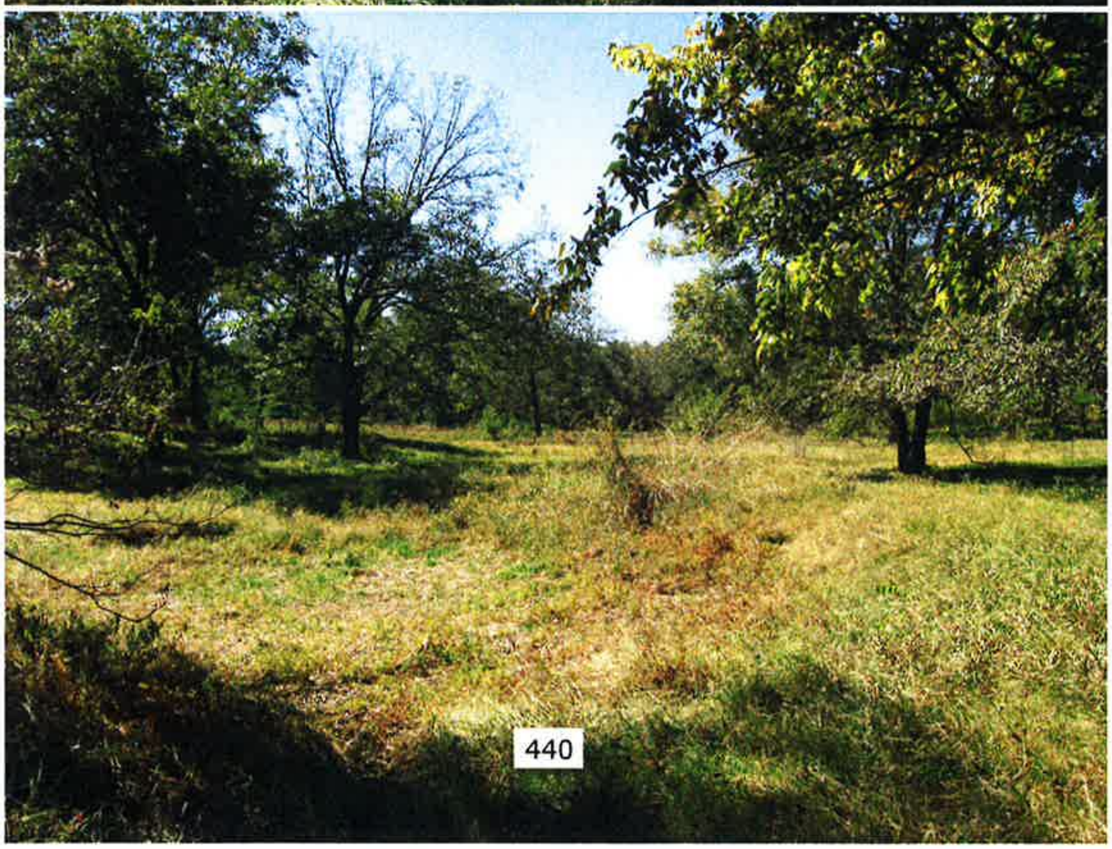

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Appendix 3. Geotechnical Report from Early Learning Center construction site, dated October 15, 2010.

Report of Subsurface Exploration and Geotechnical Evaluation
Locust Grove Elementary School
Locust Grove, Oklahoma

Building & Earth Project Number: OK10150

Prepared For:

Wallace Engineering, Inc.

Prepared By:

BUILDING & EARTH

Geotechnical, Environmental, and Materials Engineers

DATE:

October 15, 2010

TABLE OF CONTENTS

1.0 PROJECT DESCRIPTION

We understand that a new elementary school is planned in Locust Grove, Oklahoma. The project will include construction of one-story building with associated parking lots, entrance roadways and driveways. The proposed building will have a dome shaped core, which will serve as a safe house, and three separate class room wings extending from the core of the building.

Design details for the building were not available to us at the time of preparing this report. We have assumed that the proposed building will be constructed of a combination of CMU loading bearing walls, reinforced concrete walls for the safe house, joist and girder supported roof system, and grade supported concrete slab. Maximum bearing wall and column loads are assumed to be on the order of 4 kips per linear foot and 50 kips, respectively.

We understand that finish floor elevations for the proposed building will range from 686.0 feet at the dome, to 681.0 feet at the northwest wing, to 682.0 feet at the southwest wing, to 689.0 feet at the east wing. Based on the contour lines shown on the site plan provided to us by Wallace Engineering, Inc., portions of the proposed building areas will require cuts on the order of 3 feet and fill placement on the order of 10 feet to achieve design grades.

An entrance roadway will wrap around the proposed school building. A bus load/unload area will be constructed to the northeast of the proposed building. A couple of parking lots will be located to the north and south of the school building. Grading plans were not available for the pavement areas; however, we assume that cuts and/or fill will be less than 2 to 3 feet. Specific traffic information was not provided for this project; however, we anticipate that the access roadway and bus load/unload areas will be frequently subjected to school bus traffic. The parking lots are expected to be subjected to light passenger car and pick-up truck traffic only.

We understand that stem walls and below-grade walls will be part of the proposed school building in order to accommodate the grade changes across the proposed building footprint. Stem walls and below-grade walls are expected to have maximum wall heights on the order of 5 feet. We understand that site retaining walls will not be part of this project.

- Presentation of expected total and differential settlements, and recommendations to reduce the expected movements if the settlements exceed tolerable levels.
- Compaction requirements and recommended criteria to establish suitable material for structural backfill.
- Recommended typical flexible and rigid pavement sections for assumed standard-duty and heavy-duty traffic conditions.

The scope of services did not include an environmental site assessment or evaluation of potential wetland areas.

4.0 SITE GEOLOGY

Based on published geologic literature, the subject site is underlain by the Boone formation. The Boone formation consists of gray, fine to coarse grained limestone interbedded with chert and minor shale. Some sections of the formation may be predominantly limestone or chert. The chert is dark in color in the lower part and light in color in the upper part.

The Boone formation is well known for dissolution features, such as sinkholes, caves, and enlarged fissures. Although the site vicinity is prone to the development of sinkholes, there is no certainty that a sinkhole or other sinkhole related features will or will not develop in the future.

Key factors involved in the absence or presence of sinkhole activity in a particular area are the presence of soluble, carbonate rock and the movement of groundwater through the rock. As groundwater is moved from carbonate strata, cavities or voids within the rock that were once water-filled become open residual clay overlying the voids and situated between the bedrock, and ground surface begins to "spall" or migrate into these voids. This spalling results in new voids which are located in the clay. As spalling continues upward, the overlying clay eventually can no longer support itself and a depression forms at the surface, resulting in a sinkhole.

We did not encounter conditions in the boreholes drilled or observe surface depressions (indicative of sinkhole activity) at the time of our exploration and judge this site to have no greater risk of sinkhole development than similar sites in this same geological setting.

5.1 SOIL TEST BORINGS

At each boring location, soil samples were retrieved at standard sampling intervals by driving a split-tube sampler. The borehole was first advanced to the sample depth by augering, and the sampling tools were placed in the open hole. The sampler was then driven into the ground 18 inches by blows from a 140-pound hammer falling 30 inches. The number of blows required to drive the sampler each 6-inch increment was recorded. The initial increment is considered the "seating" blows, where the sampler penetrates any loose or disturbed soil in the bottom of the borehole. The blows required to penetrate the final two increments are added together and referred to as the Standard Penetration Test (SPT) N-Value. The N-Value, when properly evaluated, gives an indication of the soil's strength and ability to support structural loads. Many factors can affect the SPT N-Value, so this result should not be used exclusively to evaluate soil conditions.

Samples retrieved from the boring locations were labeled and stored in plastic bags at the jobsite before being transported to our laboratory for analysis. The project engineer prepared Boring Logs summarizing the subsurface conditions at the boring location. The Boring Logs are attached to this report. The borings were drilled at the locations indicated on the attached Location Plan.

5.2 SOIL TEST PITS

We understand that the contractor excavated test pits using a backhoe at the locations indicated on the attached Location Plan. The test pits were excavated to evaluate the general subsurface condition prior to drilling of the soil test borings. Our field representatives observed the soil types exposed in the sides and bottom of the test pit excavations and prepared test pit logs based on visual soil classification only. No soil samples were collected from the test pit excavations.

6.5 LOSS ON IGNITION (LOI) TEST (ASTM D 2974-87)

LOI tests were performed on samples of the topsoil collected from the site. The ash content of a peat or organic soil sample is determined by igniting an oven-dried sample resulting from the moisture content determination in a muffle furnace at 440°C (Method C) or 750°C (Method D). The substance remaining after ignition is the ash. The organic content is expressed as a percentage of the mass of the oven-dried sample. The results of LOI tests are presented on the boring logs and summary table included in the Appendix of this report.

The results of the laboratory testing are presented on the boring logs and in the summary table included in the Appendix of this report.

7.3 LIMESTONE UNIT

The residual clay soils at boring locations B-1 through B-04 in the building area encountered auger refusal on a limestone unit. Auger refusal is the drilling depth at which the borehole can no longer be advanced using the current drilling procedure. It is possible that boring P-3 and P-6 in the access road, P-7 in the parking area and P-5 in the bus load/unload area encountered limestone unit at termination depth. The depth to rock ranged from 6.5 to 7.5 feet in the building area, and possible 3.6 to 3.8 feet in the access road area, 4.4 feet in the parking area, and 4.2 feet in the bus load/unload area.

7.4 GROUNDWATER

No free water was encountered in the boring and test pit locations during the exploration. It should be noted that fluctuations in the water level could occur due to seasonal rainfall. Long term borehole monitoring was not included as part of this exploration.

foundations, slab-on-grade, or pavements. Tree stumps and root systems should be removed from the construction areas. If the pond located just west to southwest of the proposed school building will be relocated, then soft sediments should be removed to suitable material prior to placing structural fill.

After the clearing is completed, all areas that will require fill or that will support structures or pavements should be carefully proofrolled with a heavy, rubber-tired vehicle prior to fill placement or building construction. The proofrolling will help densify the near surface soils and identify unstable subgrade areas. The project geotechnical engineer or a qualified representative should observe the proofrolling operations.

During site preparation activities, the contractor should identify materials that will be used as fill and provide samples to the testing laboratory to evaluate whether the proposed material is suitable for structural fill and to determine appropriate moisture-density curves.

8.2 POTENTIAL DEVELOPMENT OF PERCHED WATER

Lower plasticity lean clay soils were underlain by higher plasticity fat clay soils in the borings. This condition is conducive to potential development of perched water conditions at the interface of the lower plasticity lean clay soils and higher plasticity fat clay soils. Perched water conditions will result in saturation of the near surface soils and consequently softening of the clay soils and loss of its stability with increased soil moisture levels.

The contractor should anticipate some difficulty during the earthwork phase of this project if moisture levels are moderate to high during construction. Increased moisture levels will soften the subgrade and the soils may become unstable under the influence of construction traffic.

Accordingly, wet weather conditions prior to and during construction should be avoided, as this will result in soft and unstable soil conditions at near surface. Unstable surficial soils identified during construction should be undercut to stable materials prior to fill placement.

8.3 UNDERCUTTING FAT CLAY SOILS

Soils with a liquid limit value greater than 50 and a plasticity index value greater than 30 are considered highly plastic. These materials tend to undergo significant volume changes when subjected to moisture variations.

The results of field and laboratory testing indicate that most of the on-site residual soils in the lower zone (below 2 feet from the existing site grades) are highly plastic.

The first lift of fill placed on the scarified subgrade should not exceed eight (8) inches loose measure and should be compacted to the specifications provided in the following section.

8.5 BENCHING EXISTING SLOPES

Existing slopes within the project site steeper than 5 Horizontal to 1 Vertical, 5(H): 1(V), and located in fill areas should be benched prior to fill placement. Benching of the slopes provides interlocking between the new fill and on-site materials and facilitates compaction of the fill. Benches should be cut as the fill placement progresses and should have a maximum bench height of 2 to 3 feet. Special attention should be given to interbedded rock units within the cut slopes, which may require additional drainage measures to intercept and divert groundwater flow from the slope.

8.6 STRUCTURAL FILL

We recommend that the structural fill at the site be composed of material with a maximum dry density in excess of 100 pounds per cubic foot (pcf), Plasticity Index (PI) less than 20, and Liquid Limit (LL) less than 40.

Based upon the soils encountered within the site, we anticipate that the onsite fat clay soils encountered will not be suitable for structural fill below the planned building pad within 36 inches of the finished subgrade elevation, and below planned pavement areas within one (1) foot of the subgrade elevation. Any fill to be placed at the site should be approved by the geotechnical engineer.

The lower plasticity lean clay soils encountered across the site to a typical depth of about 2 feet appear suitable for use as lower plasticity structural fill; however, the contractor should use caution as these lower plasticity lean clay soils exhibited about 3.6 to 3.8 percent loss on ignition and contain a significant silt fraction. These types of soil have are prone to loosing stability with slight increases in soil moisture levels.

Structural fill placed within proposed building areas should be compacted to a minimum of 98% of the standard Proctor maximum dry density and within ±2% of the optimum moisture as determined by ASTM D-698. Fill placed within pavement areas should be compacted to a minimum of 95% of the standard Proctor maximum dry density. The specifications should state that both density and moisture requirements should be met. The lifts should not exceed 8 to 12 inches thick, depending on the compaction equipment used. Density and moisture tests should be performed on each lift prior to placement of subsequent lifts. A commonly used testing criterion is one test per 2,500 square feet per lift in building areas, with a minimum of three (3) tests performed per lift.

encountered in excavations. The contractor should prepare for difficult excavation in very stiff to hard soils and extending below the refusal depth (limestone bed rock). The ability to excavate hard material and rock is a function of the material, the equipment used, the skill of the operator, the desired rate of removal and other factor. Each contractor should use their own method to evaluate excavation difficulty.

8.10 LANDSCAPING AND DRAINAGE CONSIDERATION

The potential for soil moisture fluctuations within buildings area and pavement subgrades should be reduced to lessen the potential of subgrade movement. Site grading should include positive drainage away from buildings and pavements. Ponding of water adjacent to buildings and pavements could result in soil moisture increases and subsequent heave of the soils. Landscaping and irrigation immediately adjacent to buildings and pavements should be limited. Trees can develop large root systems which can draw water from subgrade soils, resulting in subsequent shrinkage of the soils. Excessive irrigation of landscaping poses a risk of saturating and softening soils below shallow footings and pavements, which could result in settlement of footings and premature failure of pavements.

8.11 WET WEATHER CONSTRUCTION

Cooler temperatures and shorter days during the winter season significantly reduce the capacity to dry out wet clayey soils. Additionally, excessive movement of construction equipment across the site during wet weather will result in ruts, which will collect rainwater, prolonging the time required to dry the subgrade soils.

During rainy periods, additional effort will be required to properly prepare the site and establish/maintain an acceptable subgrade. The difficulty will increase in areas where clay or silty soils are exposed at the subgrade elevation. Grading contractors typically postpone grading operations during wet weather to wait for conditions that are more favorable. Contractors can typically disk or aerate the upper soils to promote drying during intermittent periods of favorable weather. When deadlines restrict postponement of grading operations, additional measures such as undercutting and replacing saturated soils or stabilization can be utilized to facilitate placement of additional fill material.

areas. Because of the potential differential settlement across the buildings, the structural engineer should design the structural elements such as to accommodate for possible differential movement of this magnitude.

Exterior and interior footings should be extended to a minimum depth of 24 and 12 inches, respectively, below exterior grades. Floor slab should be designed and supported by material as recommended in Section 12 of this report. Even though computed footing dimensions may be less, column footings should be at least 24 inches wide and strip footings should be at least 18 inches wide. These dimensions facilitate hand cleaning of footing subgrades disturbed by the excavation process and the placement of reinforcing steel. They also reduce the potential for localized punching shear failure.

The following items should be considered during the preparation of construction documents and foundation installation:

- The geotechnical engineer of record should observe the exposed foundation bearing surfaces prior to concrete placement to verify that the conditions anticipated during the subsurface exploration are encountered.
- All bearing surfaces must be free of soft or loose soil prior to placing concrete.
- The bottom surface of all footings should be level
- Concrete should be placed the same day the excavations are completed and bearing materials verified by the engineer. If the excavations are left open for an extended period, or if the bearing surfaces are disturbed after the initial observation, then the bearing surfaces should be re-evaluated prior to concrete placement.
- Water should not be allowed to pond in foundation excavations prior to concrete placement or above the concrete after the foundation is completed.
- Wherever possible, the foundation concrete should be placed "neat", using the sides of the excavations as forms. Where this is not possible, the excavations created by forming the foundations must be backfilled with suitable structural fill and properly compacted.
- The building pad should be sloped to drain away from the building foundations.
- Roof drains should be routed away from the foundation soils.

13.0 STEM AND BELOW GRADE WALLS

We understand that stem walls and below-grade walls will be part of the proposed school building in order to accommodate the grade changes across the proposed building footprint. Stem walls and below-grade walls are expected to have maximum wall heights on the order of 5 to 10 feet. We recommended that all stem and below grade walls be backfilled with free-draining granular fill such as No. 57 stone (ASTM D 448). The stone fill should be placed in the zone defined by projecting a 1(H):1(V) line from the base of the wall to the finished subgrade elevation / ground surface (See sketch on next page). A layer of suitable filtration fabric, such as Amoco/ProPex 4545 or Mirafi N140 or equivalent, should be placed between the soil and stone backfill to reduce migration of soil fines into the drainage zone behind the wall.

Because the stone fill behind the wall may support structures, the fill must be placed and compacted in a systematic manner. The stone fill should be placed in lifts not exceeding six (6) inches and compacted using a vibratory plate compactor. Because density tests cannot be performed in open graded aggregate, the fill placement and compaction should be visually monitored. The following equivalent fluid pressure should be used to design the stem walls and below-grade walls. At rest parameters should be used to design walls that are not allowed to rotate or translate. The surcharge loads must be included in the design.

Soils Parameters and Earth Pressure Values				
Backfill Material	Soils Parameters		Equivalent Fluid Unit Weights for Active & At-Rest Earth Pressures (pcf)	
	Wet Unit Weight (pcf)	Effective Angle of Internal Friction	At-Rest Condition	Active Condition
ASTM No. 57 Stone	110	36°	45	30
Structural Fill	120	28°	65	45

Lateral earth pressures may be greater for walls with free-draining material placed in a zone steeper than the 1(H):1(V) projection recommended above. In that case, we recommend that walls are designed using the soil parameter values for structural fill as shown in the table above.

The recommended lateral earth pressure values are based on a fully-drained condition. If hydrostatic pressure is allowed to build up behind walls, additional pressures will develop. The No. 57 aggregate backfill will function as a drainage blanket. The drainage blanket should have a minimum width of 2 feet and should be wrapped in filter fabric to minimize intrusion of fines.

14.0 PAVEMENT CONSIDERATIONS

Based on the materials encountered at the boring locations, pavements for the proposed development may be designed based on a California Bearing Ratio (CBR) of 3. Rigid pavements may be designed using modulus of subgrade reaction, k, of 100 pounds per cubic inch. Note that no CBR or plate load testing was completed to develop these recommendations. These values are based on the results of SPT and laboratory testing, using published correlation charts. We were not provided traffic information and have assumed that the standard and heavy duty pavements will be subject to no more than 100,000 and 300,000 ESALs, respectively. We have assumed the following design equivalent:

DESIGN CRITERIA	STANDARD PAVEMENT	HEAVY DUTY PAVEMENT
ESALs	100,000	300,000
Design life (Years)	20	
Terminal Serviceability	2.0	
Reliability	85%	
Initial Serviceability	4.2	
Standard Deviation	0.45(Flexible)	
Standard Deviation	0.35(Rigid)	

All subgrade, base and pavement construction operations should meet minimum requirements of the Oklahoma Department of Transportation (ODOT), *Standard Specifications for Highway Construction*, dated 1999. The applicable sections of the specifications are identified as follows:

TITLE	ODOT SPECIFICATION SECTION
Aggregate for Aggregate Base	303 & 703.01
Plant Mix Asphalt Concrete Pavement	411 & 708
Portland Cement Concrete Pavement	414 & 701

14.1 FLEXIBLE PAVEMENT

The recommendations provided below are based on assumed traffic conditions. If the assumptions presented above are not suitable for the subject site, then upon notification we will evaluate the recommendation as additional information is made available to us.

STANDARD DUTY PAVEMENT

Minimum Recommended Thickness (in)	Description
3.0	Type "C" HMAC Surface Course (ODOT 411& 708)
4.0	Type "A" Limestone Aggregate Base (ODOT 703.01)
8.0	Chemically Stabilized Subgrade

HEAVY DUTY PAVEMENT

Minimum Recommended Thickness (in)	Description
1.5	Type "C" HMAC Surface Course (ODOT 411& 708)
3.0	Type "A" HMAC Base Course (ODOT 411 & 708)
4.0	Type "A" Limestone Aggregate Base (ODOT 703.01)
8.0	Chemically Stabilized Subgrade

14.2 RIGID PAVEMENT

The following rigid pavement sections are based on the design parameters presented above. We assume an effective modulus of subgrade reaction (k) of 130 psi. We have assumed concrete elastic modulus (E_c) of 3.6 X 10^6 psi, and a concrete modulus of rupture (S'_c) of 570 psi.

Minimum Recommended Thickness (in)		Material
Standard Duty	Heavy Duty	
5.0	6.0	Portland Cement Concrete, f'_c=4000 psi
6.0	6.0	Crushed Aggregate Base

Alternatively, the above rigid pavement thickness can be reduced when chemically stabilizing the subgrade soils to a depth of at least 8 inches. Chemical stabilization should be performed as presented in Section 8.6 of this report. The following rigid pavement section is based on a minimum of 8 inches of chemically stabilized subgrade:

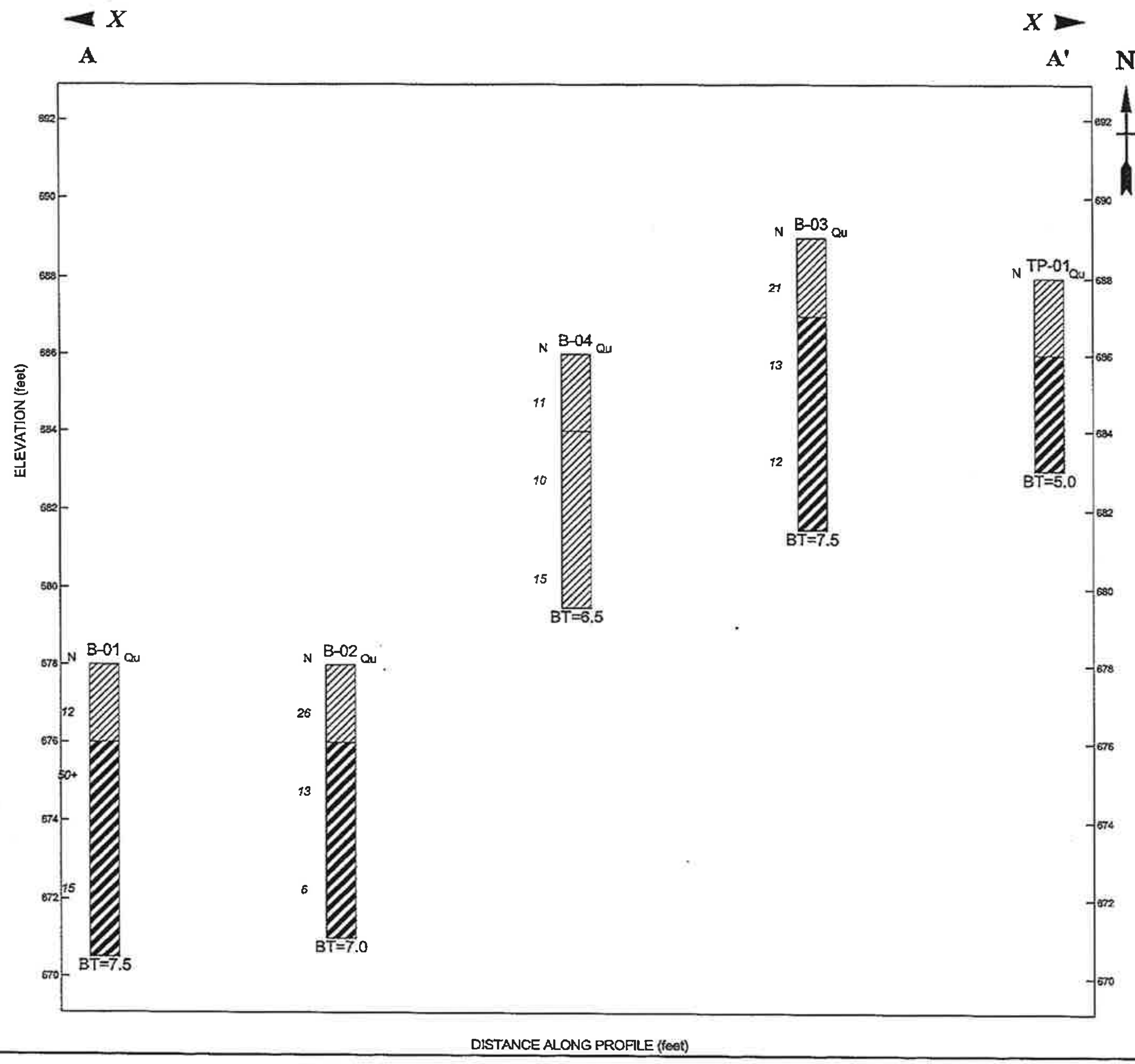
15.0 CONSTRUCTION MONITORING

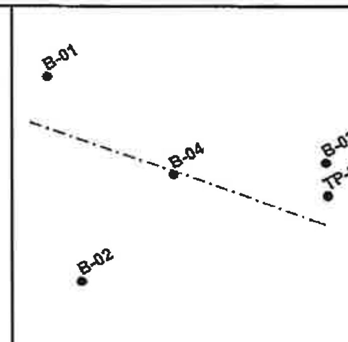
The recommendations presented in this report are based on information obtained from eleven (11) boring locations and two (2) test pit locations. Field verification of site conditions is an essential part of the services provided by the geotechnical consultant. In order to confirm our recommendations, it will be necessary for Building & Earth personnel to make periodic visits to the site during site grading. We can prepare a proposal for construction monitoring services based on the construction schedule and your risk management preferences.

Typical construction monitoring services are listed below.

- Periodic observations and consultations by a member of our engineering staff during site grading.
- Field density tests during structural fill placement.
- Observation and verification of the bearings surfaces exposed after foundation excavation.
- Molding and testing of concrete cylinders.
- Structural steel inspections.

APPENDIX





Site Map Scale 1 inch equals 195 feet

Explanation

BT=Boring Termination

AR=Auger Refusal

PPqu=Unconfined compressive strength estimate from pocket penetrometer test (tsf)

N=Standard Penetration Test N-Value

USCS Low Plasticity Clay

USCS High Plasticity Clay

Water Level Reading at time of drilling.

Water Level Reading after drilling.

0 54

Horizontal Scale (feet)

Vertical Exaggeration: 14.5x

Building & Earth Sciences, Inc.

Section Name A-A'
Subsurface Profile

Locust Grove Elementary School
Locust Grove, Oklahoma

JOB NUMBER	PLATE NUMBER	DATE
OK10150	Plate A-1	10/15/10

FANWNL01 OK10150 LOCUST GROVE ELEMENTARY SCHOOL.GPJ BESI.GDT 10/15/10

BUILDING & EARTH SCIENCES, INC.

10828 East Newton Street, Suite 111, Tulsa, OK 74116 - Phone: 918-439-9005

LOG OF BORING: B-02

Project Name: Locust Grove Elementary School
Project Number: OK10150
Drilling Method: Hollow Stem Auger and SPT
Boring Location: Southwest Building Wing

Project Location: Locust Grove, Oklahoma
Date Drilled: 10/6/10
Surface Elevation: 678

DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT
	Split Spoon	1	8-16-10
	Split Spoon	2	6-7-6
5	Split Spoon	3	5-3-3
10			

□ N-Value □ 10 20 30 40
▲ Qu (tsf) ▲ 1 2 3 4
Atterberg Limits 20 40 60 80
● % Moisture ● 20 40 60 80

SOIL DESCRIPTION

SANDY LEAN CLAY (CL): very stiff, very dark brown with chert

2.0 — 676.0

LEAN CLAY WITH SAND (CL): stiff, yellowish-red to dark reddish-brown

4.0 — 674.0

FAT CLAY (CH): firm, dark reddish-brown with chert

7.0 — (RESIDUAL) 671.0

Auger Refusal at 7 feet on Limestone

GRAPHIC

REMARKS

Sample # 2 (2.5-4')
LL = 39
PL = 22
PI = 17
% Passing # 200 = 73.6
USCS = CL

Groundwater was not encountered at time of boring

Backfilled 10/06/2010

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (ASTM D-1586)	REC	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	RQD	ROCK QUALITY DESIGNATION
⊻	GROUNDWATER LEVEL IN THE BOREHOLE	UD	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

LOG OF BORING 2 OK10150 LOCUST GROVE ELEMENTARY SCHOOL.GPJ BESI.GDT 10/15/10

BUILDING & EARTH SCIENCES, INC.

10828 East Newton Street, Suite 111, Tulsa, OK 74116 - Phone: 918-439-9005

LOG OF BORING: B-04

Sheet 1 of 1

Project Name: Locust Grove Elementary School
Project Number: OK10150
Drilling Method: Hollow Stem Auger and SPT
Boring Location: Core of Building (Safe House)

Project Location: Locust Grove, Oklahoma
Date Drilled: 10/6/10
Surface Elevation: 686

DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	SOIL DESCRIPTION	REMARKS
0–2.0	Split Spoon	1	2-3-8	LEAN CLAY (CL): stiff, very dark brown (2.0 — 684.0)	Sample # 1 (0.5-2') LL = 33, PL = 21, PI = 12, % Passing # 200 = 73.4, % Organic = 3.6, USCS = CL
2.0–6.5	Split Spoon	2	6-5-5	SANDY FAT CLAY (CH): stiff, yellowish-red with chert	
5	Split Spoon	3	6-6-9	very stiff, dark reddish-brown (RESIDUAL) (6.5 — 679.5)	Sample # 3 (5-6.5') LL = 61, PL = 24, PI = 37, USCS = CH
6.5				Auger Refusal at 6.5 feet on Limestone	
10					Groundwater was not encountered at time of boring Backfilled 10/06/2010

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (ASTM D-1586)	REC	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	RQD	ROCK QUALITY DESIGNATION
▽	GROUNDWATER LEVEL IN THE BOREHOLE	UD	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

BUILDING & EARTH SCIENCES, INC.

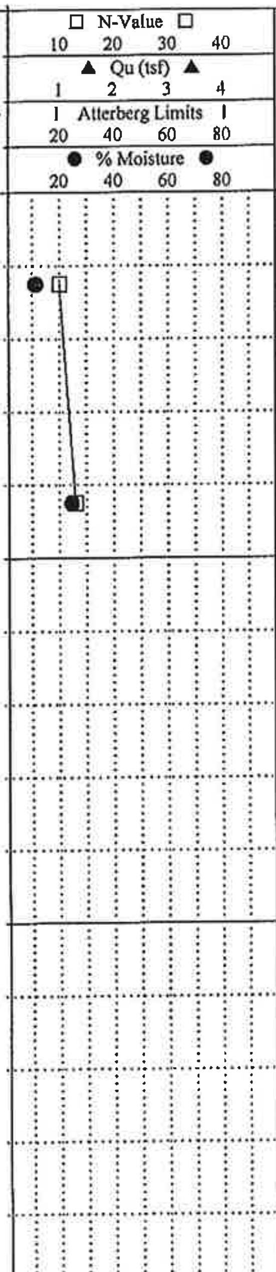
10828 East Newton Street, Suite 111, Tulsa, OK 74116 - Phone: 918-439-9005

LOG OF BORING: P-02

Project Name: Locust Grove Elementary School
Project Number: OK10150
Drilling Method: Hollow Stem Auger and SPT
Boring Location: Access Road

Project Location: Locust Grove, Oklahoma
Date Drilled: 10/6/10
Surface Elevation: 674

DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	SOIL DESCRIPTION	REMARKS
0.0–2.0	Split Spoon	1	5-3-7	LEAN CLAY (CL): stiff, very dark brown (2.0 / 672.0)	Sample # 1(0.5-2') % Organic = 3.8
2.0–5.0	Split Spoon	2	5-7-6	FAT CLAY (CH): stiff, dark redish-brown with some chert (5.0 / 669.0)	
5				Boring Terminated at 5 feet	
10					Groundwater was not encountered at time of boring Backfilled 10/06/2010



SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (ASTM D-1586)	REC	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	RQD	ROCK QUALITY DESIGNATION
∇	GROUNDWATER LEVEL IN THE BOREHOLE	UD	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

LOG OF BORING 2 OK10150 LOCUST GROVE ELEMENTARY SCHOOL.GPJ BESI.GDT 10/15/10

BUILDING & EARTH SCIENCES, INC.

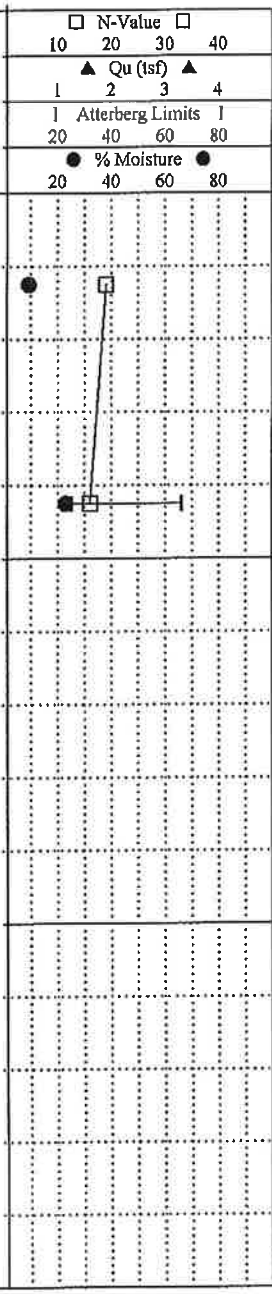
10828 East Newton Street, Suite 111, Tulsa, OK 74116 - Phone: 918-439-9005

LOG OF BORING: P-04

Project Name: Locust Grove Elementary School
Project Number: OK10150
Drilling Method: Hollow Stem Auger and SPT
Boring Location: Parking Lot

Project Location: Locust Grove, Oklahoma
Date Drilled: 10/6/10
Surface Elevation: 677

DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	SOIL DESCRIPTION	REMARKS
0–2.0	Split Spoon	1	9-15-4	SANDY LEAN CLAY (CL): very stiff, very dark brown with few root fibers and chert	
2.0 (675.0) – 5.0 (672.0)	Split Spoon	2	7-7-9	FAT CLAY (CH): very stiff, gray, yellowish-brown to dark reddish-brown	Sample # 2(3.5-5') LL = 66 PL = 25 PI = 40 USCS = CH
5.0				Boring Terminated at 5 feet	



Groundwater was not encountered at time of boring

Backfilled 10/06/2010

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (ASTM D-1586)	REC	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	RQD	ROCK QUALITY DESIGNATION
∇	GROUNDWATER LEVEL IN THE BOREHOLE	UD	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

LOG OF BORING 2 OK10150 LOCUST GROVE ELEMENTARY SCHOOL.GPJ BESI.GDT 10/15/10

BUILDING & EARTH SCIENCES, INC.

10828 East Newton Street, Suite 111, Tulsa, OK 74116 - Phone: 918-439-9005

LOG OF BORING: P-06

Project Name: Locust Grove Elementary School
Project Number: OK10150
Drilling Method: Hollow Stem Auger and SPT
Boring Location: Access Road

Project Location: Locust Grove, Oklahoma
Date Drilled: 10/6/10
Surface Elevation: 685

DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	□ N-Value □ (10 20 30 40) / ▲ Qu (tsf) ▲ (1 2 3 4) / Atterberg Limits (20 40 60 80) / ● % Moisture ● (20 40 60 80)	SOIL DESCRIPTION	GRAPHIC	REMARKS
					SANDY LEAN CLAY (CL): very stiff, brown with few root fibers and chert		
	Split Spoon	1	8-12-14				
					hard, brown with chert		
	Split Spoon	2	50/3"	>> 3.8	681.2		
					Boring Terminated at 3.8 feet on limestone		
5							
10							Groundwater was not encountered at time of boring Backfilled 10/06/2010

SAMPLE TYPE ☒ Split Spoon

N-VALUE	STANDARD PENETRATION RESISTANCE (ASTM D-1586)	REC	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	RQD	ROCK QUALITY DESIGNATION
▽	GROUNDWATER LEVEL IN THE BOREHOLE	UD	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

Birmingham 5545 Derby Dr Birmingham, AL 35210
Columbus 5045 Milgen Ct Unit 2 Columbus, GA 31907
Tulsa 10828 E. Newton St #111 Tulsa, OK 74116
Atlanta 4124 Daniel Green Trail Smyrna, GA 30080
Savannah 3911 Old Louisville Rd #107 Garden City, GA 31408

BUILDING & EARTH SCIENCES, INC.

10828 East Newton Street, Suite 111, Tulsa, OK 74116 - Phone: 918-439-9005

LOG OF BORING: TP-01

Project Name: Locust Grove Elementary School
Project Number: OK10150
Drilling Method: Backhoe Excavator
Boring Location: East Building Wing

Project Location: Locust Grove, Oklahoma
Date Drilled: 10/4/10
Surface Elevation: 688

DEPTH (ft)	SAMPLE TYPE	SAMPLE NO.	BLOWS PER INCREMENT	□ N-Value □ 10 20 30 40 / ▲ Qu (tsf) ▲ 1 2 3 4 / I Atterberg Limits I 20 40 60 80 / ● % Moisture ● 20 40 60 80	SOIL DESCRIPTION	GRAPHIC	REMARKS
	Grab Sample	1			LEAN CLAY (CL): very dark brown, with chert		
2.0					(686.0)		
	Grab Sample	2			FAT CLAY (CH): yellowish-red		
5.0					(683.0)		
					Test Pit Terminated at 5 feet		
10							Groundwater was not encountered at time of test pit Backfilled 10/04/2010

SAMPLE TYPE: Grab Sample

N-VALUE	STANDARD PENETRATION RESISTANCE (ASTM D-1586)	**REC**	RECOVERY
% MOISTURE	PERCENT NATURAL MOISTURE CONTENT	**RQD**	ROCK QUALITY DESIGNATION
∇	GROUNDWATER LEVEL IN THE BOREHOLE	**UD**	UNDISTURBED
Qu	UNCONFINED COMPRESSIVE STRENGTH ESTIMATE FROM POCKET PENETROMETER TEST		

LOG OF BORING 2 OK10150 LOCUST GROVE ELEMENTARY SCHOOL.GPJ BESI.GDT 10/15/10

BUILDING & EARTH SCIENCES, INC.

BORING LOG DESCRIPTION

Building & Earth Sciences, Inc. (Building & Earth) used the gINT software program to prepare the attached boring logs. The gINT program provides the flexibility to custom design the boring logs to include the pertinent information from the subsurface exploration and results of our laboratory analysis. The soil and laboratory information included on our logs is summarized below:

Depth
The depth below the ground surface is shown.

Sample Type
The method used to collect the sample is shown. The typical sampling methods include Split Spoon Sampling, Shelby Tube Sampling, Grab Samples, and Rock Core. A key is provided at the bottom of the log showing the graphic symbol for each sample type.

Sample Number
Each sample collected is numbered sequentially

Blows per 6", REC%, RQD%
When Standard Split Spoon sampling is used, the blows required to drive the sampler each 6-inch increment are recorded and shown in column 4. When rock core is obtained the recovery ration (REC%) and Rock Quality Designation (RQD%) is recorded.

Soil Data
Column 5 is a graphic representation of 4 different soil parameters. Each of the parameters use the same graph, however, the values of the graph subdivisions vary with each parameter. Each parameter presented on column 5 is summarized below:

- **N-Value**- The Standard Penetration Test N-Value, obtained by adding number of blows required to drive the sampler the final 12 inches, is recorded. The graph labels range from 0 to 50.
- **Qu** – Unconfined Compressive Strength estimate from the Pocket Penetrometer test in tons per square foot (tsf). The graph labels range from 0 to 5 tsf.
- **Atterberg Limits** – The Atterberg Limits are plotted with the plastic limit to the left, and liquid limit to the right, connected by a horizontal line. The difference in the plastic and liquid limits is referred to as the Plasticity Index. The Atterberg Limits test results are also included in the Notes column on the far right column of the boring log. The Atterberg Limits graph labels range from 0 to 100.
- **% Moisture** – The Natural Moisture Content of the soil sample as determined in our laboratory.

Soil Description
The soil description prepared in accordance with ASTM D 2488, Visual Description of Soil Samples. The Munsel Color chart is used to determine the soil color. Strata changes are indicated by a solid line, with the depth of the change indicated on the left side of the line. If subtle changes within a soil type occur, a broken line is used. The Boring Termination or Auger Refusal depth is shown as a solid line at the bottom of the boring.

Graphic
The graphic representation of the soil type is shown. The graphic used for each soil type is related to the Unified Soil Classification chart. A chart showing the graphic associated with each soil classification is included.

Remarks
Remarks regarding borehole observations, and additional information regarding the laboratory results and groundwater observations.

Important Information about Your

Geotechnical Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared *solely* for the client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical Engineering Report Is Based on A Unique Set of Project-Specific Factors

Geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

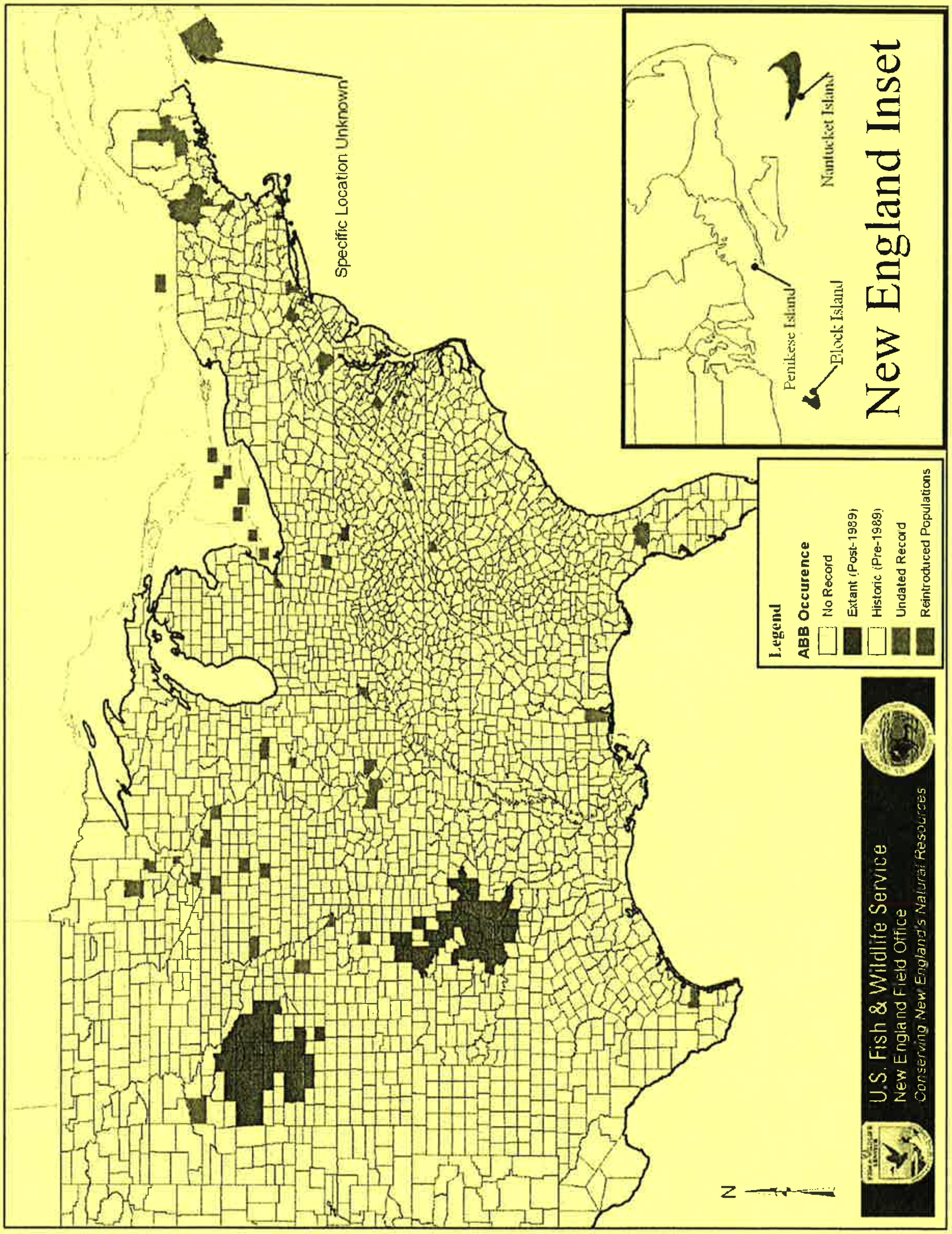
A geotechnical engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

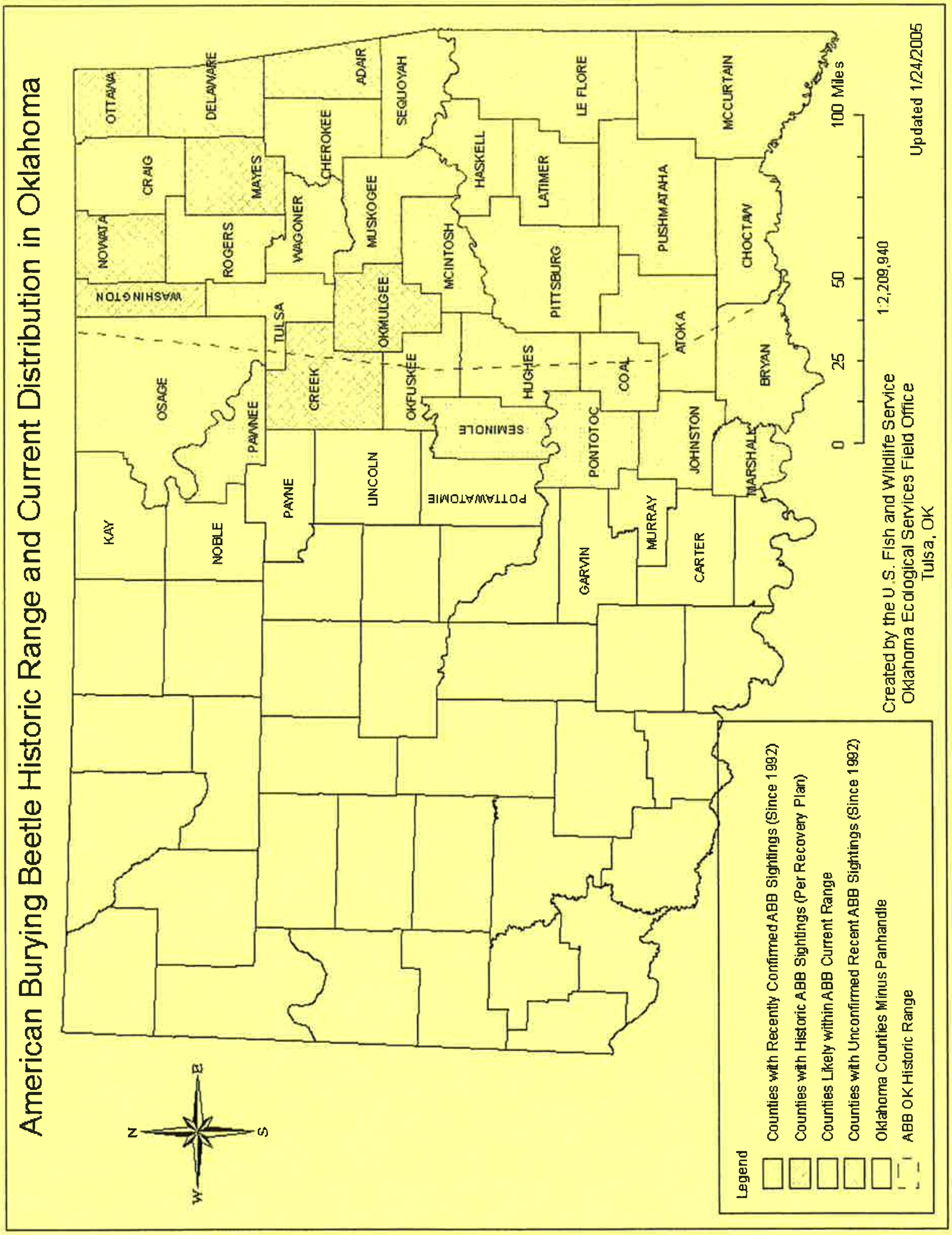
Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ—sometimes significantly—from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual



Appendix 4. American burying beetle historic and current range.



Appendix 5. American burying beetle current range in Oklahoma.