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Survey of flatwoods salamander (*Ambystoma cingulatum*) within proposed railroad corridors at Daniel Island, South Carolina

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# Survey of flatwoods salamander (*Ambystoma cingulatum*) within proposed railroad corridors at Daniel Island, South Carolina


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**Abstract**

The South Carolina Ports Authority has proposed to develop a marine cargo terminal complex at Daniel Island outside Charleston. This proposed project may include the establishment of transportation corridors which are situated near known historic localities for the flatwoods salamander, *Ambystoma cingulatum*. Because this species of salamander is protected in South Carolina and has recently been proposed for inclusion on the Federal List of Endangered and Threatened Wildlife, it is necessary to determine if this species occurs within the vicinity of proposed rail corridor alternatives prior to the initiation of construction. A total of 65 aquatic sites within and along proposed corridors were sampled for this species from 21 April through 2 May 1998. In addition to *A. cingulatum*, sites were also investigated for the occurrence of other herpetofauna species which are presently protected in South Carolina or are considered candidate species for listing by the U.S. Fish and Wildlife Service, including the dwarf siren, *Pseudobranchus striatus*, and the gopher frog, *Rana capito*, respectively.

## Introduction

The South Carolina Ports Authority has proposed to develop a marine cargo terminal complex at Daniel Island in the Charleston, South Carolina area. The proposed complex would include port terminal development at the south end of Daniel Island; wharf and berthing construction on the Cooper and Wando rivers; dredging of berthing areas; associated improvements to the Wando River and Hog Island Channels; construction of approximately 2.5 miles of multi-lane roadways; and the construction of about eleven miles of rail lines from the proposed terminal facilities to existing rail lines situated south of the town of Charity. In regards to the building of rail lines, several alternative corridors have been proposed (see Fig. 1). However, prior to construction each prospective corridor must be surveyed for various plant and animal species protected on state or federal levels, including certain members of the reptile and amphibian groups.

Within the coastal area of South Carolina a large and diverse herpetofaunal community is known to exist. In all, 45 amphibian and 65 reptile species are known to occur within this region of the state (Harrison, 1978*a*). Several of these species are protected under state and/or federal levels as threatened or endangered species. Among these protected species, two amphibians may possibly occur within the vicinity of Daniel Island. These are the flatwoods salamander, *Ambystoma cingulatum*, and the dwarf siren, *Pseudobranchus striatus*. In addition, the gopher frog, *Rana capito*, which is currently considered a candidate species for listing by the US Fish and Wildlife Service, may also inhabit areas proposed for railway construction.

Historically, the general vicinity of the proposed railway corridors is known to contain both *A. cingulatum* and *R. capito*. Quinby and Harrison (unpublished) recorded *A. cingulatum* from various localities near Cainhoy and 10.1 miles N of Cainhoy. They further noted *R. capito* from a location 2.1 miles north, thence 1.2 miles W of Cainhoy. These localities are all situated in Berkeley County. Seyle and Moulis (1987) also reported *A. cingulatum* from one locality, and heard *R. capito* in another within the Francis Marion National Forest. However, to our knowledge *P. striatus* has not been found within Berkeley County. Records for *A. cingulatum* and *R. capito* from the immediate area of proposed rail lines were compiled from specimens housed at the Charleston Museum, Savannah Science

Museum, and the private collection of Julian R. Harrison, III (see Fig. 2 and 3, respectively). The nearest record for *P. striatus* to the immediate vicinity of proposed rail corridors is within the Santee Coastal Reserve in Charleston County (Fig. 4).

Regrettably, little is available on the natural histories of these species throughout their ranges, much less in the state of South Carolina. Harrison (1978*b*) indicated that *A. cingulatum* from South Carolina is generally restricted to the margins of cypress and other shallow ponds in pine flatwoods of Beaufort, Berkeley, Charleston, Colleton and Jasper counties, while *R. capito* is found in sandy areas within pine flatwoods, usually in the vicinity of cypress or gum ponds within Berkeley, Charleston, and Jasper counties. He further noted *P. striatus* is found in ditches and shallow ponds in pine flatwoods in Beaufort, Charleston, and Jasper counties. Because of the general lack of information on these three species the following short accounts are available for each.

### ***Ambystoma cingulatum*** Cope

The flatwoods salamander, *Ambystoma cingulatum*, is a moderate sized dark black to chocolate brown salamander with a grayish or silvery network (sometimes reticulate) pattern or frosted appearance running along the lateral and dorsal surfaces. The belly is often spotted with equal amounts of black and gray pigments, producing a somewhat "salt and pepper" image. Aquatic larval forms of *A. cingulatum* are very similar in appearance to larvae of a related species, the mabee's salamander (*A. mabeei*). In larvae of both these species there is a distinct light stripe extending from the region of the gills to the end of the tail. Above these lateral stripes is a diffuse dorsolateral dark stripe which has a more-or-less jagged edge and generally contains an irregular series of light spots in *A. mabeei*. In *A. cingulatum* this dark dorsolateral stripe is well-defined with an even or straight edge, and is uniform in color. Retention of lateral stripes persist for a short time in newly metamorphosed *A. cingulatum*, but quickly disappear in transformed *A. mabeei*.

The flatwoods salamander is a unique salamander known to occur from southern South Carolina to northern Florida and southwestern Alabama (Conant and Collins, 1991). It has not been taken in Alabama during the last several years (J. Godwin, pers. comm.), and populations in this state may already be extinct. In addition, recent investigations from South Carolina (Seyle and Moulis, 1987 and 1988), Florida (Palis, 1993), and

Georgia (Moulis, 1995*a* and 1995*b*; Seyle, 1994) indicate a general decline in populations from each of these states. However, because of the terrestrial mode of reproduction, both severe drought and excessive rainfall may limit breeding success and nest-site availability of this species from year to year. It ~~is currently~~ ~~listed~~ as an endangered ~~species in South~~ Carolina, and has been proposed for federal protection as a threatened species (Federal Register, Vol. 62, No. 241:65787-65794).

The flatwoods salamander is a poorly understood species found primarily in a pine-wiregrass flatwoods environment. Both slash (*Pinus elliotii*) and longleaf (*P. palustris*) pine species have been implicated by several authors (Anderson and Williamson, 1976; Conant and Collins, 1991; and Goin, 1950) as the dominant overstory species. Breeding habitat has been reported variable as well, and includes shallow cypress ponds; cypress swamps; roadside ditches; ponds and swamps dominated by sweet and black gum trees; and open, marshy pasture ponds (Anderson and Williamson, 1976 and Martof, 1968).

This salamander apparently spends much of its life underground. Semlitsch (1983) has shown that other species of *Ambystoma* are at least able to passively burrow by using their snout and body to enlarge pre-existing holes in the lab, and Goin (1950) indicated that captive flatwoods salamanders were accomplished burrowers. Other Ambystomids have been found in underground sites in the field (Hamilton, 1946; Gordan, 1968; and Semlitsch, 1981), and Neill (1951) amplified the importance of crayfish burrows as emergence sites from underground retreats prior to the breeding season in *A. cingulatum*. Neill (1951) further reported animals found under logs and debris often run towards such openings when disturbed, and up to two or three animals have been found in a single crawfish burrow.

Courtship, spermatophore deposition, and egg laying occur on land during the fall (Anderson and Williamson, 1976). Williamson and Moulis (1979) indicated males often precede females into dry, temporary ponds and ditches during fall migrations by a few days. However, rainfall is probably the primary determinant for initiation of the breeding period. Anderson and Williamson (1977) noted that the spermatophore of *A. cingulatum* is very similar to that of *A. opacum* (see Noble and Brady, 1933), differing essentially in its smaller size. Other similarities between these two species may also exist and it is possible that like *A. opacum*, some females may enter breeding areas already fertile and ready to deposit eggs (see

Krenz and Scott, 1994).

Means (1972) reported eggs laid during mid-November from animals captured in western Florida hatched during the first week of December in the lab. However, Anderson and Williamson (1976) have indicated that larvae do not necessarily hatch upon reaching a hatchable size and stage, and that like *A. opacum*, they require inundation. They further noted that older (and further developed) eggs produced larger larvae. Thus, late fall or early winter rainfall determines when eggs actually hatch and eggs from a single pond may hatch over a rather long period of time (depending on the pond's depth and the period of time it takes to fill).

In addition, transformation may also be of an extended time period, beginning with the larger size class of larvae (from the earliest hatched eggs) towards the end of March and ending with the pond drying in May or June. In Florida, Mecham and Hellman (1952) reported larvae collected in mid March began transforming by the end of the month in the lab. Furthermore, Means (1972) found that larvae transformed in late April in the field, but were induced to transform in the lab during late March. Under field conditions, Palis (1995) postulated that growth rate and the extent of the larval period was likely correlated with water temperature.

Little has been reported of predation of this species in the wild. Williamson and Moulis (1979) noted a garter snake, *Thamnophis s. sirtalis*, which disgorged an adult *A. cingulatum* upon capture. However, predation of this species may be deterred because of concentrations of granular glands along the tail dorsum which produce a distasteful secretion (Brodie, 1977). Brodie et al. (1974) reported that all members of the subgenus *Linguaelapsus* in the genus of *Ambystoma* exhibit postures of immobility when threatened by a potential predator. Immobility has been suggested as a means of defensive behavior by serving to minimize stimulation for further attack (Gallup et al., 1971). Larval specimens which have not fully developed granular glands have been predated by crayfish in minnow traps, but whether this form of predation occurs to free-swimming larvae is unknown (pers. obs.).

### ***Pseudobranchus striatus*** (LeConte)

In many works the genus *Pseudobranchus* is treated as a single species containing five subspecies (Conant and Collins, 1991; Martof, 1972). More recently, Moler and Kezer (1993) have shown that this genus includes at least two chromosomally divergent species. In one species (*P. striatus*), N = 24 chromosomes and in the other (*P. axanthus*), N = 32 chromosomes. In addition, they noted that two of three Georgia populations north of the Altamaha River have a biarmed pair of chromosomes replaced by a pair of chromosomes with terminal centromeres (designated the 24-T karyomorph). Similar karyomorphs were found in the only population sampled from South Carolina as well as one population from Florida. However, the status of this unusual karyomorph await further research.

Members of the *Pseudobranchus* genus are small, slender, aquatic, eel-like salamanders which possess two front legs and no hind legs. Unlike the larger members of the *Siren* genus, each front foot has three toes, rather than four. They retain feathery gills throughout their lives, but these may be reduced in size during periods of drought. Patterns within the *Pseudobranchus* group consist of longitudinal stripes.

The form of dwarf siren found in South Carolina is the largest member of the dwarf siren complex, with a reported maximum size of 203 mm. (Moler and Mansell, 1986). In this form the basic body coloration is brown or light gray. A broad, dark brown, middorsal stripe with a thin light line running down the center is bordered on each side by a fairly broad cream to yellowish-orange stripe which tapers on the tail. A lower, narrow light stripe extends from the legs to the vent. The dark ventral and lateral portions are heavily mottled with yellowish pigments.

Bishop (1943) remarked that animals from Georgia and South Carolina are common in cypress ponds, where they hide among plants or burrow in the mud or muck along the bottom. Goin and Crenshaw (1949) considered the subspecies *spheniscus* as generally occurring in small to medium, shallow, limesink ponds, abounding in pond cypress (*Taxodium ascendens*) and black gum (*Nyssa biflora*). At Fort Stewart, Georgia, Williamson and Moulis (1979) found the subspecies *striatus* in cypress ponds, gum ponds, roadside ditches, branches, and creeks. Specimens can also be captured along the edges of borrow pits, where animals are usually associated with substantial leaf litter or the plant *Fimbristylis* (pers. obs.). In regions of sympatry further south, Moler and Kezer (1993) noted *P. striatus* is generally found in cypress ponds surrounded by acid pine flatwoods, while *P. axanthus* inhabits open marsh and open, prairie pond settings. Unlike *P. striatus*, they collected *P. axanthus* most readily from mats of floating water hyacinths (*Eichhornia crassipes*). However, they did secure *P. striatus* from somewhat similar floating mats of frog's bit (*Limnobium spongia*).

During drought conditions, *Pseudobranchus* tend to burrow into the mud at the bottom of their aquatic environment. Harper (1935*a*) noted recovering *Pseudobranchus* from a damp area in a dried-up swamp. Freeman (1958) reported the imprisonment of both *Pseudobranchus* and *Siren* in a segment of firm mud removed from a dried-up pond near Gainesville, Florida. In the case of the *Pseudobranchus*, the burrows were S-shaped tubes which were slightly longer than the resident animal's body. Under simulated drought conditions, Freeman (1958) found that individuals could survive at least two months of dry conditions, although when first recovered from their chambers, he remarked that their skins were not slimy and each had greatly reduced gills. He further noted that after one week in water the gills had returned to their normal size. In more recent work involving the energetics of estivating sirenids, Etheridge (1990) found that estivating *Pseudobranchus* had a 60-70% lower metabolic rate than non-estivating forms, and such estivators could survive several months without food.

Noble (1930) reported a female (TL=141 mm.) from Lakeland, Georgia collected in mid February laid a total of eleven eggs during March and early April. These eggs were laid singly or attached as pairs to the bottom of the container or the roots of a hyacinth. Similarly, Carr (1940*a*) noted eggs are scattered and attached to submerged grass. Noble (1930) originally indicated a single egg with its capsule measured 5 mm. in diameter, although in later work, Noble and Richards (1932) found that eggs laid by females induced by pituitary implants ranged from 5.5-6.0 mm.

Although it is somewhat unclear what foods are eaten in the wild, Noble (1930) indicated that captives will eat their own eggs. Harper (1935*a*) thought that the small mouth of *Pseudobranchus* restricted the size of its food to animals such as amphipods and chironomid larvae. Carr (1940*a*) stated that amphipods and chironomid larvae made up the bulk of the diet in *Pseudobranchus*. Duellman and Schwartz (1958) reported the major food item in the south Florida form of *Pseudobranchus* is aquatic oligochaetes. Freeman (1967) found amphipods, chironomid larvae, aquatic ~~oligochaetes, and~~ ostracods in the digestive tracts of *Pseudobranchus* taken in the vicinity of Gainesville, Florida.

Virtually nothing is known about natural enemies of members of the *Pseudobranchus* group. Individuals captured and confined to minnow traps have been preyed upon by crayfish, but whether this form of predation occurs to free-swimming sirens is unknown (pers. obs.). Other potential predators include fish, aquatic snakes, turtles, and certain salamanders (such as *Siren* and *Amphiuma*).

### ***Rana capito*** (LeConte)

*Rana areolata* and *R. capito* have been variously listed since their original descriptions. Cope (1875) placed the two in the same species and used the combination *R. areolata capito* for animals occurring in Georgia. Harper (1935*b*) believed that *R. areolata* and *R. capito* were two species, and that *aesopus* was a synonym of *capito*. Wright and Wright (1949) included three species in this group: *R. areolata*, *R. capito*, and *R. sevosa*. Neill (1957) listed only one species (i.e. *R. areolata*) which was composed of five subspecies. However, Conant and Collins (1991) follow the phylogenetic analysis of Hillis et al. (1983), and divide the group into two species, *R. areolata* (in the western portion of the range with two subspecies) and *R. capito* (in the east with three subspecies). In earlier work, Corcoran and Travis (1980) found that the karyotype of animals from North Carolina was distinct from those of either *R. pipiens* and *R. sphenocephala*.

LeConte (1855) originally described this species as a very rough, dark gray or slate-color frog speckled with black and rows of roundish spots on back. The sides are speckled and with irregularly marked spots of the same form and color. The underside is smooth, yellowish white, speckled, spotted and varied with a dusky coloration. The head is very large, broad, and blunt, with a deep concavity between the nostrils and the eye.

Neill (1957) pointed out that in Georgia specimens, breeding males have large and deep black vocal sacs. He further noted that animals from southern Richmond to central Screven counties were so very dark or slate-like above that the dorsal spots could scarcely be recognized, and that the venter was heavily marked with minute dark flecks aggregated to form a clouded or marbled pattern. In these specimens the dorsolateral fold was colored like the body, and the warts on the back were large, numerous and close together, almost "pavement-like."

In describing larvae from the Okefenokee Swamp, Wright (1932) said that at times this tadpole has a very greenish cast and that the color of the top of the head varied from yellowish to olive green. There are about four irregular series of black spots between the series of spots along the two lateral lines of the body, and several fairly large spots on top of the head. The tail is a light greenish brown with the muscular and upper portions of tail fin with large black spots. The lower fin is without large distinct spots, except for the terminal portion.

However, as pointed out by Braswell (1993), gopher frog tadpoles are difficult to identify, and established keys on tadpole identification (Altig, 1970; Travis, 1981) are somewhat misleading when separating *R. capito* and *R. sphenocephala*. Braswell (1993) indicated that *R. sphenocephala* larvae are usually darker than *R. capito* larvae when the two are found together. In clear water, *R. sphenocephala* larvae often exhibit a very dark tail, a condition not observed in *R. capito*. Also, the skin of *R. capito* tadpoles has a more translucent appearance than that of *sphenocephala*, and the leading edge of the dorsal fin extends further onto the body than that of *sphenocephala*. In the latter stages of development, *R. capito* tadpoles are much larger than *R. sphenocephala* larvae.

LeConte (1855) in his original description of this frog wrote that it "inhabits Georgia in the ditches of the rice fields." However, some writers have inferred that the holotype of *R. c. capito* was not necessarily from Riceboro (Neill, 1957, Schwartz and Harrison, 1956). Williamson and Moulis (1979) indicated that populations of gopher frogs were localized in pine flatwoods and dwarf oak forests surrounding suitable breeding areas. Although dry, sandy habitat is preferred, the area may or may not be associated with gopher tortoises, *Gopherus polyphemus*. They included cypress ponds and borrow pits as suitable breeding areas.

Throughout much of its range *R. capito* is often associated with areas containing the gopher tortoise, *Gopherus polyphemus*. Deckert (1914) first reported the occurrence of this species within the burrows of gopher tortoises in Florida, and as many as two or three individuals could be found in the same tortoise burrow. The association between this frog and the gopher tortoise has been remarked upon by several additional authors (Campbell and Christman, 1982; Franz, 1984; Franz et al., 1988; Hallinan, 1923; and Wright, 1932). However, the gopher tortoise is restricted to extreme southeastern South Carolina, and is not known to occur within the area of proposed railway routes. In Florida, Hallinan (1923) found specimens in loose sand and in a hole under a dead stump, in addition to individuals taken in gopher burrows, and Lee (1968) found *R. capito* in two species of

*Peromyscus* mice burrows. Also, Wright (1932) mentioned occasionally taking these frogs in the Okefenokee Swamp from cover other than tortoise burrows, and suggested rat burrows. Braswell (1993) commented that in North Carolina (where there are no *Gopherus* populations), *R. capito* probably uses a variety of animal burrows, stump holes, and other ground cavities in upland habitats as refuge.

Carr (1940*a*) suggested that this species may travel quite some distance from their upland habitat to their aquatic breeding area, as he had discovered specimens a mile (1.6 km) from water. Franz et al. (1988) have recorded an adult female travelling 2.0 km from a breeding pond to the entrance of a gopher tortoise burrow located in a disturbed longleaf pine-turkey oak site dominated by planted slash pine.

The breeding season in this frog can be quite variable. In Alabama, breeding normally takes place in winter and early spring, but some breeding may take place in the fall following heavy rainfalls associated with hurricanes (Bailey, 1991). Palis (1998) reported three temporally discrete breeding periods occurred during an eight month breeding season in a Florida population. However, Godley (1992) indicated that although gopher frogs in Florida may breed throughout the year (see Carr, 1940*b*), most reproduction (especially in northern Florida) occurs from February through April. Similarly, most of the Georgia specimens listed by Williamson and Moulis (1994) were collected between January and May, and Semlitsch et al. (1995) concluded from 25 years of data from South Carolina that the breeding season occurred between January and April, and usually lasted only a few days.

Deckert (1920) found that a captive specimen from South Carolina accepted mealworms, roaches, spiders, and occasionally earthworms. Braswell (1993) thought that gopher frogs probably eat almost any small animal they can catch, and that captives readily fed on crickets, earthworms, and baby mice. Barbour (1920) noted this frog's habit of feeding on the oak toad, *Bufo quercicus*, and Dickerson (1906) listed larger members of the *Bufo* group (*fowleri* and *terrestris*) accepted by captive specimens.

Some information is available on enemies of this species in various articles. Brandt (1953) indicated a specimen taken in early March which had lost the greater part of one hind leg in a recent accident. Although no predator was implied by Brandt (1953), Wright (1932) reported another which had lost the left leg past the thigh and suggested a turtle may have caused the injury. Williamson and Moulis (1979) mentioned a *R. capito* which was found in a breeding pond grasped by an adult *Kinosternon subrubrum*. Wright (1932) also felt that various snakes and carnivorous mammals may pose a threat to gopher frogs within their upland habitat. He indicated that water snakes (*Nerodia* ssp.) and cottonmouths (*Agkistrodon piscivorus*) could represent formidable enemies during this frog's breeding period. In addition, Moulis (1995) mentioned a giant water bug (*Lethocerus*) which was feeding on a transforming larvae in Georgia. Furthermore, Cronin and Travis (1986) found that two species of backswimmers (*Notonecta*) consumed larval stages of the gopher frog, but this predation decreased as tadpole size increased.

**Voice:** Deckert (1920) compared the call to a loud snore similar to that of *Rana pipiens* [*sphenocephala*], but much coarser and louder. He further stated that the duration of each call is between three and five seconds, and the interval between calls is about two seconds.

**Methods**

In order to determine whether any or all of the three target species exist within the vicinity of proposed rail corridors, a survey was conducted during the spring of 1998. A total of 65 aquatic sites situated near and along prospective rail corridors was sampled during this survey. All field work was conducted from 21 April 1998 through 2 May 1998. However, supplemental data for some ponds were obtained on 1 July 1998, when certain ponds were revisited in order to confirm their location coordinates. Sampling was primarily conducted by dip-netting prospective larval habitat with 5' standard landing nets having a 15.5" x 14.5" opening and 3/16" mesh netting. Dip-netting was concentrated in areas of moderate to dense vegetation, leaf litter, or where ambystomid larvae were seen stratifying. Additional sampling was conducted with plastic, funnel-ended minnow traps measuring 16 3/4" long and 8 3/4" at their largest diameter, and having a 3/16" square mesh. Unbaited minnow traps were set in ponds and left over night. Such traps were checked the following morning. A total of 87.25 man-hours were devoted to dip-netting while trapping collectively encompassed a total of 280 trap nights.

Aquatic sites were located with the use of Garmin GPS receivers (GPS 40 or GPS II), and later transferred to maps created in Street Atlas USA Ver. 4.0 (Fig. 5). Sites were classified to one of nineteen different pond types which in turn was determined by the major overstory plant species present. Each aquatic site was evaluated on the basis of habitat condition of both the sampling site and the surrounding uplands, habitat type, the presence of potential prey for larval forms, and possible predatory fish species (see Table 1). Although most herpetofauna species were identified from captured individuals, some species of frogs were identified by their calls, rather than an actual specimen. Uplands associated with aquatic sampling sites were also sampled for terrestrial forms of both *A. cingulatum* and *R. capito*. Pertinent data from each pond surveyed were recorded on data sheets specifically developed for this project (Fig. 6). Upland sampling primarily consisted of turning logs, loose bark, and other forms of cover which may be used by these secretive animals as daytime retreats. Roads in and near the entire sampling area were also checked for living and road-killed reptile and amphibian species when possible. All voucher specimens are retained in the herpetological collection at the Savannah - Ogeechee Canal Museum (SOCM).

**Results and Discussion**

A total of 65 aquatic sites were investigated during the course of this survey (Table 1). Because extensive saltwater marshlands (an environment not recognized as characteristic *A. cingulatum* habitat) occupies a majority of the southern half of the entire study area, survey work was concentrated in the northern portion of the proposed corridor region. In all, *A. cingulatum* was found at only one site (site #016), while the gopher frog, *R. capito*, was encountered at three sites (site #012, 061, and 062). During survey work two reptiles recommended as species of special concern (see Gibbons et al., 1976), were also discovered. These species are the spotted turtle, *Clemmys guttata*, and the slender glass lizard, *Ophisaurus [attenuatus] longicaudus*. All herpetofauna recorded from surveyed ponds were identified from captured individuals or by voice in the case of some frogs (Table 2). Specimens retained as vouchers were deposited in the herpetological collection at the SOCM (Table 3).

It could be argued that survey work conducted during late April/early May for larval stages of *A. cingulatum*, may have taken place too late in the larval period. In studies undertaken further to the south in Jasper County, the earliest date in which *A. cingulatum* metamorphs were found was 25 April (pers. obs.). However, it is likely that the wetter and warmer than normal winter and spring seasons of 1997-98 may have allowed early filling of ponds and a shorter larval period. If this is the case, it is possible that larval forms may have emigrated from aquatic habitat prior to our arrival. Palis (1995) has suggested that growth rate and the length of the larval period is likely correlated with water temperature in Florida populations.

Another argument could be made that sampling conducted during a single season may be inadequate to base the absence of *A. cingulatum* from an area. Semlitsch et al. (1995) has also questioned the successfulness of such short-term surveys of breeding sites regarding *R. capito* because: breeding populations are small in size; the frequency of breeding among years appears very low; the breeding period is short (generally less than two weeks); and successful metamorphs rarely recruit into the adult population. Information gathered at a recent flatwoods salamander conservation meeting held at Valdosta State University on 7 May 1998 suggest that potential larval habitat be sampled at least twice during a single season (separated by a 3-4 week period), and be supplemented by two series of funnel trapping lasting two nights each. In addition, such sampling should be conducted during two consecutive years to better assure the actual absence of this species from a possible breeding site.

It is unknown what effects habitat disturbance, such as rail corridor construction, would have on a flatwoods salamander population. Site preparation and construction could form potential barriers between aquatic breeding areas and upland adult habitat. Studies involving amphibian communities situated within disturbed areas indicate a general decline in population sizes. In Oregon studies, salamander biomass appeared directly related to stream gradient and the associated sedimentation rate in clear-cut versus old-growth coniferous forests (Murphy and Hall, 1981; Bury and Corn, 1988; Corn and Bury, 1989). Bennett et al. (1980) indicated long-term pine monoculture in South Carolina supported smaller population sizes but allowed development of a variety of amphibian niches which otherwise would not have been available. Enge and Marion (1986) found that clearcutting a flatwoods community in Florida lowered amphibian population sizes but did not affect species richness. Additionally this latter study showed populations recovered by the third year after habitat disturbance. Such information may indicate that the proposed rail line construction may have only a temporary impact on the herpetofauna of the area disturbed.

The affects of corridor construction on adjacent, undisturbed aquatic breeding sites is also unknown. In a Louisiana study which focused on an amphibian community within an unaltered breeding area, but subject to impacts from alterations in adjacent habitat, *Ambystoma talpoideum* appeared to be affected in two ways. First, adults immigrating from clear-cut portions of the terrestrial habitat appeared to suffer greater mortality between breeding seasons. Second, a shift of adults from clear-cut habitat into unaltered terrestrial habitat which seemed less suitable prior to habitat disturbance appeared to occur (Raymond and Hardy, 1991).

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Appendix

Table 1. Sites dip-netted during 1998 survey for flatwoods salamanders along proposed RR corridors for Daniels Island project in Berkeley County, South Carolina.

[cut off]e "Pond Type" is generalized from major overstory species present; "% Overstory" indicates canopy cover; "Pond Size" represents approximate size of wetland in acres; "Man-hours" depicts sampling time in pond.

| e # | Field Designation | Map # | Date | General Location | Coordinates | Pond Type | % Overstory | Pond Size | Man-hour(s) | Hab. Suit.* |
|---|---|---|---|---|---|---|---|---|---|---|
| 01 | Brick House 1 | | 21 Apr 98 | Francis Marion National Forest | N32°57.58' W79°51.06' | Cypress/gum pond | 70 | 3 | 1 | Good |
| 02 | FS 188-S1** | | 21 Apr 98*** | Francis Marion National Forest | N32°57.559' W79°51.190' | Open gum pond | 10 | 2.5 | 2 | Good |
| 03 | FS 188-N1 | | 21 Apr 98 | Francis Marion National Forest | N32°57.595' W79°51.109' | Gum pond | 75 | 2 | 1.33 | Poor |
| 04 | FS 188-N2 | | 21 Apr 98 | Francis Marion National Forest | N32°57.53' W79°50.99' | Cypress/gum pond | 60 | 10 | 1.33 | Marginal |
| 05 | FS 188-N3 | | 21 Apr 98 | Francis Marion National Forest | N32°57.637' W79°50.406' | Open gum pond | 15 | 2.5 | 1.33 | Good |
| 06 | Hwy 98-E1 | | 21 Apr 98 | Francis Marion National Forest | N32°57.591' W79°51.336' | Hardwood pond | 75 | 1.5 | 1.33 | Fair |
| 07 | Hwy 98-E2 | | 21 Apr 98 | Francis Marion National Forest | N32°57.588' W79°51.336' | Borrow pit | 5 | <0.5 | 0.67 | Poor |
| 08 | FT-N1 | | 22 Apr 98 | Francis Marion National Forest | N32°56.87' W79°50.36' | Gum/bay pond | 40 | 2 | 1 | Good |
| 09 | FT-N2 | | 22 Apr 98 | Francis Marion National Forest | N32°57.00' W79°50.26' | Mixed woods pond | 50 | 5 | 2 | Good |
| 10 | FT-N3 | | 22 Apr 98 | Francis Marion National Forest | N32°57.05' W79°50.14' | Open gum pond | 10 | 2 | 1.67 | Good |
| 11 | FT-N4 | | 22 Apr 98 | Francis Marion National Forest | N32°56.97' W79°50.11' | Open mixed woods pond | 20 | 4 | 2.33 | Good |
| 12 | FT-N5 | | 22 Apr 98 | Francis Marion National Forest | N32°56.92' W79°50.01' | Cypress/hardwood pond | 70 | 20 | 2 | Excellent |
| 13 | FS 188-S2 | | 22 Apr 98 | Francis Marion National Forest | N32°57.538' W79°50.931' | Open grassy pond | 1 | 0.5 | 0.67 | Good |
| 14 | FS 188-S3 | | 22 Apr 98 | Francis Marion National Forest | N32°57.566' W79°50.637' | Mixed woods pond | 85 | 8 | 1 | Poor |
| 15 | FS 188-S4 | | 22 Apr 98 | Francis Marion National Forest | N32°57.610' W79°50.203' | Mixed woods pond | 65 | 10 | 1.33 | Poor |
| 16 | FS 188-S5** | | 22 Apr 98 | Francis Marion National Forest | N32°57.825' W79°49.884' | Pinewoods depression | 10 | 1 | 1.67 | Excellent |
| 17 | FS 188-S6** | | 22 Apr 98 | Francis Marion National Forest | N32°57.887' W79°49.711' | Mixed woods pond | 10 | 1.5 | 1.33 | Excellent |
| 18 | FS 188-S7** | | 22 Apr 98 | Francis Marion National Forest | N32°57.912' W79°49.653' | Mixed woods pond | 10 | 1.5 | 2 | Excellent |
| 19 | Amoco #1 | | 23 Apr 98 | Amoco property off SC 98 | N32°58.029' W79°51.477' | Gum pond | 40 | 4 | 2.67 | Fair |
| 20 | Amoco #2 | | 23 Apr 98 | Amoco property off SC 98 | N32°58.147' W79°51.469' | Gum/maple pond | 55 | 5 | 1.33 | Fair |
| 21 | Amoco #3 | | 23 Apr 98 | Amoco property off SC 98 | N32°58.177' W79°51.499' | Hardwood pond | 15 | 1 | 1.67 | Good/Fair |
| 22 | Amoco #4 | | 23 Apr 98 | Amoco property off SC 98 | N32°58.243' W79°51.588' | Hardwood pond | 50 | 20 | 4 | Fair |
| 23 | Amoco #5 | | 23 Apr 98 | Amoco property off SC 98 | N32°58.268' W79°51.578' | Gum pond | 30 | 3 | 1.33 | Good |
| 24 | Amoco #6 | | 23 Apr 98 | Amoco property off SC 98 | N32°58.372' W79°51.562' | Mixed woods pond | 45 | 2 | 0.67 | Good |
| 25 | Amoco #7 | | 23 Apr 98 | Amoco property off SC 98 | N32°58.512' W79°51.307' | Cypress/gum pond | 60 | 20 | 3.33 | Excellent |
| 26 | Gut #1 | | 24 Apr 98 | Cainhoy Plantation off SC 98 | N32°57.627' W79°50.598' | Gum pond | 20 | <0.5 | 0.25 | Good |
| 27 | Gut #2 | | 24 Apr 98 | Cainhoy Plantation off SC 98 | N32°56.596' W79°50.770' | Open gum pond | 5 | 4 | 1 | Good |
| 28 | Gut #3 | | 24 Apr 98 | Cainhoy Plantation off SC 98 | N32°56.66' W79°50.86' | Pinewoods depression | 10 | <0.5 | 0.67 | Good |
| 29 | Gut #4 | | 24 Apr 98 | Cainhoy Plantation off SC 98 | N32°56.794' W79°50.834' | Pinewoods depression | 5 | <0.5 | 0.33 | Good |
| 30 | Gut #5 | | 24 Apr 98 | Cainhoy Plantation off SC 98 | N32°56.596' W79°50.535' | Pine/oak pond | 40 | 1 | 1 | Good |
| 31 | FS 188-N4 | | 26 Apr 98 | Francis Marion National Forest | N32°57.857' W79°49.844' | Cypress/gum pond | 70 | 5 | 1.5 | Fair |
| 32 | FS 188-N5 | | 26 Apr 98 | Francis Marion National Forest | N32°57.920' W79°49.953' | Gum pond | 50 | 3 | 1.67 | Good |
| 33 | FS 188-S8 | | 26 Apr 98 | Francis Marion National Forest | N32°58.060' W79°48.979' | Gum pond | 20 | 1.5 | 1 | Fair |
| 34 | FS 188-N6 | | 26 Apr 98 | Francis Marion National Forest | N32°58.014' W79°49.492' | Gum/bay pond | 70 | 2 | 1 | Marginal |
| 35 | FS 189A-W1 | | 26 Apr 98 | Francis Marion National Forest | N32°57.998' W79°49.646' | Mixed woods pond | 30 | 2 | 1 | Fair |
| 36 | FS 189A-W2 | | 26 Apr 98 | Francis Marion National Forest | N32°58.140' W79°49.604' | Gum pond | 80 | 5 | 1 | Marginal |
| 37 | FS 189A-E1** | | 26 Apr 98 | Francis Marion National Forest | N32°58.586' W79°49.660' | Gum/maple pond | 45 | 3.5 | 1.67 | Good |
| 38 | Gut #6 | | 27 Apr 98 | Cainhoy Plantation off SC 98 | N32°56.51' W79°50.55' | Gum/pine pond | <5 | <0.5 | 0.67 | Good |
| 39 | Gut #7 | | 27 Apr 98 | Cainhoy Plantation off SC 98 | N32°56.40' W79°50.79' | Pinewoods depression | 25 | <0.5 | 1.33 | Fair |
| 40 | Gut #8 | | 27 Apr 98 | Cainhoy Plantation off SC 98 | N32°56.31' W79°50.85' | Mixed woods pond | 10 | 1.5 | 1 | Marginal |
| 41 | Gut #9 | | 27 Apr 98 | Cainhoy Plantation off SC 98 | N32°56.38' W79°50.90' | Gum/bay pond | 10 | 0.5 | 1 | Fair |
| 42 | Gut #10 | | 27 Apr 98 | Cainhoy Plantation off SC 98 | N32°56.43' W79°50.66' | Open grassy pond | 0 | <0.5 | 0.67 | Fair |
| 43 | FS 189A/RR#1 | | 27 Apr 98 | Francis Marion National Forest | N32°58.68' W79°49.98' | Mixed woods pond | 65 | 3 | 0.67 | Marginal |
| 44 | FS 189A/RR#2 | | 27 Apr 98 | Francis Marion National Forest | N32°58.600' W79°50.056' | Gum pond | 40 | 1 | 1 | Fair |
| 45 | FS 189A/RR#3 | | 27 Apr 98 | Francis Marion National Forest | N32°58.607' W79°50.034' | Gum pond | 40 | 1 | 1.17 | Fair |
| 46 | Willie's Pond | | 27 Apr 98*** | Francis Marion National Forest | N32°57.95' W79°50.10' | Open grassy pond | 0 | <0.5 | 1.5 | Excellent |
| 47 | Cainhoy #1 | | 28 Apr 98 | Cainhoy Plantation off SC 33 | N32°55.57' W79°52.98' | Gum pond | 50 | 1 | 1.33 | Good |
| 48 | Cainhoy #2 | | 28 Apr 98 | Cainhoy Plantation off SC 33 | N32°55.63' W79°52.97' | Oak/pine depression | 15 | 1 | 1 | Excellent |
| 49 | Cainhoy #3 | | 28 Apr 98 | Cainhoy Plantation off SC 33 | N32°55.61' W79°52.79' | Bay pond | <5 | 1.5 | 1 | Good |
| 50 | 5-E-1 | | 28 Apr 98 | Behind sand pit off SC 33 | N32°54.79' W79°54.78' | Bay/gum pond | near 100 | 1 | 0.67 | Marginal |
| 51 | 5-F-1 | | 28 Apr 98 | Behind sand pit off SC 33 | N32°55.19' W79°54.19' | Pinewoods depression | <5 | 4 | 2 | Fair |
| 52 | Cainhoy #4 | | 29 Apr 98 | Cainhoy Plantation off SC 33 | N32°56.645' W79°53.105' | Mixed woods pond | 40 | 5 | 2.5 | Good |
| 53 | Cainhoy #5 | | 29 Apr 98 | Cainhoy Plantation off SC 33 | N32°57.386' W79°52.180' | Mixed woods pond | 35 | 3.5 | 1.67 | Excellent |
| 54 | Cainhoy #7 | | 29 Apr 98 | Cainhoy Plantation off SC 33 | N32°57.339' W79°52.207' | Cypress/oak/gum pond | 45 | 10 | 2.5 | Good |
| 55 | Cainhoy #8 | | 29 Apr 98 | Cainhoy Plantation off SC 33 | N32°57.197' W79°52.423' | Open grassy pond | <5 | 2 | 1 | Excellent |
| 56 | Cainhoy #9 | | 29 Apr 98 | Cainhoy Plantation off SC 33 | N32°57.045' W79°52.634' | Cypress/gum pond | 60 | 2.5 | 1 | Excellent |
| 57 | Cainhoy #6 | | 29 Apr 98 | Cainhoy Plantation off SC 33 | N32°57.17' W79°53.22' | Cypress/oak pond | 30 | 15 | 1.33 | Fair |
| 58 | Cainhoy #00 | | 29 Apr 98 | Cainhoy Plantation off SC 33 | N32°56.78' W79°53.07' | Gum pond | 25 | 5 | 0.67 | Fair |
| 59 | 5-3-1 | | 30 Apr 98 | Cainhoy Plantation off SC 33 | N32°54.458' W79°53.959' | Hardwood pond | 80 | 3 | 1.67 | Marginal |
| 60 | 3-C-1 | | 30 Apr 98 | Cainhoy Plantation off SC 33 | N32°55.21' W79°52.13' | Gum pond | 20 | <0.5 | 1.67 | Marginal |
| 61 | Cainhoy #10** | | 30 Apr 98*** | Cainhoy Plantation off SC 33 | N32°55.979' W79°52.675' | Open grassy pond | 0 | 2 | 1 | Excellent |
| 62 | FMNF #1 | | 30 Apr 98*** | Francis Marion National Forest | N32°57.147' W79°50.410' | Cypress pond | 60 | 8 | 2 | Excellent |
| 63 | Cainhoy #11 | | 01 May 98 | Cainhoy Plantation off SC 33 | N32°56.053' W79°52.522' | Gum/pine pond | 30 | 1 | 2.33 | Good |
| 64 | Cainhoy #12 | | 01 May 98 | Cainhoy Plantation off SC 33 | N32°56.994' W79°52.534' | Gum/bay pond | 60 | <1 | 1 | Good |
| 65 | RR #1** | | 02 May 98 | Francis Marion National Forest | N32°58.434' W79°51.128' | Gum/pine pond | 50 | 5 | 0.25 | Good |

[cut off]Hab. Suit. derived subjectively by principle investigators on basis of pond type, water depth, presence of fish, other herpetofauna encountered, etc.

[cut off]Pond sampled with funnel-ended minnow traps, man-hours represents time dip-netting pond only.

[cut off]Pond sampled on more than one occasion, man-hours represents total dip-netting time from all visits combined.

Table 2. Herpetofauna encountered at wetlands sampled during 1998 flatwoods salamander survey. No species were found at site 5.

| Site # | Species Encountered |
|---|---|
| 001 | *Rana virgatipes, Diadophis punctatus, Eumeces sp.* |
| 002 | *Ambystoma mabeei, A. talpoideum, Pseudacris ocularis, P. ornata, Rana clamitans**, *R. sphenocephala, Eumeces inexpectatus* |
| 003 | *Rana virgatipes** |
| 004 | *Rana virgatipes* |
| 006 | *Ambystoma mabeei, A. talpoideum, Rana sphenocephala* |
| 007 | *Rana sphenocephala* |
| 008 | *Rana clamitans**, *Anolis carolinensis* |
| 009 | *Rana clamitans**, *Rana sphenocephala, Anolis carolinensis* |
| 010 | *Pseudacris ocularis, Rana clamitans, R. sphenocephala, R. virgatipes, Eumeces fasciatus* |
| 011 | *Acris gryllus, Pseudacris ocularis, Rana clamitans**, *R. virgatipes, Anolis carolinensis* |
| 012 | *Rana capito, R. clamitans, Anolis carolinensis, Lampropeltis triangulum, Thamnophis sirtalis* |
| 013 | *Pseudacris ocularis, Rana sphenocephala* |
| 014 | *Eurycea quadridigitata* |
| 015 | *Tantilla coronata* |
| 016 | *Acris gryllus**, *Ambystoma cingulatum, Rana sphenocephala, R. virgatipes* |
| 017 | *Ambystoma talpoideum, Pseudacris ornata,Rana sphenocephala, R. virgatipes* |
| 018 | *Acris gryllus**, *Ambystoma mabeei, A. talpoideum, Pseudacris ocularis, P. ornata, Rana sphenocephala, Diadophis punctatus* |
| 019 | *Amphiuma means, Pseudacris ocularis, Rana clamitans, Eumeces inexpectatus* |
| 020 | *Rana clamitans, R. virgatipes* |
| 021 | *Rana sphenocephala, R. virgatipes, Eumeces fasciatus* |
| 022 | *Acris gryllus, Eurycea quadridigitata, Plethodon variolatus, Rana catesbeiana**, *R. clamitans, Anolis carolinensis, Eumeces fasciatus, Tantilla coronata* |
| 023 | *Ambystoma mabeei, Eurycea quadridigitata, Virginia striatula* |
| 024 | *Eurycea quadridigitata, Rana clamitans, R. sphenocephala* |
| 025 | *Ambystoma mabeei, A. talpoideum, Rana clamitans, R. sphenocephala, Diadophis punctatus* |
| 026 | *Acris gryllus, Ambystoma talpoideum, Pseudacris ocularis, Rana sphenocephala* |
| 027 | *Acris gryllus**, *Rana sphenocephala, Eumeces sp., Tantilla coronata* |
| 028 | *Ambystoma talpoideum, Rana clamitans, R. sphenocephala, Rana virgatipes* |
| 029 | *Pseudacris ocularis, Rana sphenocephala* |
| 030 | *Bufo quercus, Pseudacris ocularis, P. ornata, Rana sphenocephala* |
| 031 | *Ambystoma talpoideum, Rana clamitans**, *R. sphenocephala, R. virgatipes**, *Siren intermedia, Eumeces fasciatus, Nerodia erythrogaster, Tantilla coronata* |
| 032 | *Ambystoma talpoideum, Rana sphenocephala, R. virgatipes* |
| 033 | *Acris gryllus**, *Rana sphenocephala, R. virgatipes* |
| 034 | *Eurycea quadridigitata, Rana sphenocephala, R. virgatipes* |
| 035 | *Eurycea quadridigitata, Rana virgatipes* |
| 036 | *Eurycea quadridigitata, Pseudacris ocularis, Rana clamitans, R. sphenocephala, R. virgatipes* |
| 037 | *Ambystoma mabeei, A. talpoideum, Pseudacris ocularis, Rana virgatipes* |
| 038 | *Rana sphenocephala* |
| 039 | *Pseudacris ornata, Rana sphenocephala* |
| 040 | *Rana clamitans, R. sphenocephala, Eumeces inexpectatus* |
| 041 | *Acris gryllus, Eurycea quadridigitata, Rana sphenocephala* |
| 042 | *Rana sphenocephala, Coluber constrictor* |
| 043 | *Eurycea quadridigitata, Anolis carolinensis* |

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Table 2 con't.

| Site # | Species Encountered |
|---|---|
| 044 | *Ambystoma talpoideum, Eurycea quadridigitata, Rana sphenocephala, Lampropeltis triangulum* |
| 045 | *Ambystoma talpoideum, Eurycea quadridigitata, Rana sphenocephala, Lampropeltis getula* |
| 046 | *Ambystoma mabeei, A. talpoideum, Pseudacris ocularis, Rana sphenocephala, R. virgatipes* |
| 047 | *Acris gryllus, Rana clamitans** |
| 048 | *Rana sphenocephala, Thamnophis sauritus* |
| 049 | *Acris gryllus*, Rana sphenocephala* |
| 050 | *Cnemidopherus sexlineatus* |
| 051 | *Acris gryllus*, Pseudacris ocularis, Rana sphenoceophala, Anolis carolinensis, Coluber constrictor* |
| 052 | *Rana sphenocephala* |
| 053 | *Acris gryllus*, Ambystoma talpoideum, Rana sphenocephala, Anolis carolinensis* |
| 054 | *Rana clamitans, R. sphenocephala, Scaphiopus holbrookii, Eumeces fasciatus, Rhadinea flavilata* |
| 055 | *Rana sphenocephala, Virginia striatula* |
| 056 | *Rana sphenocephala, Sceloperus undulatus* |
| 057 | *Acris gryllus*, Rana clamitans* |
| 058 | *Rana sphenocephala* |
| 059 | *Ambystoma talpoideum, Rana sphenocephala, Kinosternon subrubrum* |
| 060 | *Rana sphenocephala, Clemmys guttata, Kinosternon subrubrum* |
| 061 | *Ambystoma mabeei, A. talpoideum, Acris gryllus, Hyla femoralis, H. gratiosa, Rana capito, R. sphenocephala* |
| 062 | *Acris gryllus, Ambystoma talpoideum, Hyla femoralis, Rana capito, R. catesbeiana, R. sphenocephala, R. virgatipes, Deirochelys reticularia, Eumeces inexpectatus, Lampropeltis triangulum, Tantilla coronata* |
| 063 | *Acris gryllus*, Hyla femoralis, Pseudacris ocularis, Rana sphenocephala, Eumeces inexpectatus, Lampropeltis triangulum, Virginia striatula* |
| 064 | *Acris gryllus*, Rhadinea flavilata, Storeria occipitomaculata, Tantilla coronata, Virginia striatula* |
| 065 | *Rana sphenocephala, R. virgatipes, Coluber constrictor* |

Note: * indicates frog species identified by call only.

Table 3. Voucher specimens taken during 1998 flatwoods salamander survey in Berkeley County, South Carolina.

| SOCM # | Species | Location | Remarks |
|---|---|---|---|
| 0638 | *Rana virgatipes* | Brick House 1 | 2 subadults |
| 0639 | *Diadophis punctatus* | Brick House 1 | adult ♀ |
| 0640 | *Rana sphenocephala* | FS 188–S1 | 5 larvae |
| 0641 | *Pseudacris ocularis* | FS 188–S1 | larva |
| 0642 | *Pseudacris ornata* | FS 188–S1 | larva |
| 0643 | *Ambystoma talpoideum* | FS 188–S1 | 9 larvae |
| 0645 | *Ambystoma mabeei* | FS 188–S1 | 3 larvae |
| 0644 | *Rana virgatipes* | FS 188–N2 | larva |
| 0649 | *Ambystoma talpoideum* | Hwy 98–E1 | larva |
| 0650 | *Ambystoma mabeei* | Hwy 98–E1 | larva |
| 0651 | *Rana sphenocephala* | Hwy 98–E1 | 7 larvae |
| 0652 | *Rana sphenocephala* | FT–N2 | larva |
| 0646 | *Rana virgatipes* | FT–N3 | larva |
| 0647 | *Rana sphenocephala* | FT–N3 | 3 larvae |
| 0646 | *Rana clamitans* | FT–N3 | 8 larvae |
| 0653 | *Acris gryllus* | FT–N4 | adult |
| 0654 | *Anolis carolinensis* | FT–N4 | adult ♂ |
| 0655 | *Acris gryllus* | FT–N4 | adult |
| 0656 | *Rana clamitans* | FT–N4 | larva |
| 0657 | *Rana virgatipes* | FT–N4 | larva |
| 0659 | *Rana clamitans* | FT–N5 | 4 transformlings |
| 0660 | *Rana capito* | FT–N5 | larva |
| 0691 | *Lampropeltis triangulum* | FT–N5 | adult ♂ |
| 0661 | *Eurycea quadridigitata* | FS 188–S3 | 4 larvae |
| 0658 | *Tantilla coronata* | FS 188–S4 | adult ♀ |
| 0662 | *Ambystoma cingulatum* | FS 188–S5 | larva |
| 0663 | *Pseudacris ornata* | FS 188–S6 | 3 larvae |
| 0664 | *Rana sphenocephala* | FS 188–S6 | 6 larvae |
| 0665 | *Ambystoma talpoideum* | FS 188–S6 | 4 larvae |
| 0666 | *Ambystoma mabeei* | FS 188–S7 | 7 larvae |
| 0667 | *Ambystoma talpoideum* | FS 188–S7 | 4 larvae |
| 0668 | *Rana sphenocephala* | FS 188–S7 | 2 larvae |
| 0669 | *Pseudacris ocularis* | FS 188–S7 | larva |
| 0670 | *Pseudacris ornata* | FS 188–S7 | 2 larvae |
| 0671 | *Diadophis punctatus* | FS 188–S7 | adult ♀ |
| 0709 | *Amphiuma means* | Amoco #1 | subadult |
| 0672 | *Rana clamitans* | Amoco #1 | 8 larvae |
| 0673 | *Eumeces inexpectatus* | Amoco #1 | subadult |
| 0674 | *Rana virgatipes* | Amoco #2 | subadult |
| 0675 | *Eumeces fasciatus* | Amoco #3 | adult ♂ |
| 0676 | *Rana sphenocephala* | Amoco #3 | 2 larvae |
| 0677 | *Rana virgatipes* | Amoco #3 | adult |
| 0678 | *Acris gryllus* | Amoco #4 | adult |
| 0679 | *Eurycea quadridigitata* | Amoco #4 | adult |
| 0680 | *Rana clamitans* | Amoco #4 | larva |
| 0681 | *Tantilla coronata* | Amoco #4 | adult ♂ |
| 0682 | *Virginia striatula* | Amoco #5 | adult ♀ |
| 0683 | *Eurycea quadridigitata* | Amoco #5 | larva |
| 0684 | *Ambystoma mabeei* | Amoco #5 | 7 larvae |
| 0685 | *Eurycea quadridigitata* | Amoco #6 | larva |
| 0686 | *Rana clamitans* | Amoco #6 | 3 larvae |
| 0687 | *Rana sphenocephala* | Amoco #7 | 6 larvae |
| 0688 | *Rana clamitans* | Amoco #7 | 2 larvae |
| 0689 | *Ambystoma talpoideum* | Amoco #7 | 8 larvae |

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Table 3 con't.

| SOCM # | Species | Location | Remarks |
|---|---|---|---|
| 0690 | *Ambystoma mabeei* | Amoco #7 | larva |
| 0692 | *Rana sphenocephala* | Gut #1 | 3 larvae |
| 0693 | *Ambystoma talpoideum* | Gut #1 | 4 larvae |
| 0694 | *Tantilla coronata* | Gut #2 | subadult ♀ |
| 0695 | *Rana clamitans* | Gut #3 | 3 larvae |
| 0696 | *Rana virgatipes* | Gut #3 | larva |
| 0697 | *Ambystoma talpoideum* | Gut #3 | 8 larvae |
| 0705 | *Sceloperus undulatus* | Gut #3 | adult ♀ |
| 0698 | *Rana sphenocephala* | Gut #4 | 3 larvae |
| 0699 | *Pseudacris ocularis* | Gut #4 | 3 larvae |
| 0703 | *Lampropeltis triangulum* | Gut #4 | adult ♂ |
| 0706 | *Plethodon variolatus* | Gut #4 | adult |
| 0707 | *Diadophis punctatus* | Gut #4 | adult ♀ |
| 0708 | *Virginia striatula* | Gut #4 | adult ♂ |
| 0700 | *Pseudacris ornata* | Gut #5 | 9 larvae |
| 0701 | *Pseudacris ocularis* | Gut #5 | larva |
| 0702 | *Rana sphenocephala* | Gut #5 | 2 larvae |
| 0704 | *Clemmys guttata* | SC 98; 0.2 mi. N of SC 33 | DOR ♂ |
| 0710 | *Rana sphenocephala* | FS 188–N4 | 9 larvae |
| 0711 | *Siren intermedia* | FS 188–N4 | 11 larvae |
| 0712 | *Ambystoma talpoideum* | FS 188–N4 | neotenic larva |
| 0751 | *Tantilla coronata* | FS 188–N4 | adult ♀ |
| 0713 | *Rana sphenocephala* | FS 188–N5 | 11 larvae |
| 0714 | *Ambystoma talpoideum* | FS 188–N5 | 3 larvae |
| 0730 | *Rana virgatipes* | FS 188–N5 | adult |
| 0715 | *Rana sphenocephala* | FS 188–S8 | 4 larvae |
| 0716 | *Eurycea quadridigitata* | FS 188–N6 | 4 larvae |
| 0717 | *Rana virgatipes* | FS 188–N6 | subadult |
| 0718 | *Rana virgatipes* | FS 188–N6 | subadult |
| 0719 | *Rana virgatipes* | FS 188–N6 | subadult |
| 0720 | *Rana virgatipes* | FS 188–N6 | adult |
| 0721 | *Rana clamitans* | FS 189A–W2 | 16 larvae |
| 0722 | *Rana virgatipes* | FS 189A–W2 | adult |
| 0723 | *Eurycea quadridigitata* | FS 189A–W2 | 6 larvae |
| 0724 | *Rana sphenocephala* | FS 189A–E1 | 7 larvae |
| 0725 | *Pseudacris ornata* | FS 189A–E1 | larva |
| 0726 | *Eurycea quadridigitata* | FS 189A–E1 | 5 larvae |
| 0727 | *Ambystoma talpoideum* | FS 189A–E1 | 29 larvae |
| 0728 | *Ambystoma mabeei* | FS 189A–E1 | 5 larvae |
| 0729 | *Hyla femoralis* | FS 188; S of FS 6302 | adult |
| 0731 | *Rana sphenocephala* | Gut #6 | 8 larvae |
| 0732 | *Pseudacris ornata* | Gut #7 | larva |
| 0733 | *Rana sphenocephala* | Gut #7 | 6 larvae |
| 0734 | *Rana clamitans* | Gut #8 | 3 larvae |
| 0735 | *Pseudacris ocularis* | Gut #9 | adult |
| 0736 | *Rana sphenocephala* | Gut #9 | 2 larvae |
| 0737 | *Eurycea quadridigitata* | Gut #9 | larva |
| 0738 | *Rana sphenocephala* | Gut #10 | 5 larvae |
| 0739 | *Eurycea quadridigitata* | FS 189A/RR #1 | 2 larvae |
| 0740 | *Rana sphenocephala* | FS 189A/RR #2 | 6 larvae |
| 0741 | *Eurycea quadridigitata* | FS 189A/RR #2 | larva |
| 0742 | *Ambystoma talpoideum* | FS 189A/RR #2 | 10 larvae |
| 0743 | *Rana sphenocephala* | FS 189A/RR #3 | larva |
| 0744 | *Rana clamitans* | FS 189A/RR #3 | larva |
| 0745 | *Eurycea quadridigitata* | FS 189A/RR #3 | larva |
| 0746 | *Ambystoma talpoideum* | FS 189A/RR #3 | 8 larvae |

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Table 3 con't.

| SOCM # | Species | Location | Remarks |
|---|---|---|---|
| 0747 | *Pseudacris ornata* | Willie's Pond | 5 larvae |
| 0748 | *Rana sphenocephala* | Willie's Pond | 6 larvae |
| 0749 | *Ambystoma mabeei* | Willie's Pond | 2 larvae |
| 0750 | *Rana sphenocephala* | Cainhoy #2 | 5 larvae |
| 0752 | *Rana sphenocephala* | Cainhoy #5 | 8 larvae |
| 0753 | *Ambystoma talpoideum* | Cainhoy #5 | larva |
| 0754 | *Rana sphenocephala* | Cainhoy #7 | larva |
| 0755 | *Rana clamitans* | Cainhoy #7 | larva |
| 0756 | *Scaphiopus holbrookii* | Cainhoy #7 | 41 larvae |
| 0757 | *Rana sphenocephala* | Cainhoy #8 | 5 larvae |
| 0758 | *Rana clamitans* | Cainhoy #6 | larva |
| 0759 | *Rana sphenocephala* | Cainhoy #00 | 6 larvae |
| 0760 | *Rana sphenocephala* | FS 188–S7 | 4 larvae |
| 0761 | *Rana virgatipes* | FS 188–S7 | larva |
| 0762 | *Rana virgatipes* | Willie's Pond | adult |
| 0763 | *Rana capito* | FMNF #1 | transformling |
| 0764 | *Rana capito* | FMNF #1 | 2 larvae |
| 0765 | *Rana sphenocephala* | FMNF #1 | 6 larvae |
| 0766 | *Ambystoma talpoideum* | FMNF #1 | 3 larvae |
| 0780 | *Tantilla coronata* | FMNF #1 | adult ♀ |
| 0767 | *Rana sphenocephala* | 5–3–1 | larva |
| 0768 | *Ambystoma talpoideum* | 5–3–1 | 6 larvae |
| 0769 | *Pseudacris crucifer* | FS 189A–E1 | larva |
| 0770 | *Hyla femoralis* | Cainhoy #10 | adult |
| 0771 | *Rana sphenocephala* | FS 188–S7 | transformling |
| 0772 | *Rana sphenocephala* | FS 188–S7 | transformling |
| 0773 | *Rana virgatipes* | FS 188–S7 | adult |
| 0774 | *Rana sphenocephala* | RR #1 | 3 larvae |
| 0775 | *Rana virgatipes* | RR #1 | subadult |
| 0776 | *Rana virgatipes* | RR #1 | adult |
| 0777 | *Rana catesbeiana* | FS 189A–E1 | subadult |
| 0778 | *Storeria occipitomaculata* | FS 189A; 0.8 mi. N of FS 188 | AOR, adult ♂ |
| 0781 | *Ambystoma talpoideum* | Cainhoy #10 | larva |
| 0782 | *Ambystoma mabeei* | Cainhoy #10 | larva |
| 0783 | *Rana sphenocephala* | Cainhoy #10 | 12 larvae |
| 0784 | *Rana capito* | Cainhoy #10 | 2 larvae |
| 0785 | *Rana capito* | Cainhoy #10 | larva |
| 0786 | *Rana capito* | Cainhoy #10 | transformling |
| 0787 | *Ophisaurus attenuatus* | Cainhoy Plantation off SC 33 | DOR adult ♂ |
| 0788 | *Sceloperus undulatus* | Cainhoy #9 | gravid adult ♀ |
| 0789 | *Eumeces inexpectatus* | Cainhoy #11 | adult ♂ |
| 0790 | *Hyla femoralis* | Cainhoy #12 | adult |
| 0791 | *Lampropeltis triangulum* | Cainhoy #12 | subadult ♀ |
| 0792 | *Tantilla coronata* | Cainhoy #11 | adult ♂ |
| 0793 | *Thamnophis sauritus* | FS 189A–E1 | adult ♀ |
| 0794 | *Nerodia erythrogaster* | FS 188–N4 | adult ♀ |
| 0795 | *Virginia striatula* | Cainhoy #8 | adult ♂ |
| 0796 | *Nerodia fasciata* | Gut #2 | adult ♀ |
| 0797 | *Cnemidophorus sexlineatus* | FMNF; Fire Tower Road | adult ♂ |
| 0798 | *Ambystoma talpoideum* | FS 188–S1 | 13 larvae |
| 0799 | *Rana clamitans* | FS 188–S1 | larva |
| 0800 | *Ambystoma talpoideum* | FMNF #1 | 8 larvae |
| 0801 | *Acris gryllus* | FMNF #1 | adult ♀ |
| 0802 | *Rana sphenocephala* | FMNF #1 | 8 larvae |
| 0803 | *Rana catesbeiana* | FMNF #1 | larva |
| 0804 | *Hyla gratiosa* | Cainhoy #10 | 5 transforming larvae |
| 0805 | *Rana sphenocephala* | Cainhoy #10 | 1 transforming larva |

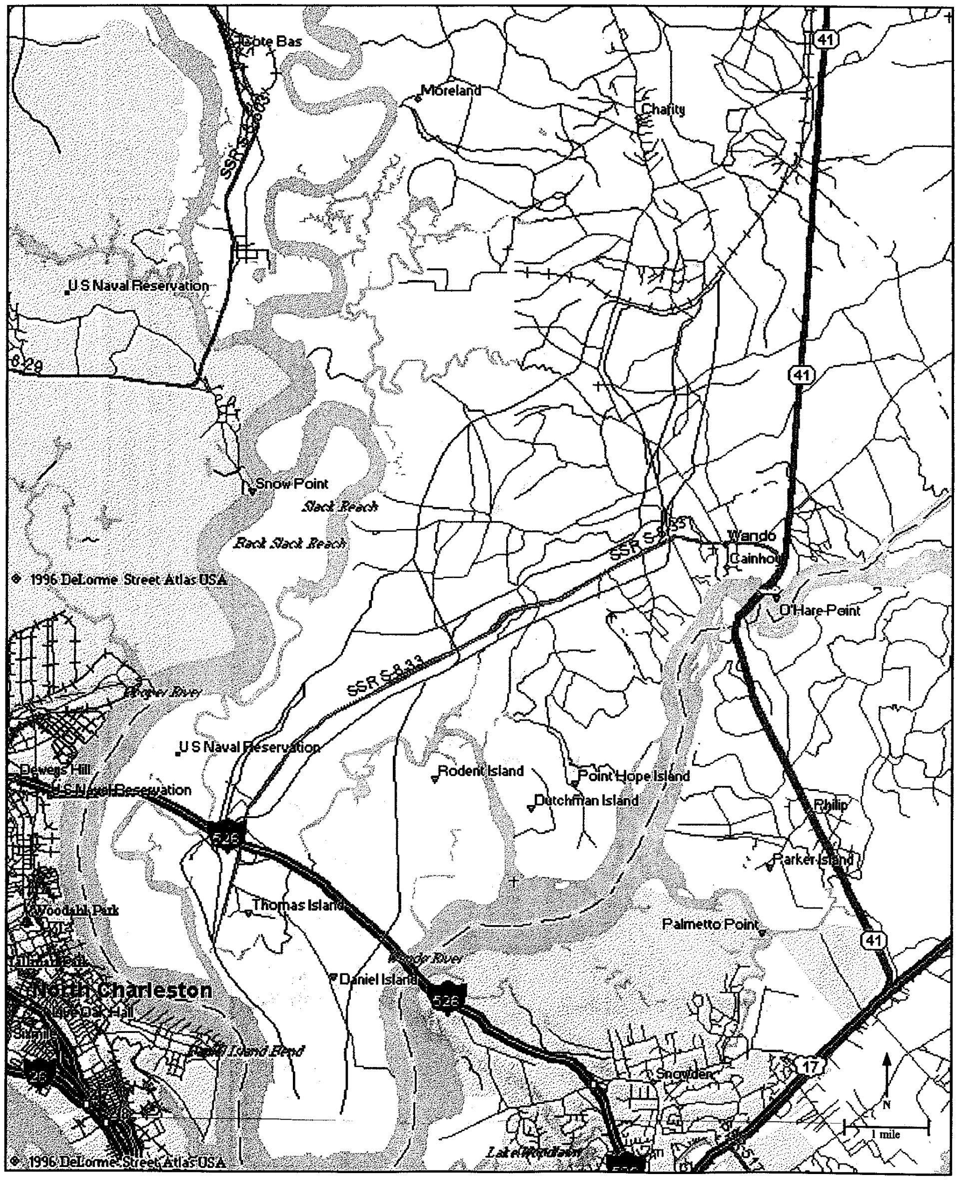


**Figure 1.** Approximate locations of proposed rail corridors (represented by thin black lines) in Berkeley County, South Carolina.

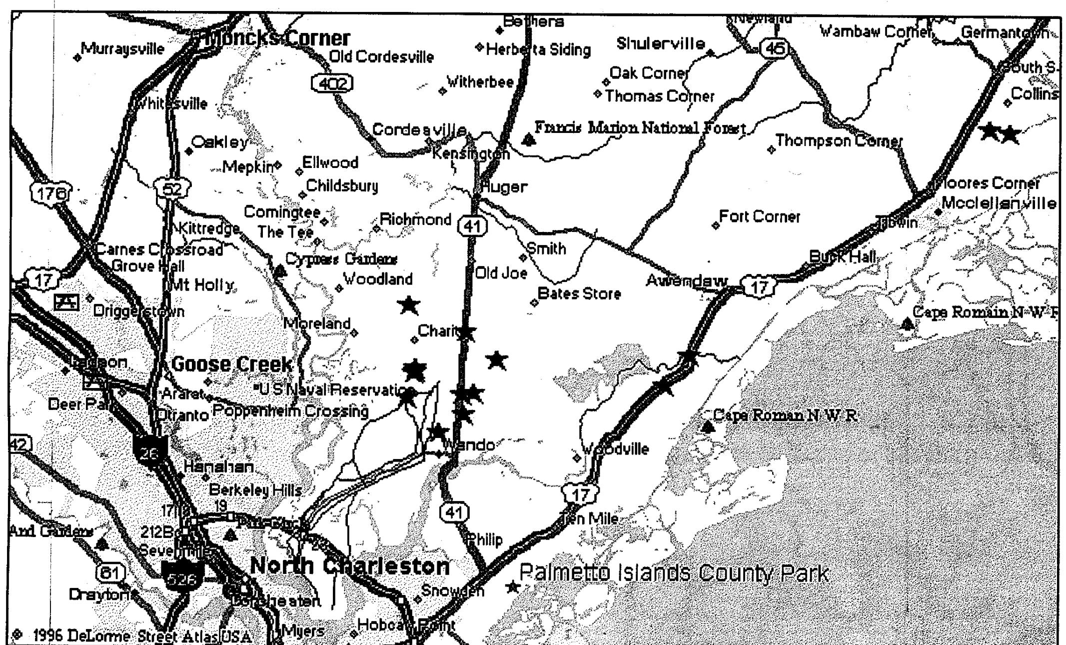


**Figure 2.** Historic localities for *Ambystoma cingulatum* in the vicinity of proposed rail corridors (represented by thin black lines) in Berkeley County, South Carolina.

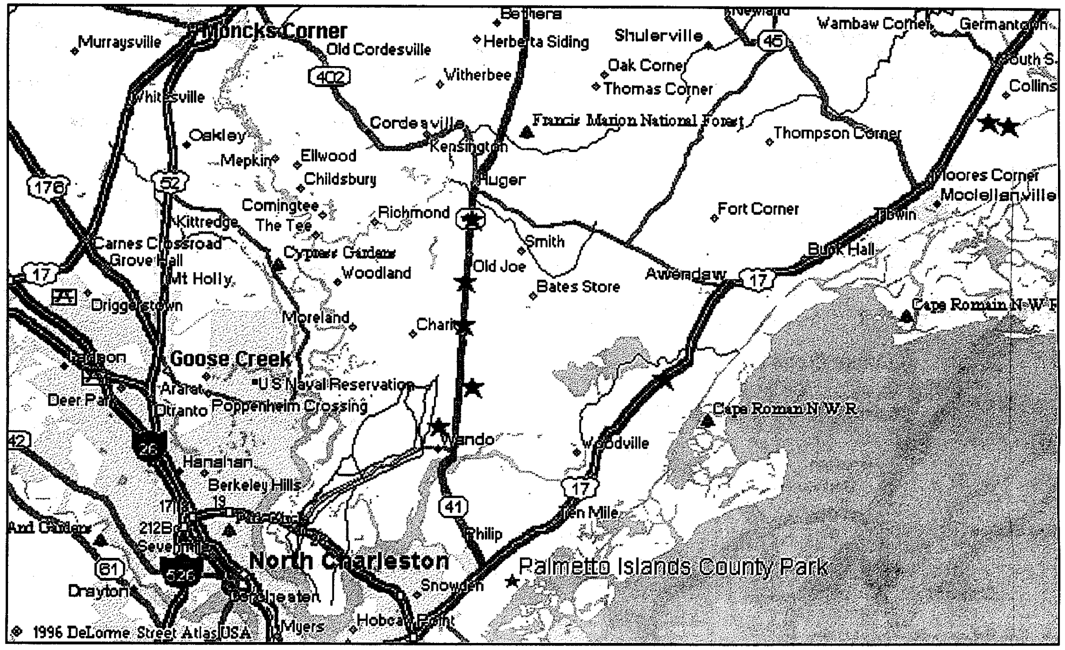


**Figure 3.** Historic localities for *Rana capito* in the vicinity of proposed rail corridors (represented by thin black lines) in Berkeley County, South Carolina. Note black stars indicate literature records not supported by voucher specimens.

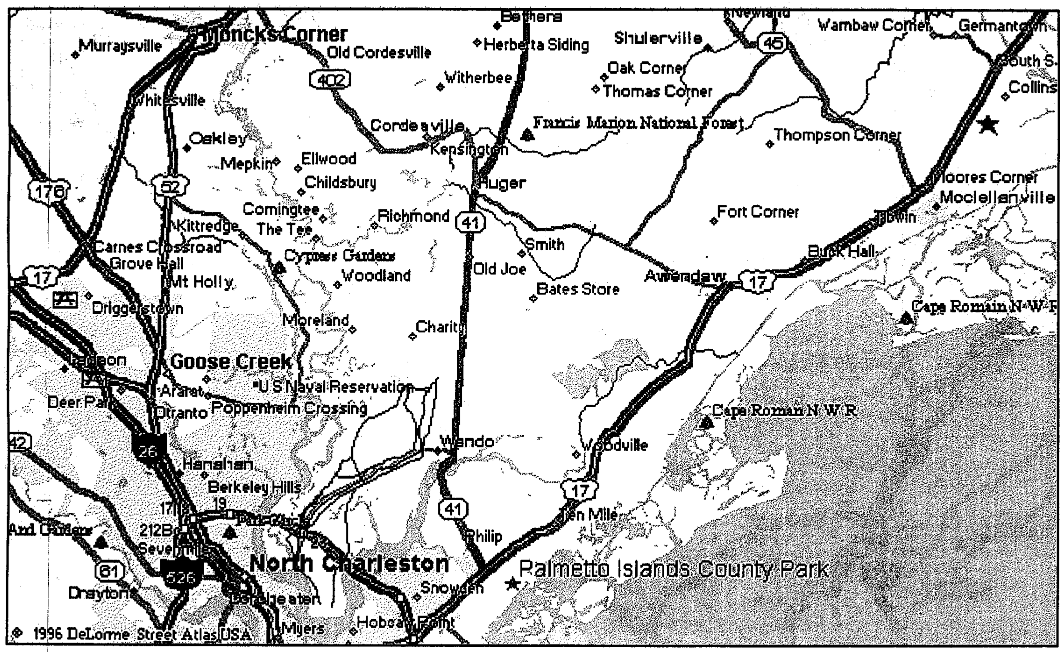


**Figure 4.** Historic localities for *Pseudobranchus striatus* in the vicinity of proposed rail corridors (represented by thin black lines) in Berkeley County, South Carolina.

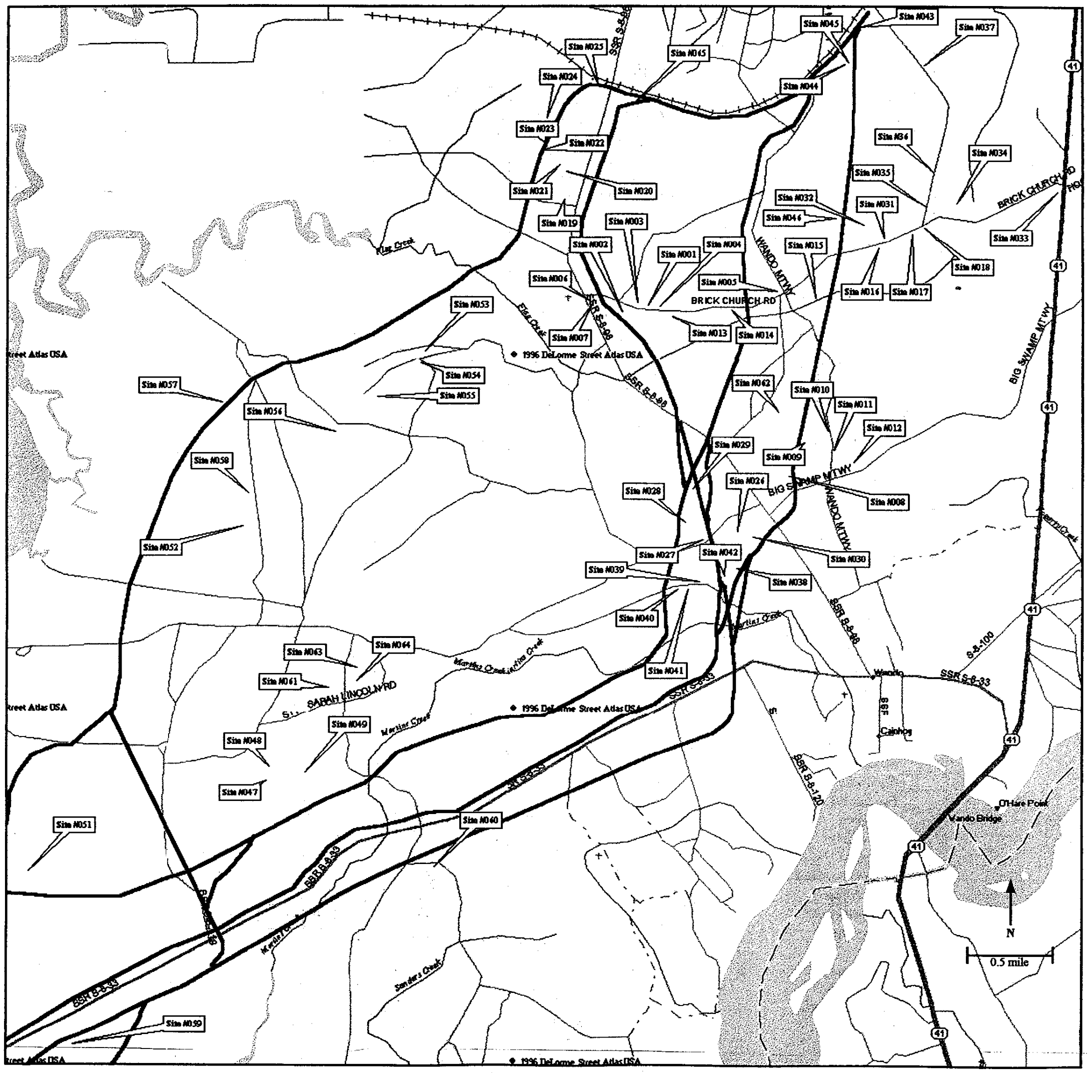


**Figure 5.** Locations of sites sampled during *Ambystoma cingulatum* survey in Berkeley County, South Carolina (proposed rail corridors represented by bold lines). Note *A. cingulatum* and *Rana capito* were found at site #016 and sites #012, 061, and 062, respectively.

Daniel's Island *Ambystoma cingulatum* survey

Photo No. (if applicable):____

**Date:**
**Observer(s):**
**State:**__________ **County:**______________ **Site Number:**______________
**Survey Time:** (from_____ to _____) **pH:**_____ **$H_2O$ Temp.:**_____ **Air Temp.**_____
**Pond Size:**______ **Pond Habitat Quality:** excellent good fair marginal poor
**% Canopy Cover:**_____ **Pond Bottom:** leaf litter vegetation muck silt hard-bottom

| Major Overstory Species | Dominant Understory Species | Fish Species (if present) |
| --- | --- | --- |
| | | |

**Surrounding Upland Type:** Nat. Pine ____ Nat. Hardwood ____ Mixed Woods ____
(% of edge) Pine Plantation ____ (Approx. Age ____) Other ____

| Amphibians | Reptiles |
| --- | --- |
| ____ *Acris gryllus* | ____ *Agkistrodon contortrix* |
| ____ *Ambystoma cingulatum* | ____ *A. piscivorus* |
| ____ *A. mabeei* | ____ *Alligator mississippiensis* |
| ____ *A. opacum* | ____ *Anolis carolinensis* |
| ____ *A. talpoideum* | ____ *Chelydra serpentina* |
| ____ *A. tigrinum* | ____ *Clemmys guttata* |
| ____ *Amphiuma means* | ____ *Coluber constrictor* |
| ____ *Bufo terrestris* | ____ *Crotalus horridus* |
| ____ *B. quercicus* | ____ *Deirochelys reticularia* |
| ____ *Eurycea quadridigitata* | ____ *Diadophis punctatus* |
| ____ *E. cirrigera* | ____ *Elaphe obsoleta* |
| ____ *Gastrophryne carolinensis* | ____ *E. guttata* |
| ____ *Hyla cinerea* | ____ *Eumeces fasciatus* |
| ____ *H. chrysoscelis* | ____ *E. inexpectatus* |
| ____ *H. femoralis* | ____ *E. laticeps* |
| ____ *H. squirella* | ____ *Kinosternon baurii* |
| ____ *Notophthalmus viridescens* | ____ *K. subrubrum* |
| ____ *Plethodon variolatus* | ____ *Lampropeltis getula* |
| ____ *Pseudacris crucifer* | ____ *L. triangulum* |
| ____ *P. nigrita* | ____ *Nerodia erythrogaster* |
| ____ *P. ocularis* | ____ *N. fasciata* |
| ____ *P. ornata* | ____ *Ophisaurus ventralis* |
| ____ *Pseudobranchus striatus* | ____ *Regina rigida* |
| ____ *Rana capito* | ____ *Scincella lateralis* |
| ____ *R. catesbeiana* | ____ *Seminatrix pygaea* |
| ____ *R. clamitans* | ____ *Sternotherus odoratus* |
| ____ *R. grylio* | ____ *Terrapene carolina* |
| ____ *R.sphenocephala* | ____ *Trachemys scripta* |
| ____ *R. virgatipes* | ____ *Thamnophis sirtalis* |
| ____ *Siren intermedia* | ____ *T. sauritus* |
| ____ *S. lacertina* | ____ *Virgina striatula* |
| ____ | ____ |

Figure 6. Data sheet (reduced) used during amphibian survey work conducted at Daniel Island in Berkeley County, South Carolina during spring of 1998.