Wildlife Crossing Feasibility Study

SR 29

North of Florida Panther National Wildlife Refuge

FPID 449143-1

Collier County

Prepared For:

Florida Department of Transportation

District One

December 2021

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1 INTRODUCTION

The Florida Department of Transportation (FDOT) is conducting a feasibility study for opportunities to enhance the passage of wildlife across SR 29 in Collier County. A 0.97-mile segment of SR 29 was identified to study locations and design concepts for enhanced wildlife passage. Two alternative locations and two alternative design concepts were evaluated to provide passage under SR 29 and to pass over a canal on the east side of the roadway.

The study segment is approximately 2.5 miles south of the intersection of SR 29 and Oil Well Road, and 7.7 miles north of the SR 29/I-75 Alligator Alley interchange (Figure 1). The Barron Canal, also known as the SR 29 Canal, parallels SR 29 along the east side of the road throughout the study segment and an overhead power transmission line parallels SR 29 to the west. The Florida Panther National Wildlife Refuge (FPNWR) and Big Cypress National Preserve (BCNP) are approximately 0.4 miles to the south of the study segment. Four existing wildlife crossings were constructed as underpasses along SR 29 (circa 2007) to enhance wildlife movement in the region. These existing crossings are south of the study segment within the limits of the FPNWR and BCNP. This feasibility study evaluates adding a fifth opportunity for wildlife movement under SR 29 in this section of roadway spanning from south of Immokalee to I-75/Alligator Alley through important panther habitat. The SR 29 Project Development and Environment (PD&E) Study for Oil Well Road to I-75 encompasses this segment of roadway. A wildlife connectivity assessment was conducted as part of that study. Currently, the PD&E is on hold.

Five Florida black bear mortalities were documented between 2000 and the present and ten Florida panther mortalities were documented between 1987 and the present along the study segment due to collisions with vehicles. This segment of SR 29 is mapped as a red Hot Spot by the Southwest Florida Roads Hot Spots Mapping Report (PRIT Transportation Subteam, 2020). Hot Spots are assigned to road segments in which multiple mortalities result from panther-vehicle collisions. A red segment is the highest rank indicating a segment in which ten or more panther-vehicle collisions have occurred.

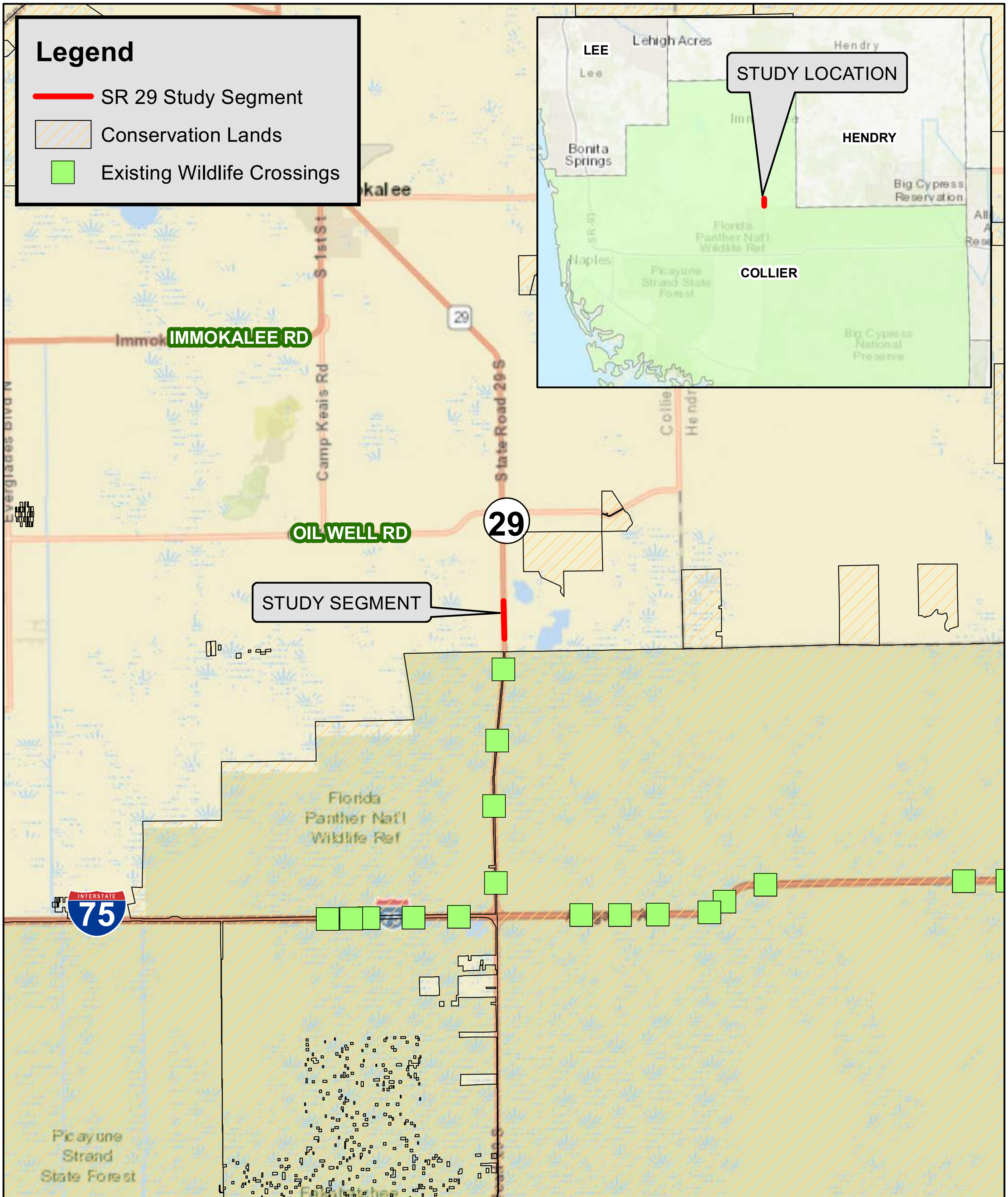


Figure 1 - Project Location

FPID 449143-1

SR 29 - Wildlife Crossing Feasibility Study

Collier County, FL

Data Source:
- FDA
- ESRI

N

1 inch = 20,000 feet

0 10,000 20,000 Feet

Coordinate System: NAD 1983 Florida State Plane East

Path: H:\55210\449143-1_SR 29\Figures\Figure 1 - Project Location.mxd

2 EXISTING ROADWAY

This segment of SR 29 is a two-lane roadway in a rural area of Collier County. The roadway has two 12-foot travel lanes, four-foot paved shoulders within an existing right-of-way of approximately 185 feet. The western right-of-way limit is at the maintained edge of the power line while the eastern right-of-way is roughly at the top of the western bank of the Barron Canal, just beyond the SR 29 guardrail. The posted speed limit is 60 mph. A guardrail is present along the east side for the Barron Canal for the entire length of the study segment. There are no major underground utilities. Buried telephone lines are present on the east side of SR 29 between the edge of pavement and the guardrail. Overhead utilities are present to the west of SR 29 and outside FDOT right-of-way. A typical section for the roadway is provided in Appendix A and is from the as-built plans from a SR 29 resurfacing project (FPID 425219-1). The study segment begins at Station 1269+00 and extends to Station 1319+00. A Straight-Line Diagram of SR 29 including the study segment is also included in Appendix A. Photographs of the roadway setting are provided in Appendix B, see photographs 1, 2 and 3.

3 ENVIRONMENTAL SETTING

Land use immediately surrounding the location includes one industry, an active aggregates mine on the east side of SR 29 and one grouping of three residences on the west side of SR 29 opposite the driveway to the mine. The remaining area is undeveloped and in natural condition.

The study segment is within a stretch of SR 29 that has very few intersecting roads and no intersections for public roads. Oil Well Park Road is a rural residential road and is the nearest intersecting public road located about 1 mile north of the End Study point; Oil Well Road is 2.5 miles to the north of the End Study point. Big Cypress Road is a gated access road into BCNP about 3.0 miles south of the Begin Study point. The SR 29 interchange with I-75/Alligator Alley is 7.8 miles south of the Begin Study point.

The Vulcan Materials Company operates an aggregates mine at the north end of the study segment on the east side of SR 29. There are water-filled pits from surface mining within the property boundaries. The mine was permitted by South Florida Water Management District (SFWMD). A review of the permit application indicates the mining operation has been ongoing since the late 1980's and appears to be close to mining all the permitted areas and did not reveal any applications for expansion to the mine.

3.1 Driveways and Existing Fencing

Driveways were reviewed in the field and in the FPID 425219-1 as-built plans. Stationing referenced below is relative to the as-built plans. The driveways are shown in Figure 2 and include:

- Residential
  - one, 12-foot utility gate, observed during site visits to be closed.
  - Located at Station 1315+00 Left

- Industrial
  - Access to the aggregates mine; limerock base driveway, cattle grate, no existing gates, observed during site visits to be used regularly by dump trucks, smaller vehicles, and industry-support vehicles. See Photograph 4 in Appendix B.
  - Located at Station 1313+60 Right

- Utility/Private Land Access
  - Three access points to the overhead power line and contiguous private land to the west are present. Two have 12-foot utility gates, one has double utility gates; all are chained and locked. See Photographs 5, 6 and 7 in Appendix B.
  - Located at Station 1298+40 Left, 1270+60, and 1303+80

- Driveways for Future Use
  - Two additional driveways were observed however these were driveways that terminate at the vegetation adjacent to SR 29. No off-site access was evident, and no indications of development were present.
  - Located at Station 1310+00 Left and 1302+80 Left

Fencing was present around the residential cluster (four-foot woven wire) and along the western right-of-way limit (barbed wire). Wildlife fencing is present to the south in the region of the existing wildlife crossings. The existing fence begins about 0.6 miles to the south of the Begin Study point generally just south of the limits of the FPNWR and BCNR. This existing fencing is ten-foot chain link with three strands of barbed wire along the top rail. On the east side of SR 29 the existing wildlife fence is located just behind the guardrail and in front of the canal, and on the west is located along the east edge of the maintained limit for the overhead power line. Vehicular and pedestrian access points into the FPNWR and BCNR are wildlife-proof gates.

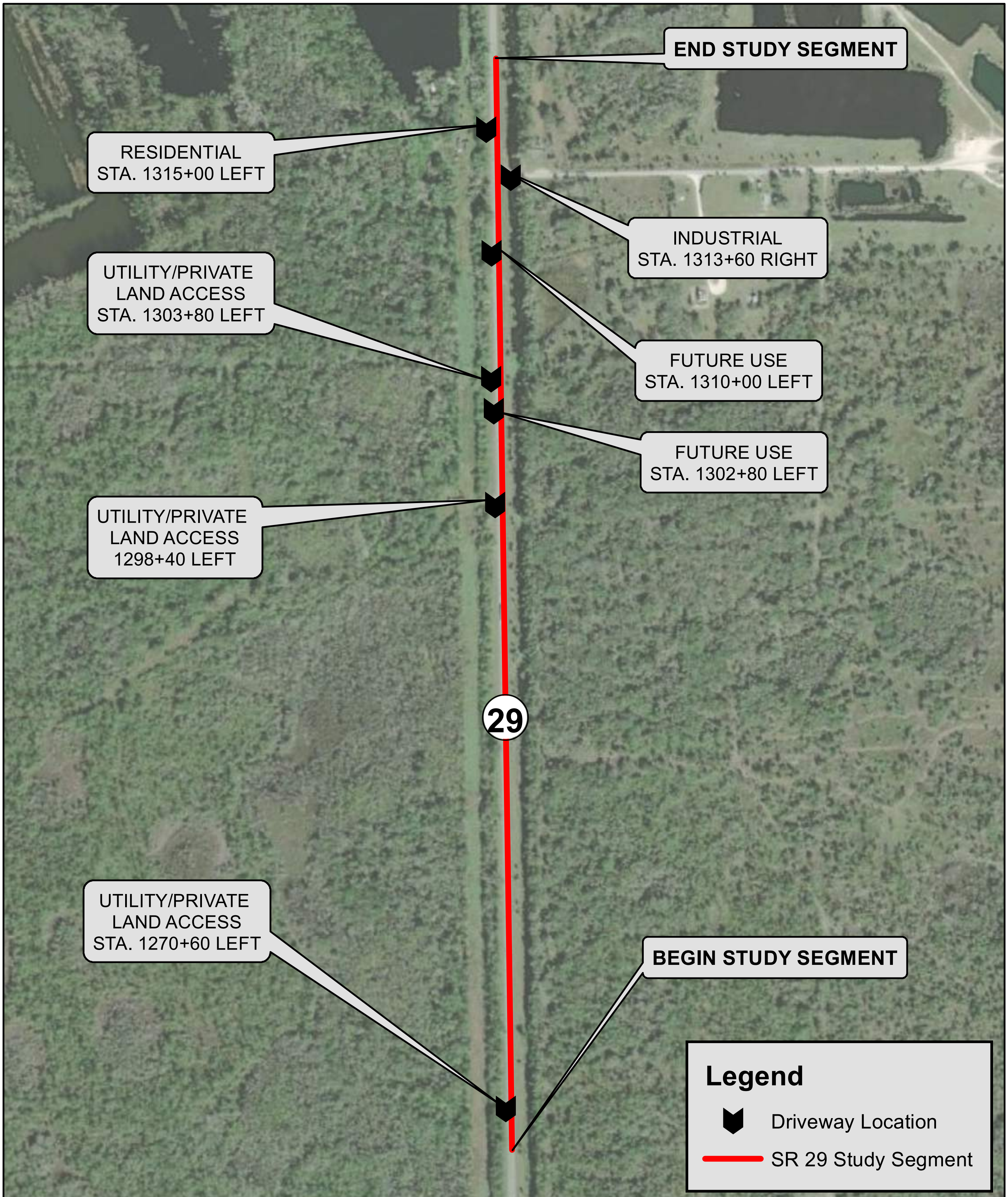


Figure 2 - Driveways in Study Segment
FPID 449143-1
SR 29 - Wildlife Crossing Feasibility Study
Collier County, FL

Data Source:
- FDA, ESRI
1 inch = 691 feet
0 360 720 Feet
N
Coordinate System: NAD 1983
Florida State Plane East

Path: H:\55210\449143-1_SR 29\Figures\Figure 2 - Driveways in Study Segment.mxd

3.2 Barron Canal

The Barron Canal is a waterway feature that parallels SR 29 within the study segment and beyond. The canal was originally dug for spoil to support a railroad base. The railroad was eventually removed, and SR 29 was constructed in the rail corridor. The canal remains in place and is currently maintained by Collier County. The canal is fairly uniform with a top-of-bank width of approximately 65-feet. A water control feature is located at the driveway for the aggregates mine entrance. This structure has three water gates that are controlled by hand cranks. The seasonal high elevation was estimated to be 15.7 ft NAVD on the upstream side based on staff gauges and staining observed.

3.3 Land Use

The Florida Natural Areas Inventory (FNAI) Cooperative Land Cover code system (FNAI, 2019) for this area was reviewed. Mapped land cover adjacent to the study segment are:

- 1311, Mesic Flatwoods
- 1500, Shrub and Brushland
- 2210, Cypress/Tupelo mixed
- 2112, Prairies and Bogs
- 2233, Mixed Wetland Hardwoods*
- 2240, Mixed Hardwood Coniferous Swamps*
- 4210, Canal*
- 18212, Residential Low Density

Dominant mapped land cover is marked with an asterisk. Site visits confirmed the mapped land cover codes are accurate on a large scale. Land cover is depicted in Figure 3.

3.4 Conservation Lands and Existing Wildlife Crossings in the Region

The FPNWR and BCNP are to the south of the study segment. Picayune Strand State Forest and Fakahatchee Strand Preserve State Park are adjacent to the southern boundaries of FPNWR and BCNP (Figure 4). The FNAI GIS data for conservation lands was used as a reference (FNAI, 2018). Four wildlife underpasses for SR 29 were previously constructed to the south of the study segment within the limits of FPNWR and BCNR. Regionally, thirteen additional wildlife crossings are present along I-75/Alligator Alley.

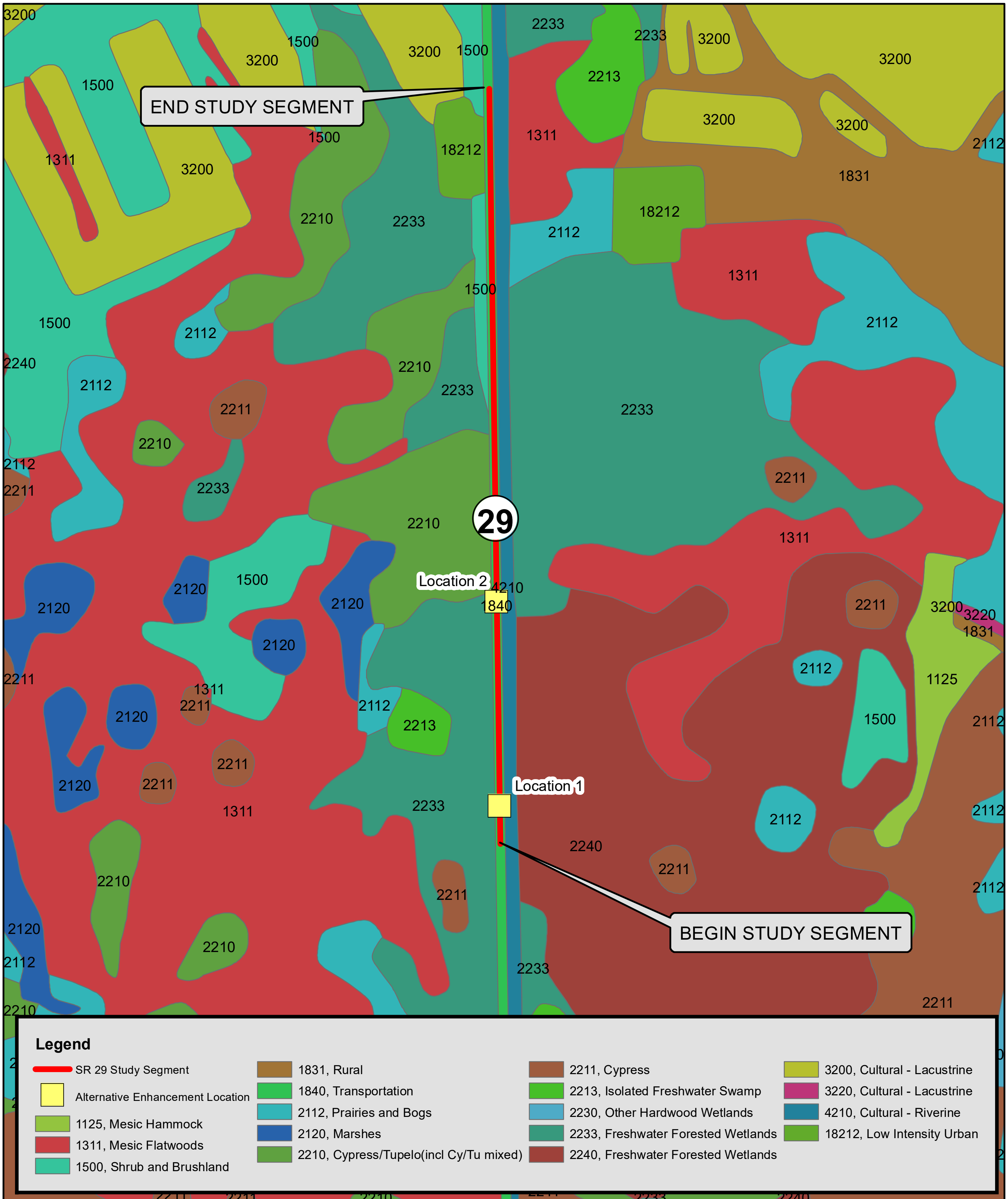


Figure 3 - FNAI Cooperative Land Cover

FPID 449143-1

SR 29 - Wildlife Crossing Feasibility Study

Collier County, FL

Data Source:
- FNAI
- ESRI

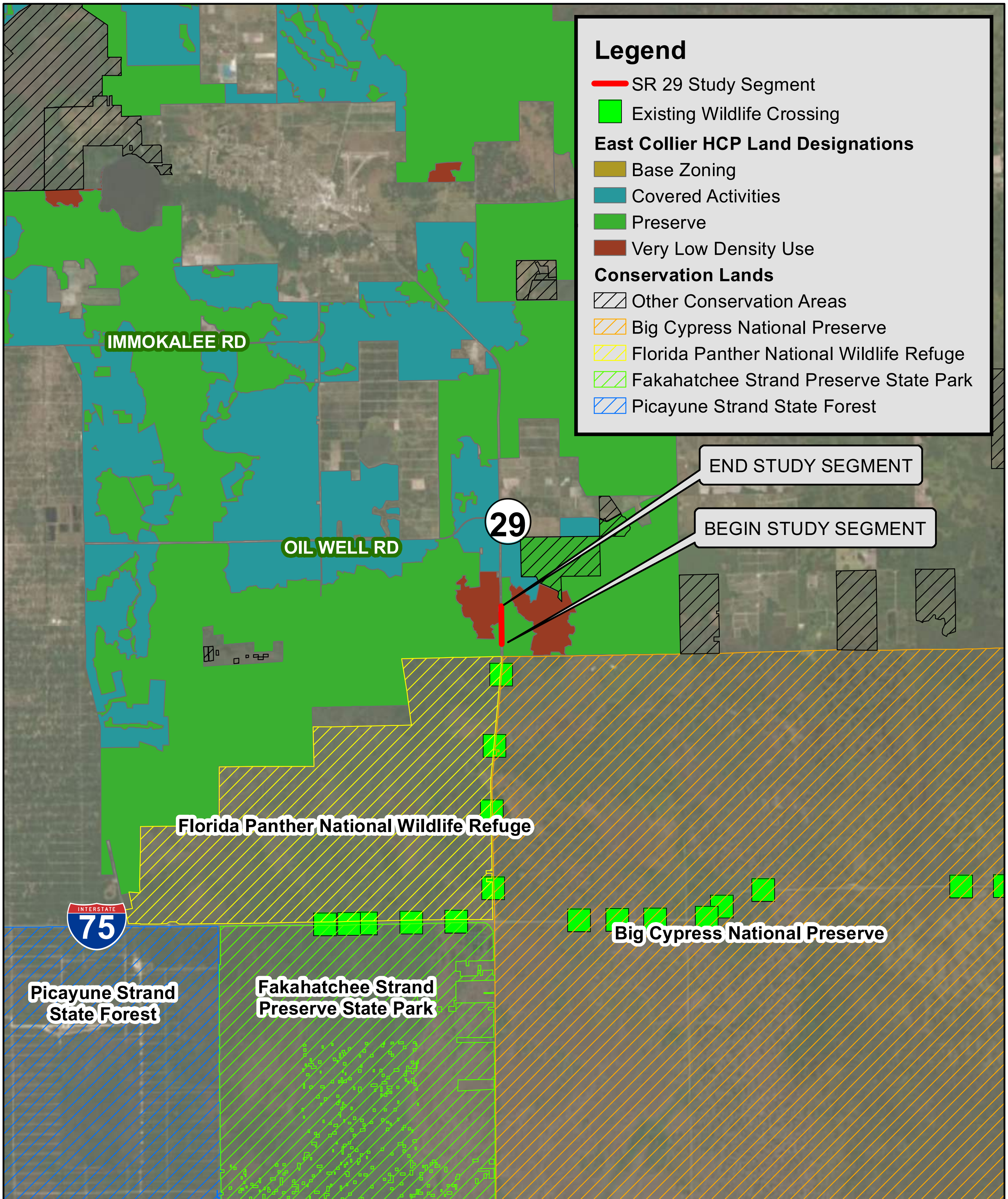
N

1 inch = 1,000 feet

0 510 1,020 Feet

Coordinate System: NAD 1983 Florida State Plane East

Path: H:\55210\449143-1_SR 29\Figures\Figure 3 - Mapped Land Cover.mxd



FDOT

Figure 4 - Conservation Lands

FPID 449143-1

SR 29 - Wildlife Crossing Feasibility Study

Collier County, FL

Data Source:
- FDOT, FDA
- FNAI, ESRI

N

1 inch = 20,000 feet

0 10,000 20,000 Feet

Coordinate System: NAD 1983 Florida State Plane East

Path: H:\55210\449143-1_SR 29\Figures\Figure 4 - Conservation Lands.mxd

3.5 Eastern Collier County Multiple Species Habitat Conservation Plan

The study segment is within lands covered by the Eastern Collier County Multiple Species Habitat Conservation Plan (HCP) (Stantec Consulting Services, Inc., 2018). The HCP was developed as a collaborative effort among landowners, conservation organizations, and wildlife agencies to address long-term planning issues related to the conservation of the Florida panther. Given that privately held, native habitats within eastern Collier County have the potential to benefit the Florida panther, the HCP can provide a mechanism for achieving permanent protection of the landscape-scale features that support panther ecology. Property owners can plan and coordinate future development or permitted activities in defined areas within the HCP while enabling integrated and effective conservation planning. The HCP supports regional habitat connectivity facilitating panther use and movement through the preservation of large expanses of native panther habitats. The HCP covers eight federally listed species, three federal candidate species, and eight additional state listed species. The Florida panther is among this list.

The landowners participating in the HCP include Barron Collier Partnership, LLLP, JB Ranch, and Sunniland Family Limited Partnership, among others. Ownership adjacent to the study segment includes large parcels owned by Barron Collier Partnership, LLLP and Sunniland Family Limited Partnership, and three small privately owned parcels (Clarke property) (Figure 5). Early coordination meetings were held with owners and representatives of the Barron Collier and Sunniland Family properties. Meeting minutes are provided in Appendix C.

Very Low Density Use and long-term (50 year) Preservation areas are mapped by the HCP. The areas were selected because they are interconnected lands that currently may support, and preservation will benefit, the Florida panther and other listed species. Very Low Density Use is described in the HCP as areas that could be used for isolated residences, lodges, and hunting or fishing camps. Construction would be limited to one dwelling unit per 50 acres. Preservation/Plan-Wide Activities include predominantly agricultural activities; however, the activities preserve the current extent and function of habitats that support species covered by the HCP, including the Florida panther. The HCP Land Designations figure was referenced to map proposed Very Low Density Use and Preserve Areas surrounding the study segment (Figure 6).

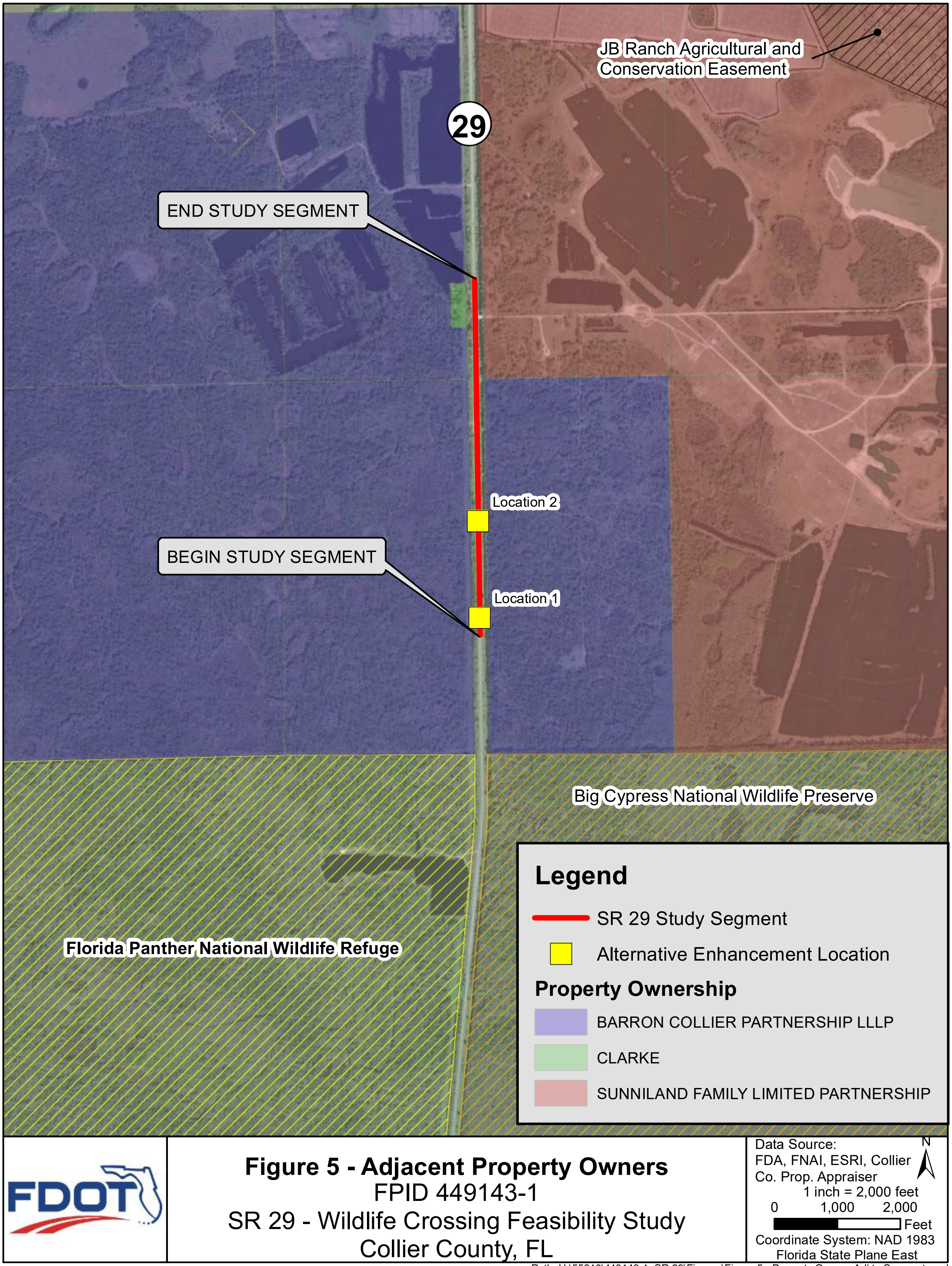


Figure 5 - Adjacent Property Owners
FPID 449143-1
SR 29 - Wildlife Crossing Feasibility Study
Collier County, FL

Path: H:\55210\449143-1_SR 29\Figures\Figure 5 - Property Owners Adj to Segment.mxd

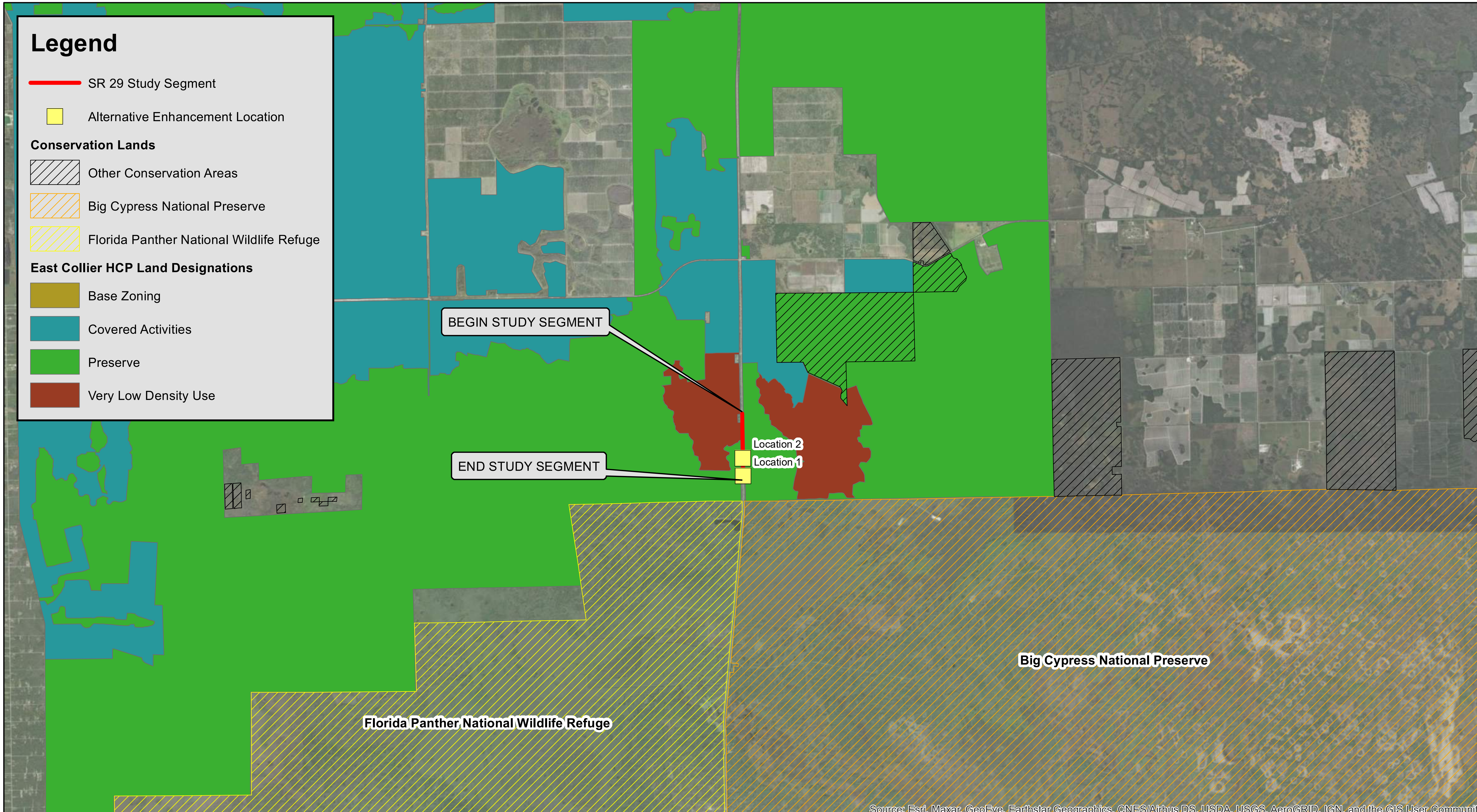


Figure 6 - Eastern Collier Habitat Conservation Plan
FPID 449143-1
SR 29 - Wildlife Crossing Feasibility Study
Collier County, FL

Data Source:
- FDA
- ESRI
1 inch = 8,000 feet
0 4,000 8,000
Feet
Coordinate System: NAD 1983
Florida State Plane West

Document Path: H:\55210\449143-1_SR 29\Figures\Figure 6 - Eastern Collier HCP LANDSCAPE.mxd

3.6 Documented Wildlife Use

Documented wildlife usage in the study segment includes data in the form of telemetry (FWC, 2020) (FWC, 2017) (Figure 7), and wildlife-vehicle mortality locations (FWC, 2019) (FWC, 2021) (Figure 8). Reviewing data through the year 2020, ten panther-vehicle mortalities have occurred in this segment between 1987 and the present. Five Florida black bear-vehicle mortalities have occurred between 2000 and the present. This segment is coincident with a mapped Hot Spot coded as red which denotes a segment with up to 10 recorded panther-vehicle mortalities. Camera data for wildlife crossings to the south have captured photos of Florida panther, Florida black bear, bobcat, coyote, deer, fox, possum, rabbit, turkey and wading birds (FDOT, 2021). Camera data within the study segment has captured photographs of white-tailed deer approaching and presumably crossing SR 29.

The wildlife-vehicle mortalities are somewhat grouped. After reviewing these locations on the ground, it is interesting to note that two clusters of mortalities occurred at gated openings for power line and private property access points and one cluster occurred at the mine driveway. Only one panther and one bear mortality occurred at locations not adjacent to the gated access points or the mine driveway. It is plausible to conclude that wildlife travelling west to east view the gated access points as gaps in the thick vegetation between the power line corridor and SR 29 and follow the openings to the roadway. The access points on the west side of SR 29 are gated with 12-foot utility gates and are not wildlife-proof. At these three access points, the fence at the existing right-of-way was only barbed wire and would not function as a significant barrier to wildlife. The vegetation between the power line and the roadway is forested with a wide but shallow ditch within the vegetation (see Photograph 8 in Appendix B).

The driveway at the aggregates mine is used regularly throughout the day and is a well-maintained unpaved road. Three single family homes in a ranchette setting are immediately opposite the mine driveway and represent the only residential land use in the study segment. This property is fenced with woven wire fencing and a gate was observed closed during site visits.

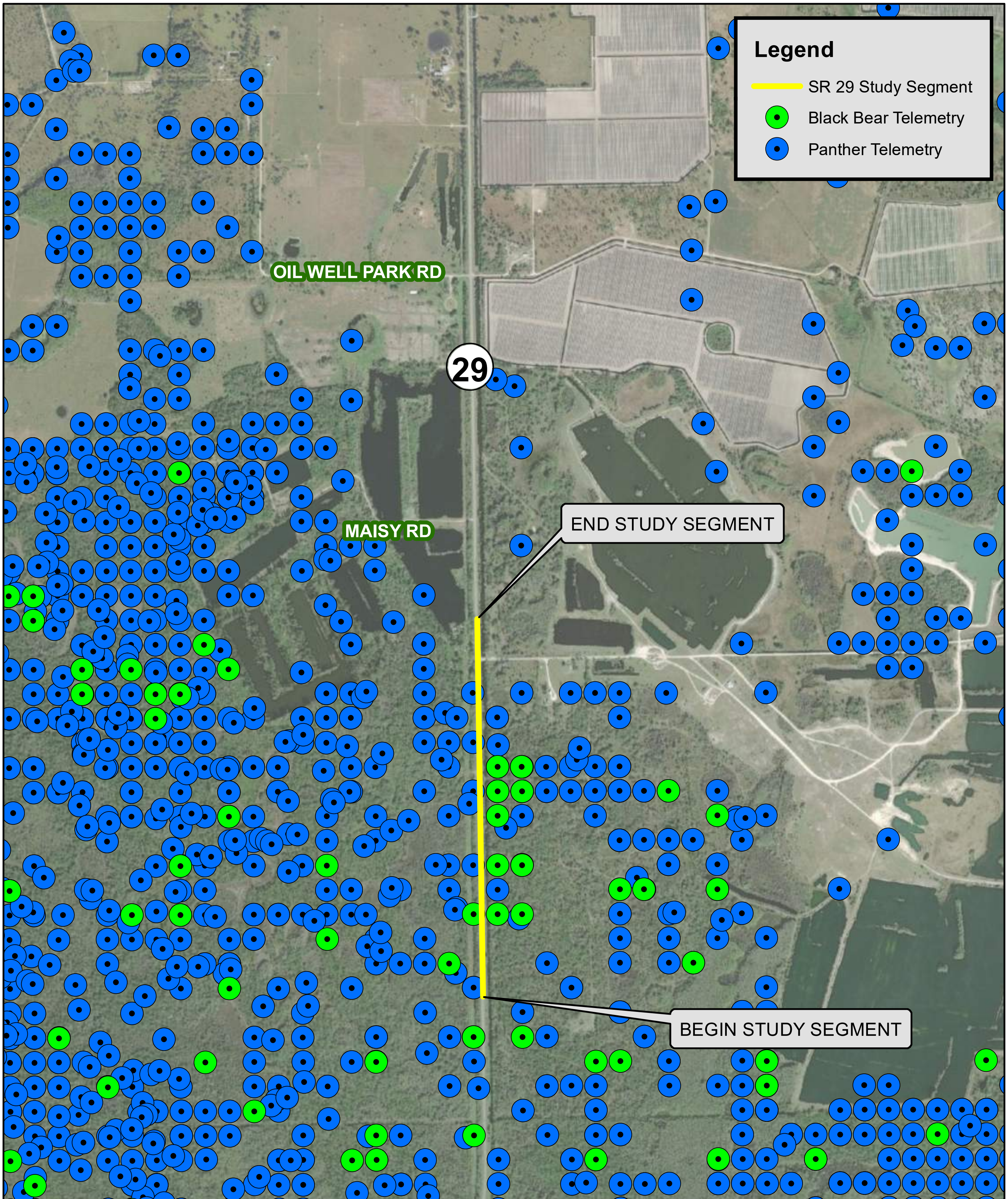


Figure 7 - Panther and Bear Telemetry

FPID 449143-1

SR 29 - Wildlife Crossing Feasibility Study

Collier County, FL

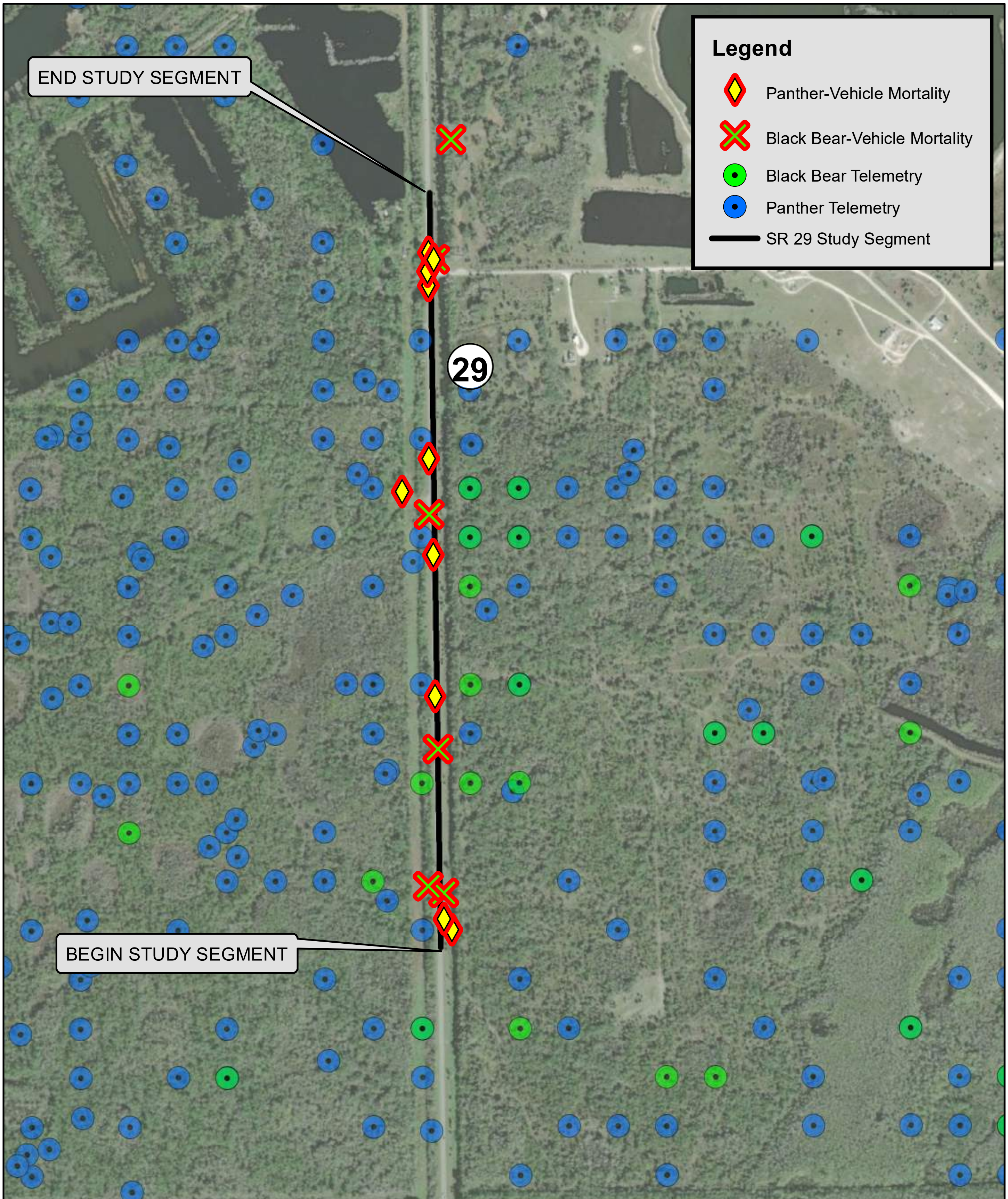
Data Source:
- FDA, FWC
- FDOT, ESRI

1 inch = 2,000 feet

0 1,000 2,000 Feet

Coordinate System: NAD 1983 Florida State Plane East

Path: H:\55210\449143-1_SR 29\Figures\Figure 7 - Panther and Bear Telemetry.mxd



FDOT

Figure 8 - Panther and Bear Vehicle Mortalities
FPID 449143-1
SR 29 - Wildlife Crossing Feasibility Study
Collier County, FL

Data Source:
- FDA, FWC
- FDOT, ESRI
1 inch = 1,000 feet
0 520 1,040 Feet
Coordinate System: NAD 1983
Florida State Plane East

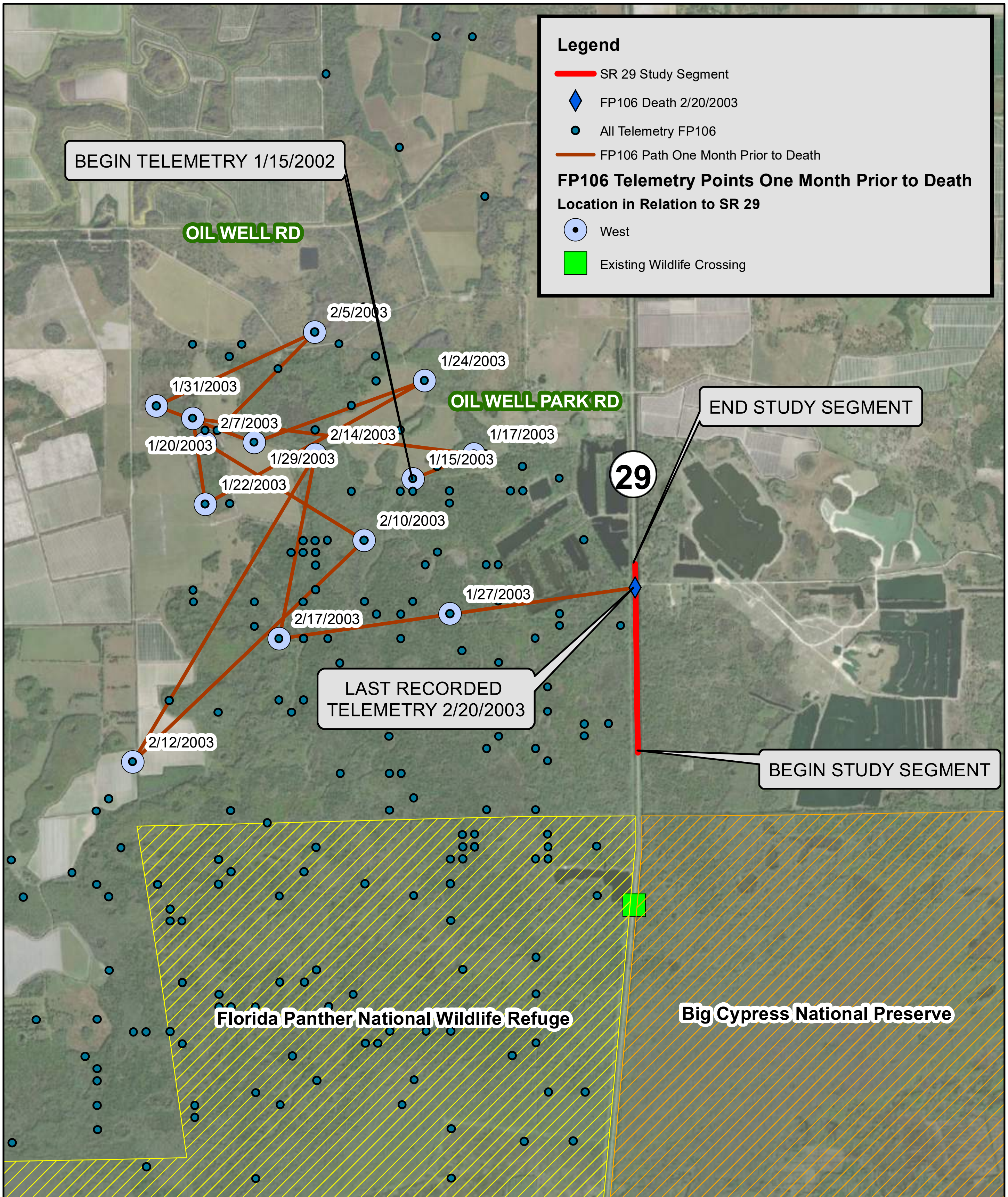
Path: H:\55210\449143-1_SR 29\Figures\Figure 8 - Panther_Bear Mortality Locations.mxd

Given the high number of wildlife-vehicle mortalities at the mine driveway, it was important to evaluate the driveway as a preferred corridor for wildlife movement. Panther and bear telemetry data was reviewed for the entire region. Telemetry data were sporadic and light within the aggregates mine compared to the rest of the region and no telemetry has documented panthers using the mine driveway east of the canal. There was a lack of both panther and bear telemetry within the residential area (refer to Figure 7).

The high number of mortalities at this location is likely due to the presence of a dry crossing over Barron Canal provided by the driveway rather than a preferred route for wildlife movement. This canal crossing is the only dry crossing between Oil Well Park Road and the canal crossings at the wildlife crossings to the south.

Five of the ten panthers killed by vehicles had telemetry data. The movements of these five panthers were plotted using the telemetry points and GIS to determine the direction from which the panthers were travelling when the vehicle mortalities occurred. This was done to identify any apparent preferences or trends in movement to narrow down alternative locations for study.

- FP106 was a collared panther that was killed at the mine driveway. This panther's telemetry data indicates her entire range was west of SR 29 up until her death. Tracking the last month of telemetry data for this panther indicates she travelled west to east at the time of her death (Figure 9).
- FP013 spent the majority of his life east of SR 29 but had at least one successful crossing of SR 29 prior to his death. Tracking telemetry points from the last month of data would suggest he was crossing east to west at the time of his death (Figure 10).
- FP031 spent most of her life during GPS monitoring west of SR 29. From telemetry points it would appear she had successfully crossed SR 29 at least one time previously but was crossing west to east at the time of her death. The telemetry indicates she previously crossed at the same location at which she ultimately collided with a vehicle resulting in her death (Figure 11).
- FP098 appears to have spent most of his time within the BCNR and FPNWR but had successfully crossed SR 29 several times (including apparent use of existing wildlife crossings to the south) based on telemetry data points. At the time of his death, he was travelling west to east (Figure 12).
- FP063 reviewing the last month of telemetry data for FP063 suggests he successfully crossed SR 29 to the north of the study segment on four other occasions. Review of all telemetry for this panther indicates he spent his life predominantly east of SR 29 in BCNR. Just prior to his death, it appears he crossed SR 29 near the mine driveway (east to west) but was killed by a vehicle in returning west to east in the southern part of the study segment (Figure 13).



FDOT

Figure 9 - Panther Telemetry Data for FP106
FPID 449143-1
SR 29 - Wildlife Crossing Feasibility Study
Collier County, FL

Data Source:
- FWC, FDA
- ESRI, FDOT
1 inch = 4,000 feet
0 2,000 4,000 Feet
N
Coordinate System: NAD 1983
Florida State Plane East

Path: H:\55210\449143-1_SR 29\Figures\Figure 9 - Panther Telemetry - FP106.mxd

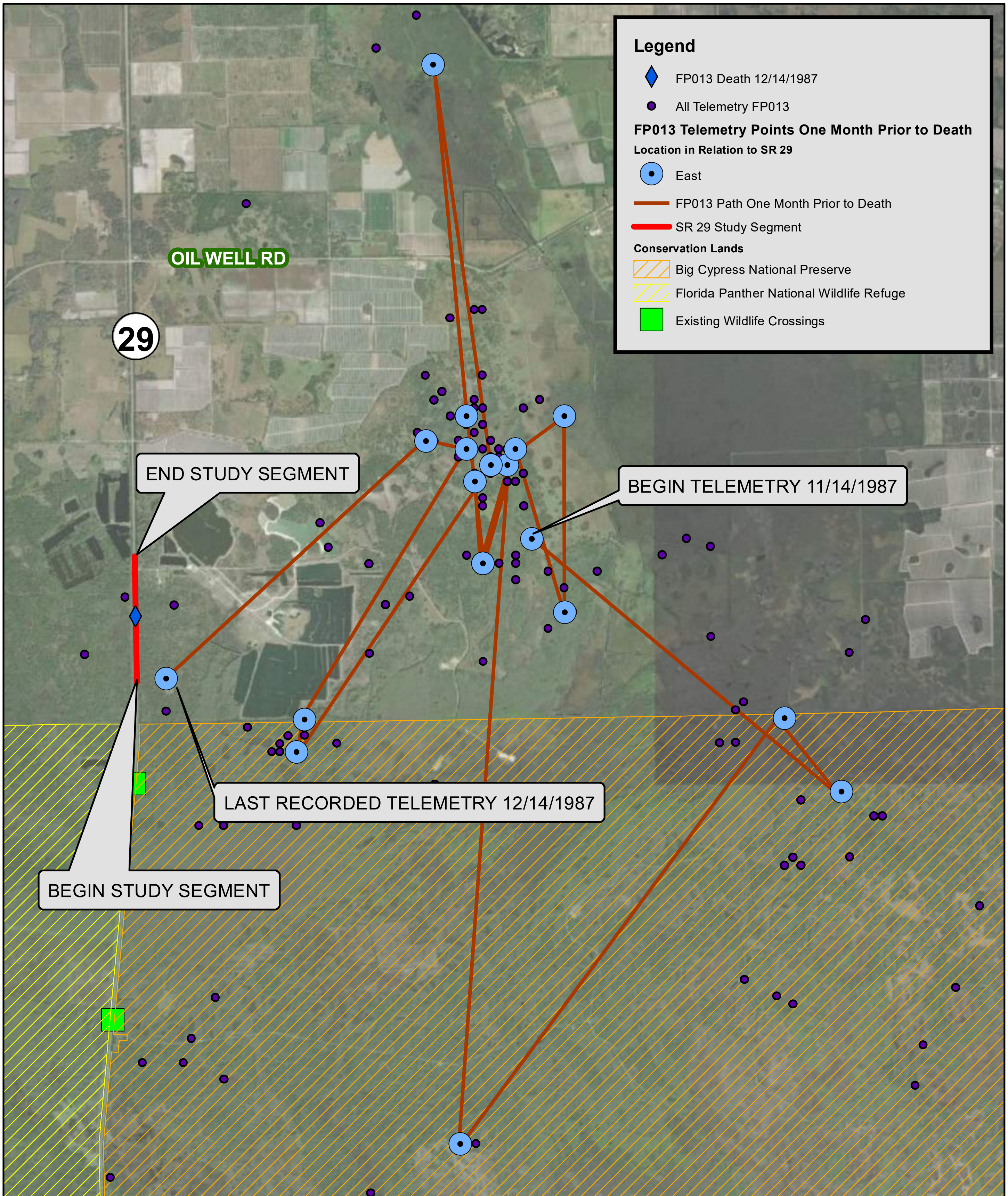


Figure 10 - Panther Telemetry Data for FP013
FPID 449143-1
SR 29 - Wildlife Crossing Feasibility Study
Collier County, FL

Data Source:
- FDA, FWC
- ESRI, FDOT
1 inch = 6,000 feet
0 3,000 6,000 Feet
N
Coordinate System: NAD 1983
Florida State Plane East

Path: H:\55210\449143-1_SR 29\Figures\Figure 10 - Panther Telemetry - FP013.mxd

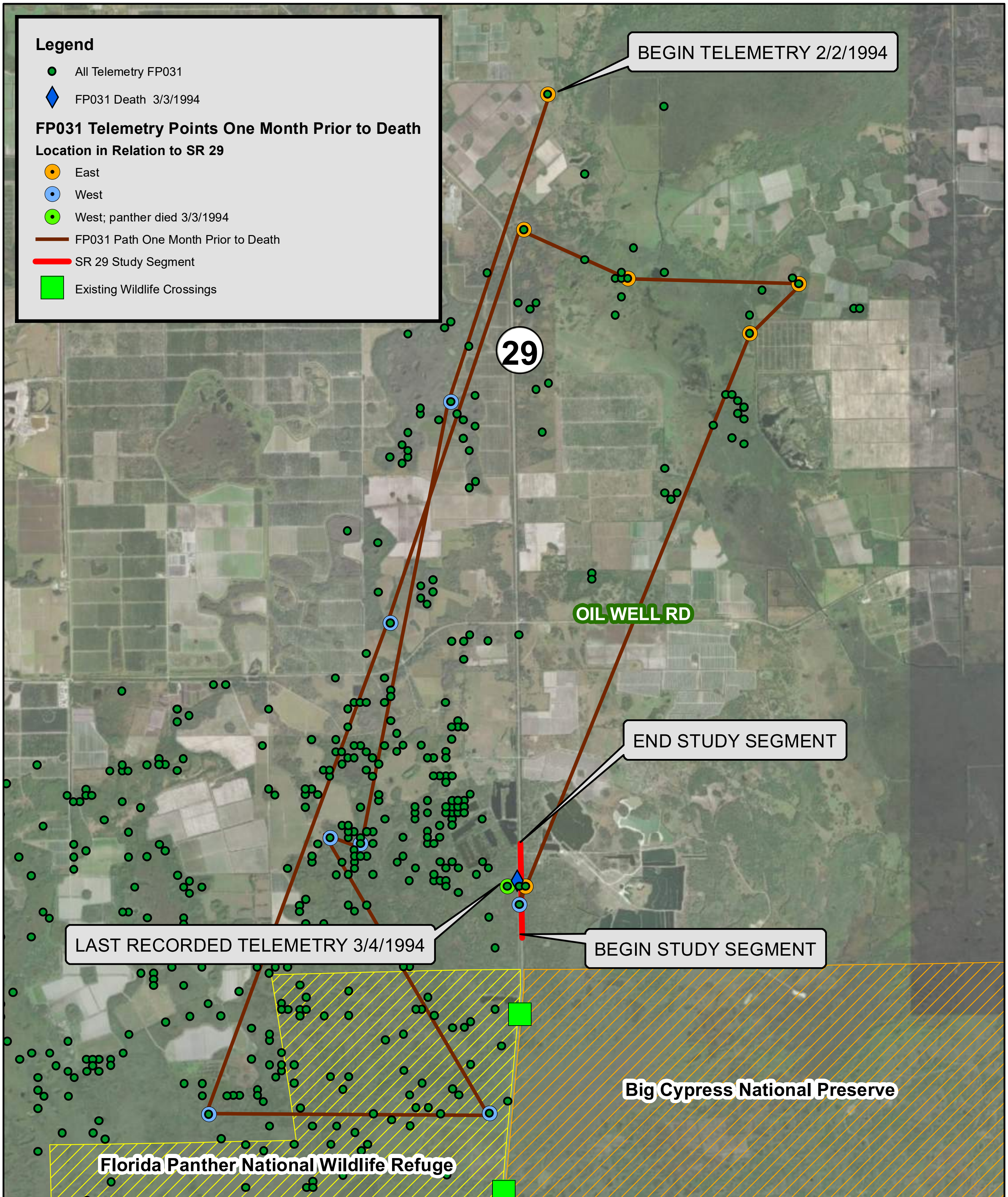


Figure 11 - Panther Telemetry Data for FP031
FPID 449143-1
SR 29 - Wildlife Crossing Feasibility Study
Collier County, FL

Data Source:
- FDA, FNAI, FWC
- ESRI, FDOT
1 inch = 8,000 feet
0 4,000 8,000 Feet
Coordinate System: NAD 1983
Florida State Plane East

Path: H:\55210\449143-1_SR 29\Figures\Figure 11 - Panther Telemetry - FP031.mxd

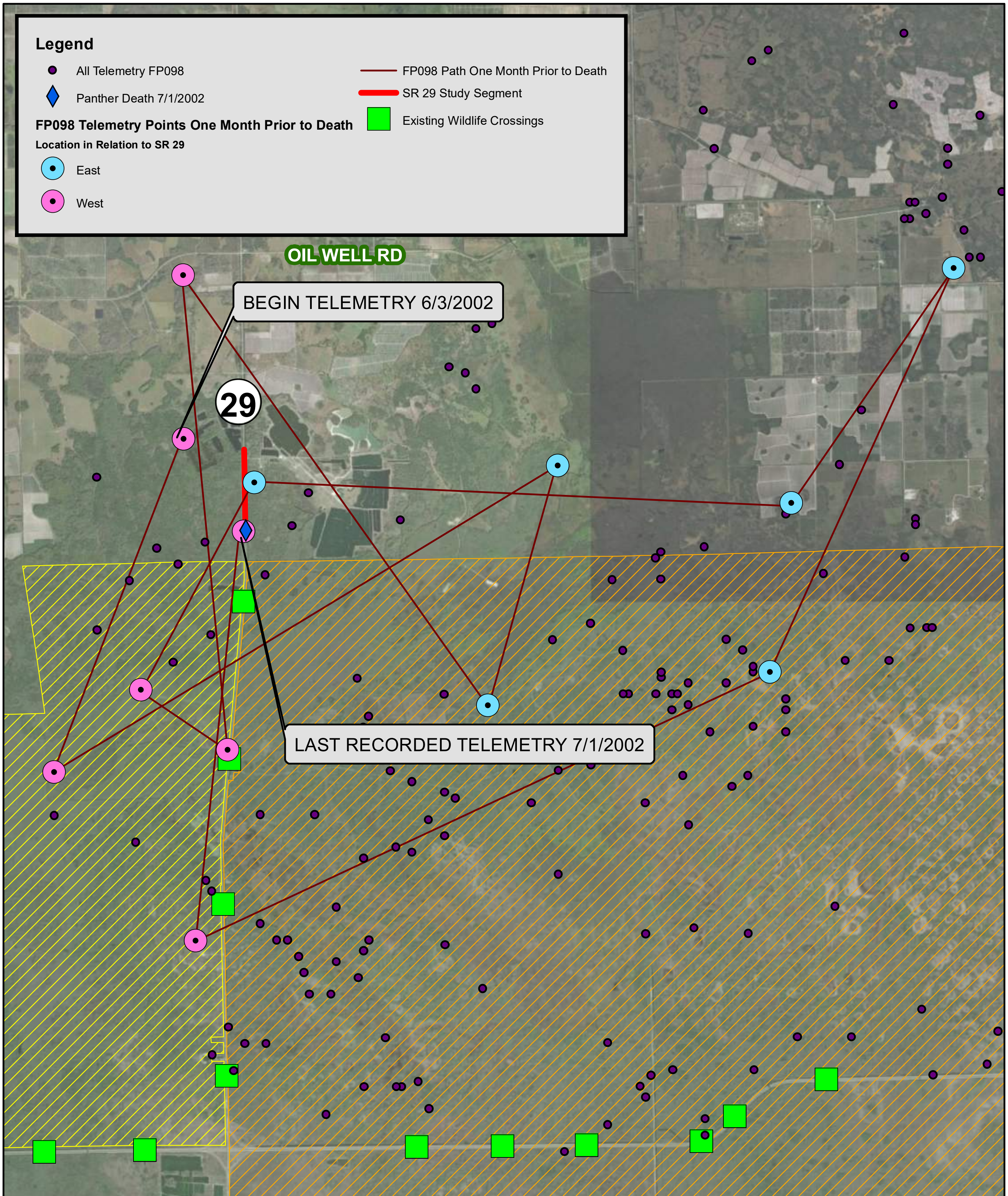


Figure 12 - Panther Telemetry Data for FP098
FPID 449143-1
SR 29 - Wildlife Crossing Feasibility Study
Collier County, FL

Data Source:
- FDA, FNAI, FWC
- ESRI, FDOT
1 inch = 9,000 feet
0 4,500 9,000 Feet
Coordinate System: NAD 1983
Florida State Plane East

Path: H:\55210\449143-1_SR 29\Figures\Figure 12 - Panther Telemetry - FP098.mxd

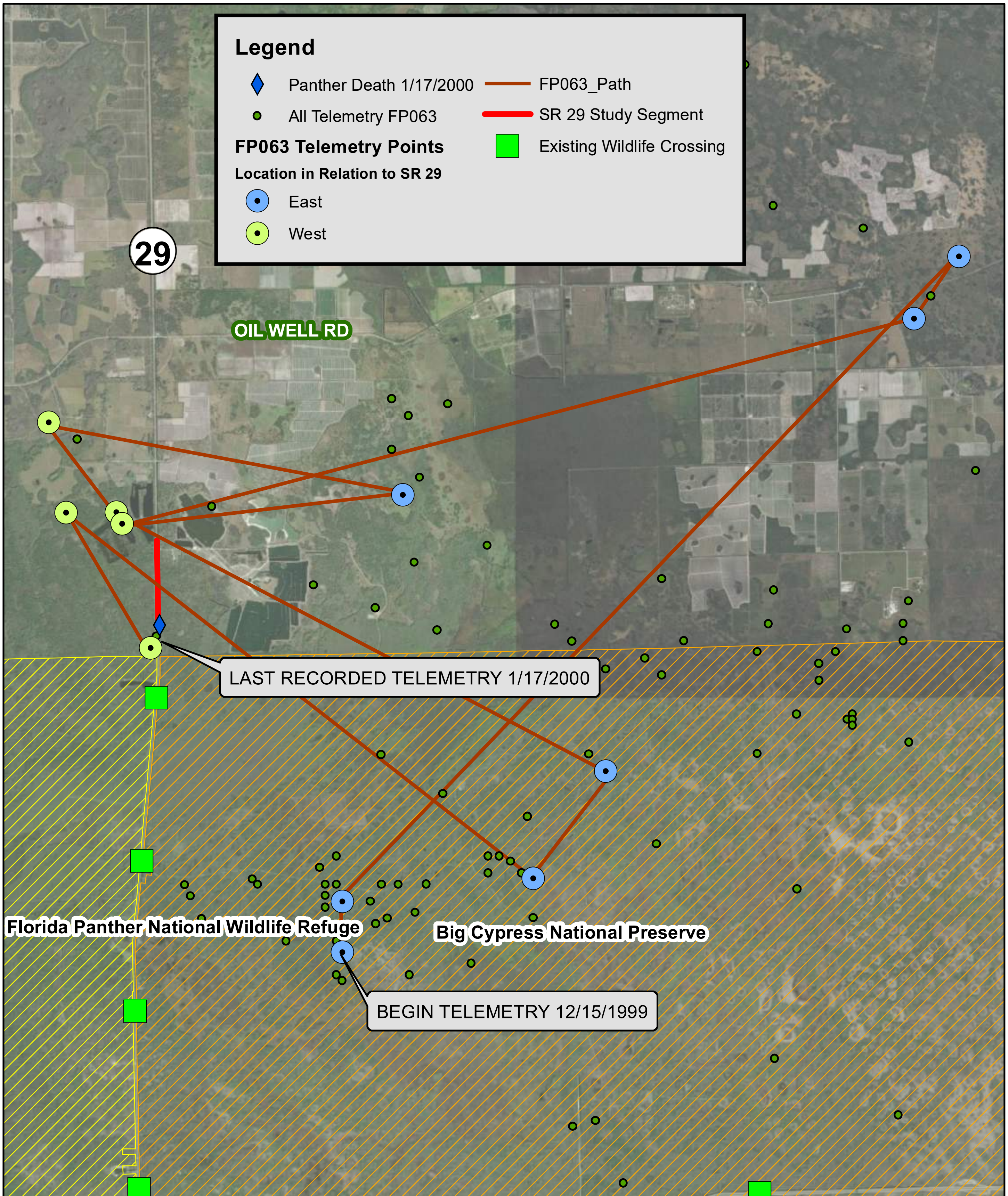


Figure 13 - Panther Telemetry Data for FP063
FPID 449143-1
SR 29 - Wildlife Crossing Feasibility Study
Collier County, FL

Data Source:
- FDA, FNAI, FWC
ESRI, FDOT
1 inch = 8,690 feet
0 4,400 8,800 Feet
Coordinate System: NAD 1983
Florida State Plane East

Path: H:\55210\449143-1_SR 29\Figures\Figure 13 - Panther Telemetry - FP063.mxd

Five sets of data were reviewed (three male and two female). Four panthers were apparently travelling west to east at the time of being struck by a vehicle. Telemetry points are less dense to the east of the study segment which may suggest panthers were going east to get to less panther-populated areas. While the review did not reveal obvious routes of travel, it did demonstrate that individual panthers can either roam significantly or may tend to avoid crossing roads. Finally, the review indicates that panthers are using habitats far beyond the one-mile study segment which requires crossing either SR 29 or other roadways to access these areas.

3.7 Roadside Animal Detection System

The FDOT plans to install a Roadside Animal Detection System (RADS) in this segment of SR 29 in mid-2022. The system will be in place for three years and will serve as a pilot test since it plans to use different technology than previous systems which often resulted in false detections. The performance of the RADS on SR 29 will be used in evaluating the need for further types of crossing enhancements in this segment and potentially other corridors.

4 ENHANCED CROSSING LOCATION ALTERNATIVES

The analysis included an assessment of two locations for wildlife crossing enhancements (see Figure 14). These locations are being evaluated because of the clusters of bear and panther-vehicle mortalities that have been recorded. The study segment is very consistent throughout in terms of land use, vegetative characteristics, roadway elements and right-of-way. There are no existing box culverts or drainage features suitable for enhancement in the segment. Both locations are within the area mapped as “Preserve” by the East Collier HCP.

Reviews were conducted on both sides of SR 29 including the east side of the Barron Canal to determine the habitat types leading up to the proposed canal crossings. Several panther-vehicle mortalities occurred to the north of the two alternative crossing locations near an existing mine driveway. As discussed in Section 2 of this analysis, the driveway itself does not appear to be a preferred corridor for wildlife travel based on telemetry data. It is hypothesized that the attraction for wildlife at this location is the dry crossing over Barron Canal the driveway provides. There is no documented evidence of the wildlife using the driveway to access active mine areas, however the dry crossing here could be used to access more natural areas to the south of the active mining.

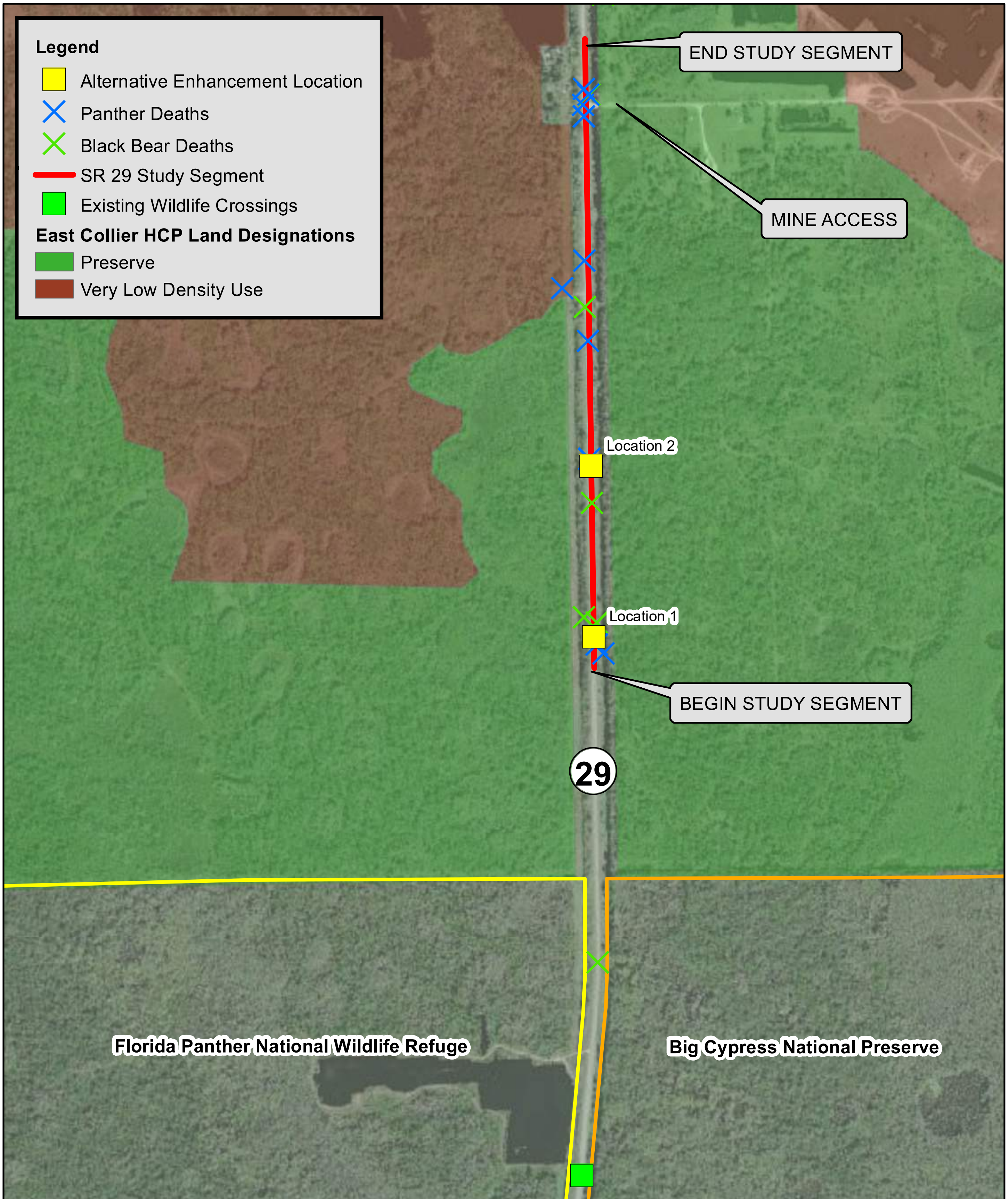


Figure 14 - Alternative Crossing Locations

FPID 449143-1

SR 29 - Wildlife Crossing Feasibility Study

Collier County, FL

Data Source:
- FDA, FNAI
- ESRI, FDOT

1 inch = 1,200 feet

0 600 1,200 Feet

Coordinate System: NAD 1983 Florida State Plane East

Path: H:\55210\449143-1_SR 29\Figures\Figure 14 - Crossing Locations.mxd

4.1 Location 1

This location is close to the Begin Study point of the segment around Station 1272+00[1] and approximately one mile north of the nearest existing SR 29 wildlife crossing. The four existing crossings to the south are spaced approximately one mile apart. Two panther and two bear-vehicle mortalities occurred in this vicinity. Mapped land cover (Section 2.4) is Mixed Hardwood Coniferous Swamp to the east of Barron Canal and Mixed Wetland Hardwoods to the west. See photographs 7, 9, and 10 in Appendix B.

This location was evaluated because of the cluster of wildlife-vehicle mortalities, and it would provide a crossing one mile north of the existing crossings. One access point to the power line easement is near this location.

4.2 Location 2

This location is south of the mid-point of the study segment at Station 1285+00 and approximately 0.3 miles north of Alternative Location 1. One panther death occurred in this vicinity. Mapped land cover is Mixed Wetland Hardwoods both to the east of Barron Canal and to the west. See photographs 11-16 in Appendix B.

It is recognized that a cluster of wildlife-vehicle mortalities is present north of Location 2 in the mid-section of the study segment, however, it was ruled out as an enhancement location following a site review due to the wetland conditions that were just to the east of the Barron Canal. Location 2 was selected due to drier conditions beyond the canal and being within the mapped Preserve area of the HCP.

5 ENHANCED CROSSING DESIGN ALTERNATIVES

Alternative structural designs were considered to provide a safer method for wildlife to cross SR 29 and the adjacent canal. Crossing configurations that were considered included going over or under SR 29. To go over the road, a wildlife overpass was considered but dismissed mainly due to existing overhead power lines along the west side of SR 29 and the amount of right-of-way that would be needed for an overpass including the approach slopes. Therefore, only underpass alternatives were considered. The two alternatives considered were a bridge structure and a box culvert, both would be dry year-round. Neither design would function in the roadway drainage system and serve only for wildlife use. Both alternatives involve raising the grade of SR 29 to an elevation which can accommodate a wildlife crossing underneath the roadway. Two concepts were

[1] A survey alignment file from a resurfacing project (425219-1) is referenced as a baseline.

considered to span the width of the Barron Canal. These include a Florida I-beam concrete bridge and a bridge using horizontally placed prestressed concrete piles.

Development of the alternatives and the criteria were based on previous experience with wildlife crossing designs for existing underpasses and canal crossings. Wildlife crossings will be constructed one foot above the seasonal high water (SHW) elevation and a minimum of eight feet of vertical clearance will be provided between the wildlife crossing and the low member of the superstructure or top of the box culvert. The SHW elevation at the proposed locations was estimated as 15.7 ft NAVD based on field observations of staff gauges present at a Barron Canal control structure located within the study segment. Design alternatives considered are described in Table 1.

Table 1 Design Alternatives Summary and Estimated Cost

Design Alternative	Description	Estimated Cost
SR 29 Alternative 1	Bridge structure for wildlife underpass (design matches existing crossings to the south)	$548,645
SR 29 Alternative 2	Dry concrete box culvert	$204,806
Barron Canal Alternative 1	Florida I-Beam concrete bridge (design matches existing crossings to the south)	$258,034
Barron Canal Alternative 2	Two 30” prestressed concrete piles placed side by side	$64,467

5.1 SR 29 Design Alternative 1

SR 29 Alternative 1 evaluates elevating the existing grade of SR 29 and using a prestressed concrete bridge to provide a wildlife underpass beneath the roadway. Two existing wildlife crossings along SR 29, which are just south of the proposed location, utilize a similar design concept. The proposed bridge structure would match the provided vertical and horizontal clearance of the existing wildlife crossings. In addition, the proposed bridge would match the typical section of the previously widened segment of SR 29, which contains a four-foot paved shoulder (10 ft. total shoulder width).

The height of the wildlife bridge was determined by providing a minimum 8 feet of vertical clearance between the proposed ground elevation and the low beam member of the bridge. To ensure the wildlife crossing would remain dry, even during the rainy season, the proposed ground elevation was set to 1 ft. above the seasonal highwater elevation. To accommodate a wildlife crossing height of 8 feet, the existing SR 29 roadway profile would have to be raised approximately 9 feet at this location. MSE wall would be employed to build up the grade of the approaching roadway leading to the underpass.

A total of 50 feet of horizontal clearance was provided between the faces of MSE walls. To accommodate the wrap-around MSE walls, along with the horizontal clearance, a total structural bridge length of 59'-2" is required. With consideration to the overall span length, and to maintain uniformity with the existing structures in the proximity, an AASHTO Type II beam superstructure was selected for this alternative. Florida Slab Beams were also considered but would require the use of 18 in. slab units which proved a less economical alternative. Refer to Figures 15 and 16 for a plan and elevation view of this alternative.

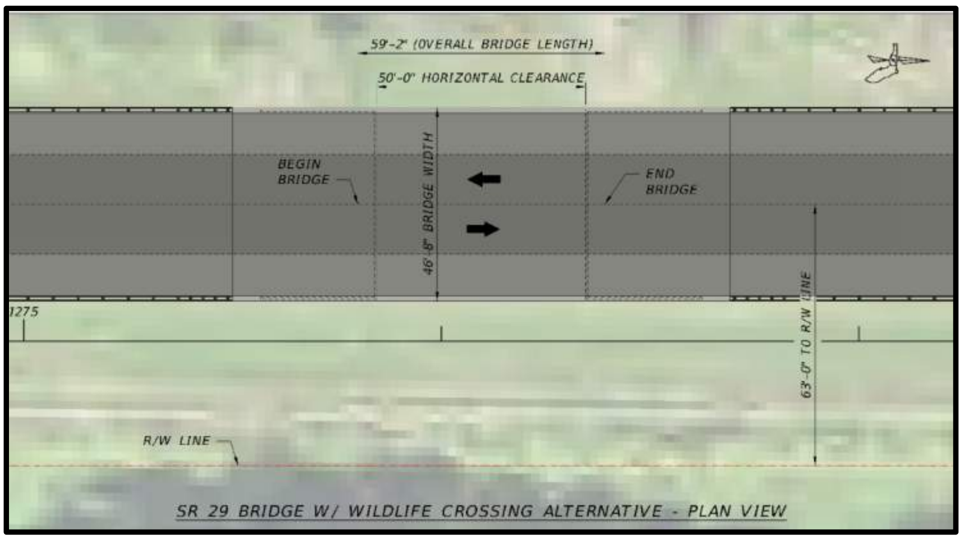


Figure 15 SR 29 Alternative 1 Plan View

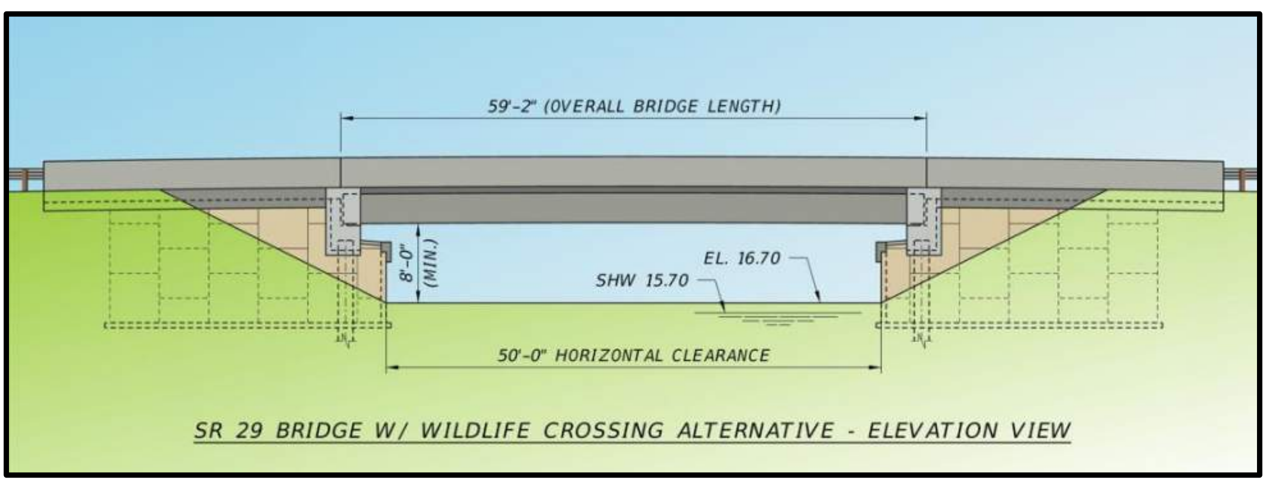


Figure 16 SR 29 Alternative 1 Elevation View

5.2 SR 29 Design Alternative 2

Alternative 2 evaluates elevating the existing grade of SR 29 and using a single 10 ft. x 8 ft. concrete box culvert to provide a wildlife underpass beneath the roadway. The box culvert will be 57 ft. long with roadway side slopes of 1:2 with shoulder gutter. Guardrail will be provided since the culvert headwalls are located within the clear zone.

Similar to Alternative 1, this alternative provides a vertical clearance of 8 ft. for wildlife utilizing the crossing—matching the clearance being provided by the existing wildlife crossings in the area. To ensure the box culvert would remain dry, even during the rainy season, the proposed invert elevation was set to 1 ft. above the seasonal highwater elevation. To accommodate a vertical clearance of 8 ft., the existing SR 29 roadway profile would have to be raised approximately 8 ft. at this location. Wingwalls will be used to elevate the grade of the approaching roadway leading to the underpass.

Alternative 2 provides 10 ft. of clear distance from the face of the box culvert interior walls. While this alternative may provide less overall horizontal clearance than Alternative 1 and appear less open to wildlife passing through the crossing, it presents a more economical underpass option. Refer to Figure 17 for an elevation view of this alternative.

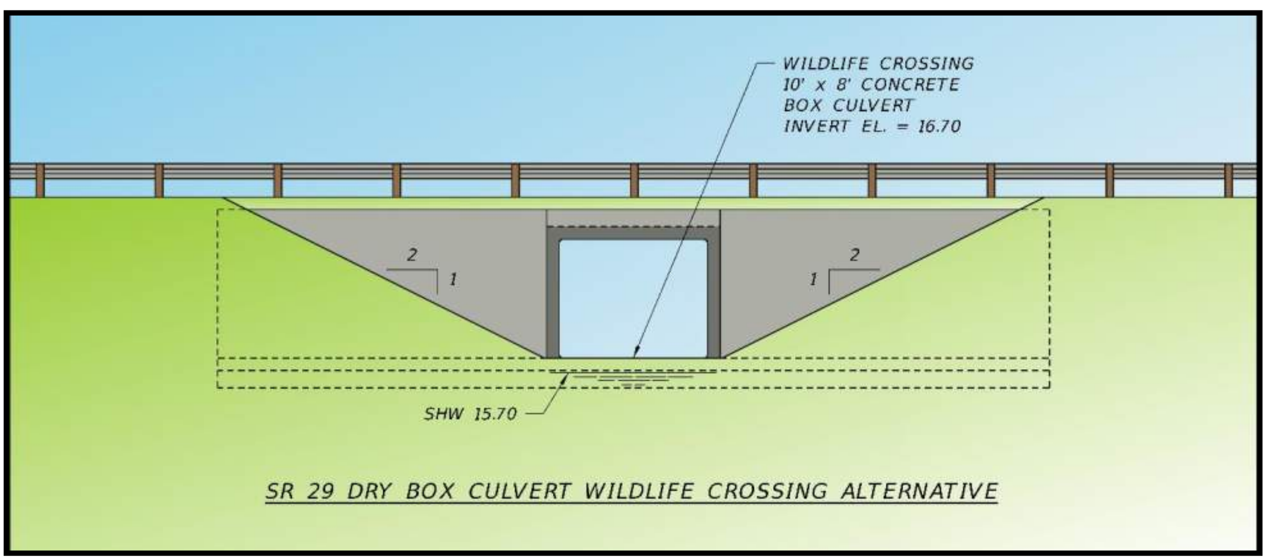


Figure 17 SR 29 Alternative 2 Elevation View

5.3 Barron Canal Alternative 1

This alternative evaluates the construction of a wildlife bridge over the Barron Canal, which runs parallel to SR 29. The intent of this alternative is to match the dimensions and general design of the two existing wildlife crossings south of the proposed project limits. To clear the entire length of the canal, an overall bridge length of approximately 80 ft. is required. With consideration to the overall span length, the use of a Florida-I Beam superstructure is recommended for this alternative. By spanning the entire length of the canal, this alternative would preclude the need to install substructure elements within the canal, which may impede flow and have adverse hydraulic impacts. Slope protection will be utilized at each end bent to protect the structure from any future erosion along the canal bank. Bank and shore rubble riprap will be utilized at each bent to protect the structure from erosion along the canal bank.

The bridge height was determined such that an adequate amount of room between the bottom of the beam members and the seasonal high water was provided. This will allow for unhindered passage of debris underneath the bridge. This alternative provides an overall bridge width of 12 ft., with a clear distance of 10’-5” between the face of 27” concrete parapets. To best simulate the natural terrain of the area, a 2’-3” layer of soil substrate, located between concrete parapets, would be employed over the bridge deck for local vegetation to grow. Bollards can be provided at the ends of the bridge to prevent any vehicle incursion onto the wildlife crossing. Refer to Figures 18 and 19 for a plan and elevation view of this alternative.

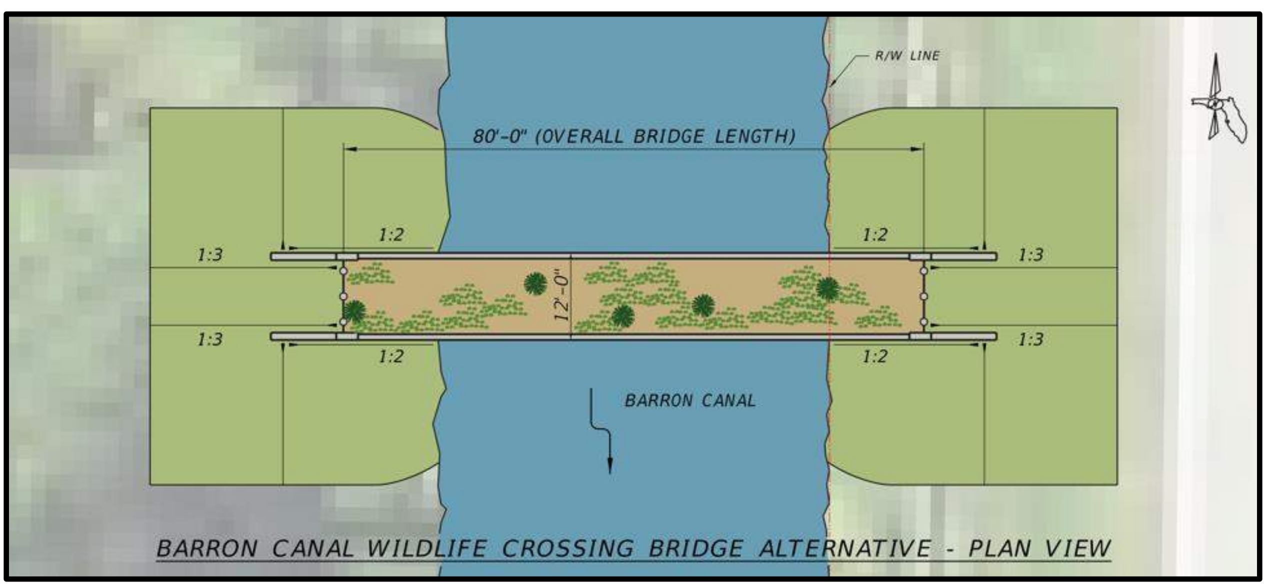


Figure 18 Barron Canal Alternative 1 Plan View

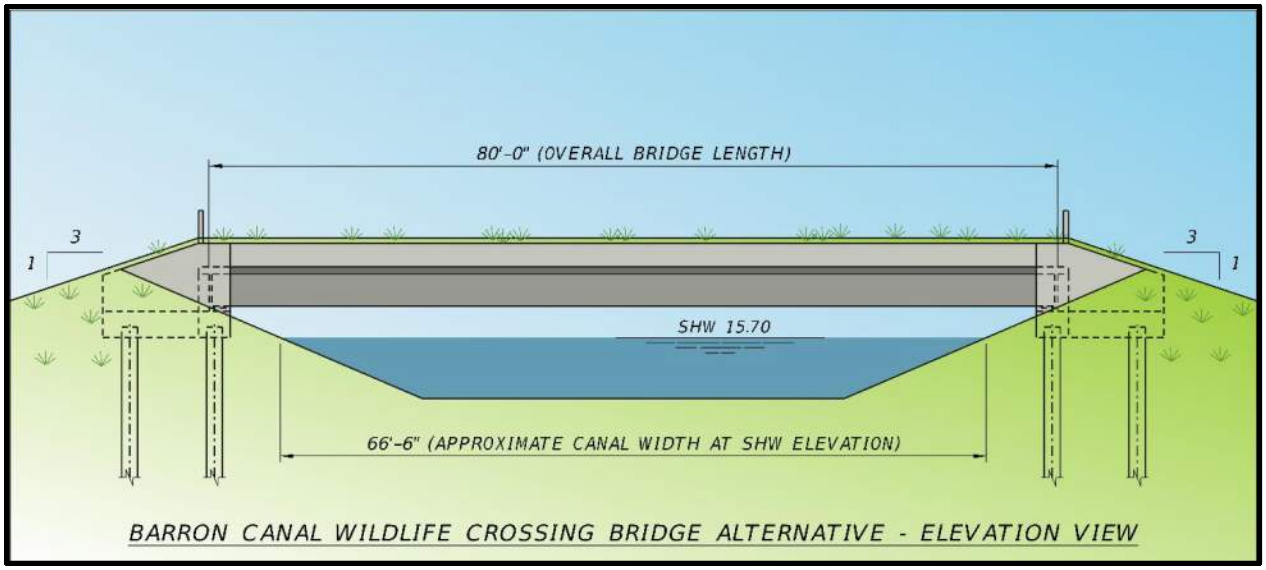


Figure 19 Barron Canal Alternative 1 Elevation View

5.4 Barron Canal Alternative 2

Barron Canal Alternative 2 evaluates the use of 30" prestressed concrete piles to clear the width of the canal. The piles would be placed side-by-side horizontally to create a 5 ft. walking surface to cross the canal. The use of concrete end blocks would be employed at the ends of the piles with slope protection to prevent any future bank erosion at the structure location.

Alternative 2 presents a less costly canal crossing alternative to the wildlife bridge. However, a vegetative cover on the walking surface would not be able to be provided for this alternative. Refer to Figure 20 for an elevation view of this alternative.

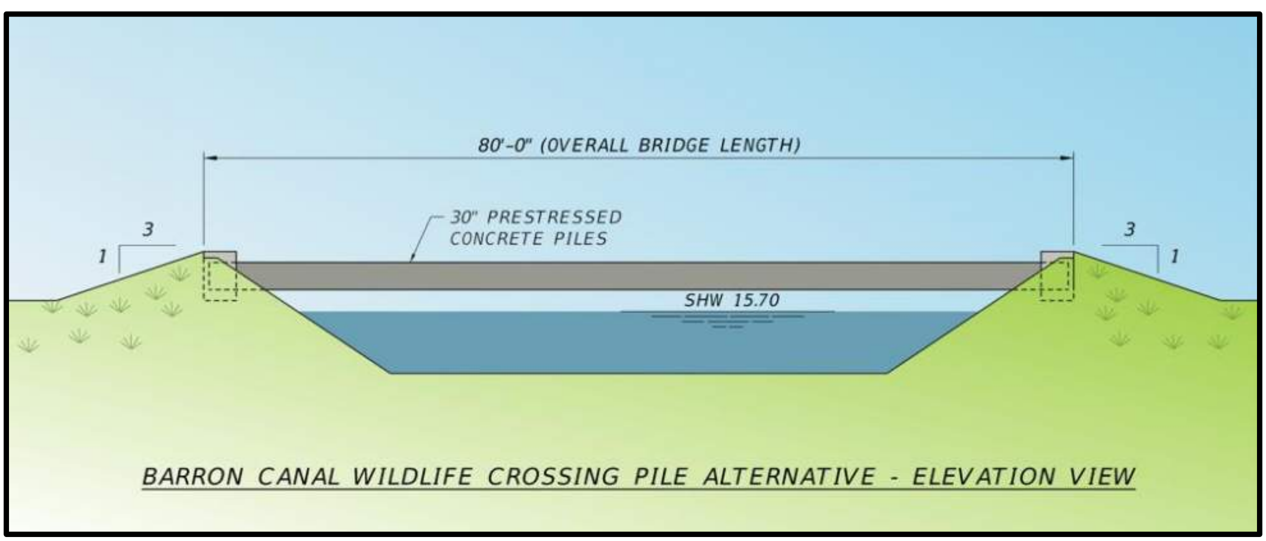


Figure 20 Barron Canal Alternative 2 Elevation View

5.5 Temporary Traffic Control Plan

SR 29 Structures Alternatives 1 and 2 propose to raise the roadway elevation 8 to 9 feet above the existing grade. This will require pavement reconstruction to accommodate the proposed profile changes. Construction of both alternatives will require a Special Detour to maintain traffic on this SIS corridor and provide a work zone area which accommodates the proposed elevation differences. Two 12-foot lanes with four-foot shoulders of temporary pavement will be utilized on the west side of SR 29, between the existing pavement and the existing utility easement. The existing right-of-way width can accommodate the special detour and work zone area without the use of temporary walls. Advanced warning signs, including PCMS boards, are proposed to alert the driver of the special detour. The Barron Canal Alternatives will be constructed in the same phase as the SR 29 structures.

6 WILDLIFE FENCING ANALYSIS

Wildlife fencing is proposed both north and south of proposed crossing locations along SR 29 and the canal. Fence alternatives were considered to address not only the enhancement location, but to also help reduce the wildlife-vehicle mortalities through a nearly one-mile-long segment of roadway.

6.1 Fence Alternative 1

FDOT wildlife crossing guidelines recommend providing adequate fencing to guide wildlife for a sufficient distance to the wildlife crossing feature. Type B fence, ten feet in height with barbed wire, in the Standard Plans Index 550-002 is recommended and would match the existing wildlife fencing to the south. Often a length of 1,000 feet north and south (2,000 feet total per side) is adequate to guide wildlife to crossing features.

This fence length was mapped at Location Alternatives 1 and 2 to visualize the potential effect (assuming that ultimately only one location would be recommended). Figure 21 is a depiction of what the 2,000 foot per side of roadway looks like in relation to the study segment and the mapped panther and bear mortalities. For this study segment, 1,000 feet north and south of one crossing enhancement location did not seem to adequately address the needs of the corridor given the length being about one mile with 15 combined panther/bear-vehicle mortalities. Following this conclusion, two other fence options were evaluated.

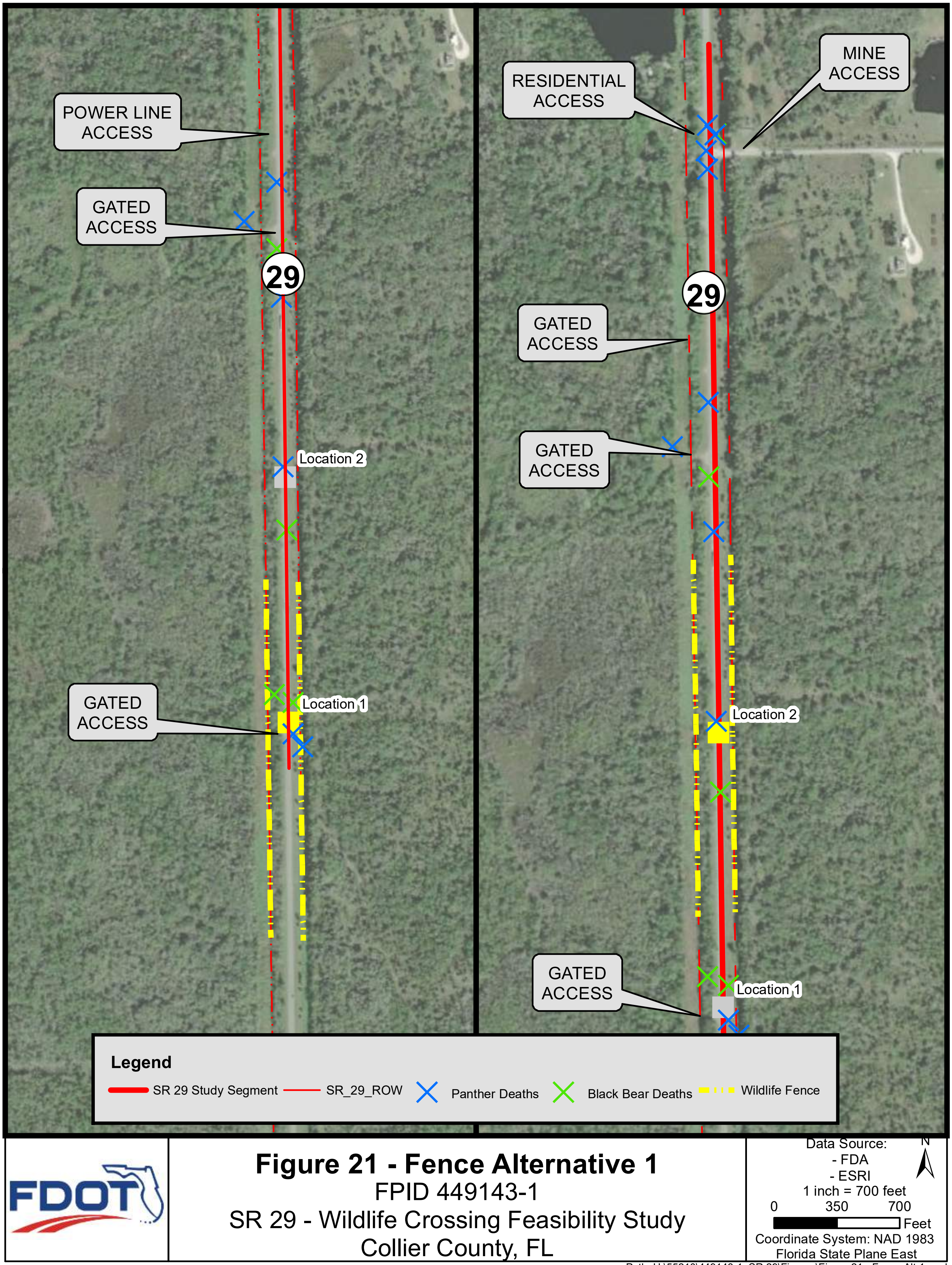


Figure 21 - Fence Alternative 1

FPID 449143-1

SR 29 - Wildlife Crossing Feasibility Study

Collier County, FL

Path: H:\55210\449143-1_SR 29\Figures\Figure 21 - Fence Alt 1.mxd

6.2 Fence Alternative 2

There appears to be three concentrated areas where wildlife-vehicle mortalities are occurring in this study corridor. Providing segments of fencing only around the clusters of mortalities would leave gaps; therefore, Fence Alternative 2 (Figure 22) proposes to install wildlife fencing for the length of the segment and install wildlife-proof gates at the gated access points and the mine driveway. The wildlife fence on the west side would terminate at the residential property limits. The fence would extend about 400 feet north of the mine driveway on the east.

Two power line access points currently have 12-foot utility gates while one is a double gate. These would be replaced with wildlife-proof gates of the same width as currently in place.

Again, referencing the analysis and site visits, it appears wildlife do not heavily use the residential area, abandoned mine pits to the north, and the active mine to the east as frequently as other habitat types in the region. However, there remains a record of four panther and one bear-vehicle mortalities at the mine driveway. The regular vehicular traffic at the driveway during the daytime would likely be enough to discourage wildlife from using the dry crossing during the day. Coordination with the landowners and tenants would be necessary; however, night-use gates (two 12-foot gates) and wildlife fencing would exclude wildlife from using the driveway as a canal crossing nights and weekends. A three-foot-wide swing gate for pedestrian access is also proposed at the driveway. If Location Alternative 1 is the recommended alternative, the fence length should be extended further to the south than depicted in Figure 22.

6.3 Fence Alternative 3

Fence Alternative 3 (Figure 23) is a big-picture, regional view of wildlife fencing. This alternative proposes to install wildlife fencing beginning at the termination of the wildlife fencing within the FPNWR and BCNP northward, through the study segment to the residences on the west and 400 feet north of the mine driveway on the east. Wildlife-proof gates at the three power line access points and the mine are included. Also included are 3-foot pedestrian access swing gates at these access locations. Table 2 summarizes the fence alternatives.

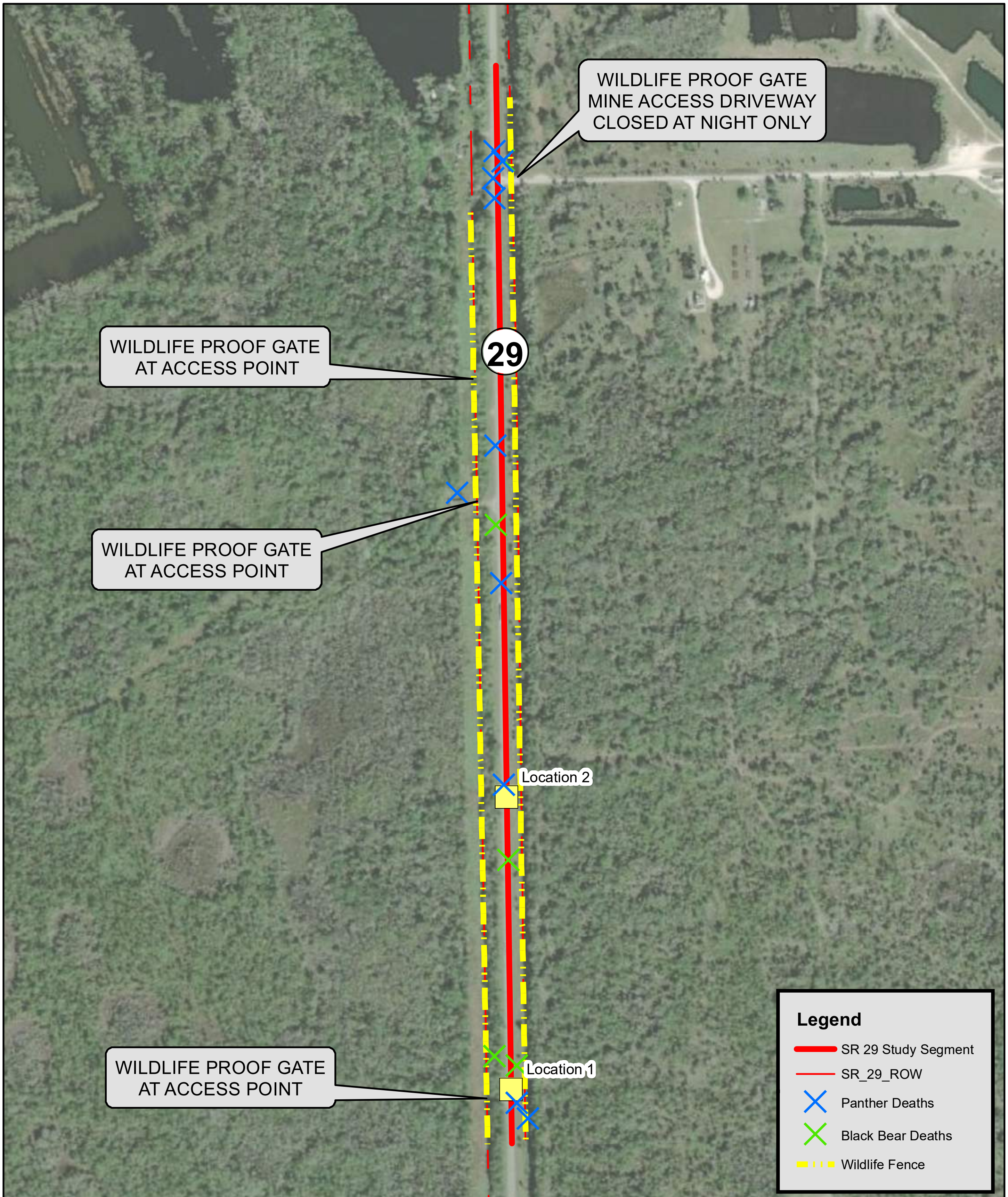


Figure 22 - Fence Alternative 2
FPID 449143-1
SR 29 - Wildlife Crossing Feasibility Study
Collier County, FL

Data Source:
- FDA, FDOT
- ESRI
1 inch = 700 feet
0 350 700 Feet
Coordinate System: NAD 1983
Florida State Plane East

Path: H:\55210\449143-1_SR 29\Figures\Figure 22 - Fence Alt 2.mxd

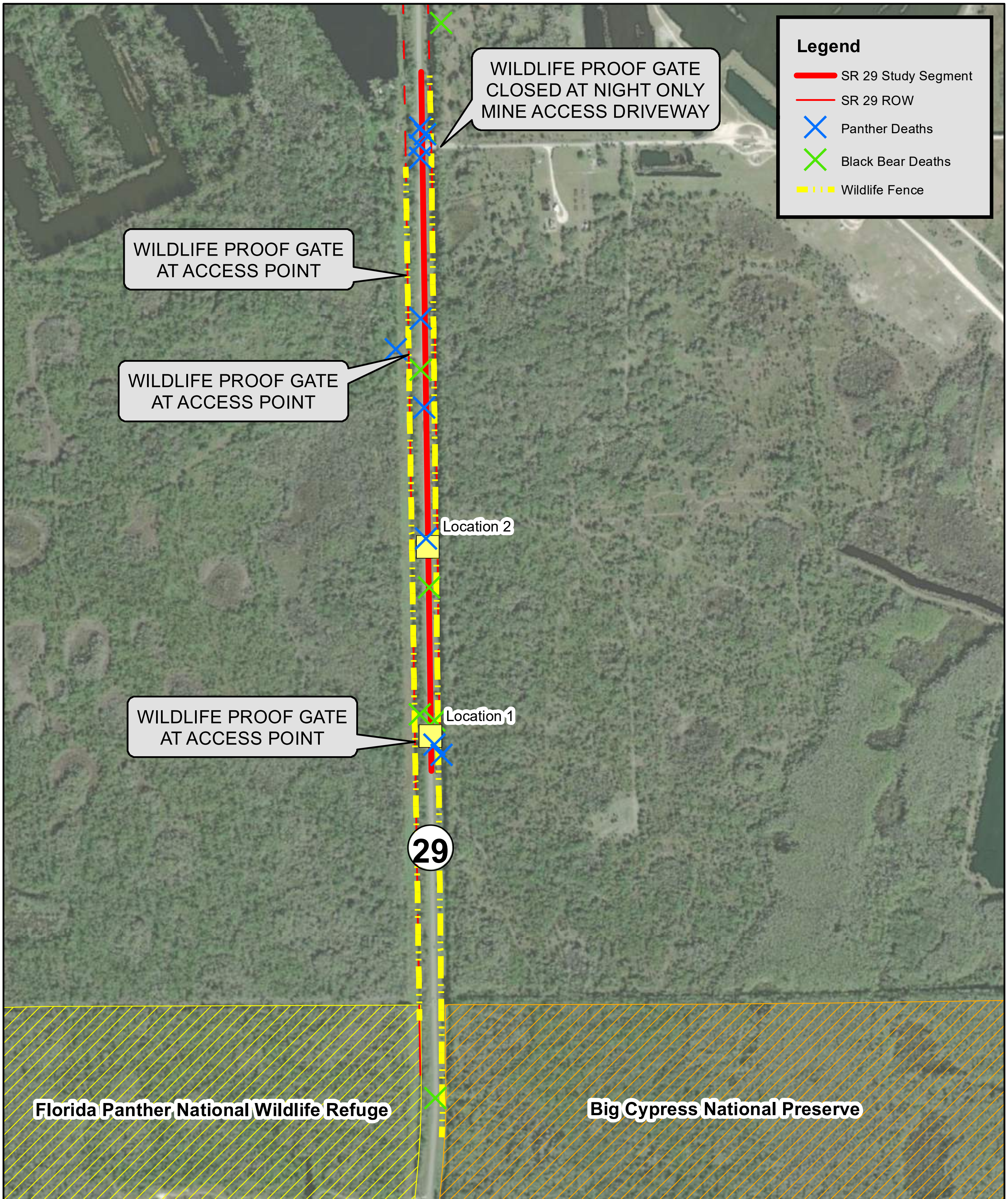


Figure 23 - Fence Alternative 3
FPID 449143-1
SR 29 - Wildlife Crossing Feasibility Study
Collier County, FL

Data Source:
- FDA, FNAI
- ESRI, FDOT

1 inch = 1,080 feet
0 540 1,080 Feet
Coordinate System: NAD 1983
Florida State Plane East

Path: H:\55210\449143-1_SR 29\Figures\Figure 23 - Fence Alt 3.mxd

Table 2 Fence Alternatives and Estimated Cost

Alternative	Length	12-foot Driveway Gates	3-foot Swing Gates	Estimated Cost
1	4,000 ft*	1 single	2 (at crossing location)	$243,776
2	9,300 ft	2 single 2 double	2 (at crossing location) 4 (at access points)	$571,070
3	13,800 ft	2 single 2 double	2 (at crossing location) 4 (at access points)	$841,970

*Assumes fencing at one of the alternative locations

7 ALTERNATIVES COST ANALYSIS

The various costs by alternative are provided below in the following sections. Separate costs for structures, roadway and fencing are included in Appendix D.

7.1 SR 29 Alternative 1

Alternative 1 is the bridge structure for wildlife to cross under SR 29 and is similar to existing crossings to the south. The estimated structures cost for this alternative is $548,645. Roadway cost, including maintenance of traffic, mobilization and project unknowns was totaled at $1,271,187. The structures and roadway cost combined is $1,819,832.

7.2 SR 29 Alternative 2

Alternative 2 is a box culvert under SR 29. The estimated structures cost is $204,806. The roadway cost is estimated to be $1,167,025. The structures and roadway cost combined is $1,371,832.

7.3 Barron Canal Alternative 1

Alternative 1 to cross the Barron Canal is a concrete bridge similar to existing canal crossings to the south. The structures cost of this alternative is $258,034. The roadway cost is estimated to be $4,978. The combined cost for structures and roadway is $263,012. Right-of-way either as a purchase or as an easement would be needed for either alternative to cross the canal and these costs have not been included in the estimate.

7.4 Barron Canal Alternative 2

Alternative 2 to cross the Barron Canal is two concrete bridge piles placed horizontally side-by-side. The structures cost estimate for this alternative is $64,467. The roadway cost is estimated to be $1,698. The combined cost for structures and roadway is $66,165. Right-of-way either as a purchase or as an easement would be needed for either alternative to cross the canal and these costs have not been included in the estimate.

7.5 Fence Alternative 1

This fence alternative proposes the minimum fencing length of 4,000 feet with access gates to the enhanced crossing location. The estimated cost is $243,776.

7.6 Fence Alternative 2

Alternative 2 for fencing proposes 9,300 feet of fence with access gates at the enhanced crossing location, at the power line access points, and mine driveway. This alternative's estimated cost is $571,070.

7.7 Fence Alternative 3

The final fence alternative proposes 13,800 feet of fencing with access gates at the enhanced crossing location, at the power line access points, and mine driveway. This alternative's estimated cost is $841,070.

8 RECOMMENDATION

The recommendations based on this feasibility study are Location 2, SR 29 Alternative 2 (box culvert), Barron Canal Alternative 2 (prestressed concrete piles), and Fence Alternative 3. Both alternative locations considered in this feasibility study were identified in the SR 29 PD&E wildlife connectivity analysis as suitable locations. The culvert designs in this study and the PD&E analysis are similar with slight variations on the sizing. The draft analysis from the PD&E study is provided as Appendix E.

Location 2 was selected because the off-site habitats approaching the crossing are drier than other areas in the corridor. Heavy use of adjacent habitat by panthers and bear is documented by telemetry data on both sides of SR 29. This location is south of the residences and active mining operation and about 1.2 miles north of nearest wildlife crossing to the south. There are no power line access driveways that would be in conflict with roadway profile changes at this location and is within mapped Preserve land referencing the Eastern Collier HCP. Although the PD&E study analysis recommended two crossing locations, based on this feasibility study and the recommended fencing alternative, a crossing at one location will be ecologically effective and would have less impacts on the nearby power line access driveway.

To cross under SR 29, the box culvert (SR 29 Alternative 2) is the recommended alternative which consists of elevating the existing grade of SR 29 and using a single 10 ft. x 8 ft. concrete box culvert to provide a wildlife underpass beneath the roadway. The box culvert is proposed to be 57 ft. long. This alternative will provide a vertical clearance of 8 ft. for wildlife utilizing the crossing—matching the clearance being provided by the existing wildlife crossings in the area. The proposed invert elevation will be 1 ft. above the seasonal high water elevation. To accommodate a vertical clearance of 8 ft., the existing SR 29 roadway profile would have to be raised approximately 8 ft. at this location.

To cross the Barron Canal, Alternative 2 is recommended which consists of the prestressed concrete piles. Although the recommended canal crossing is a different design from the canal crossings to the south, it will function the same as a bridge although its design is simpler overall. The simple design has its own benefits: environmental impacts, permitting and construction footprint should be less than the other alternative. Because the existing right-of-way limit is approximately the canal bank, most of the canal crossing will be located outside the right-of-way. If right-of-way is purchased, the smaller footprint will be less costly. The cost of the concrete pile bridge is about four times less than the cost of the Florida I-beam making it the more cost-effective option.

The recommended fence alternative is Fence Alternative 3. This alternative proposes to install wildlife fencing beginning at the termination of the wildlife fencing within the FPNWR and BCNP northward, through the study segment to the residences on the west and 400 feet north of the mine driveway on the east. Wildlife-proof gates at the three power line access points and the mine are included. Also included are 3-foot pedestrian access swing gates at these access locations.

The three power line access points and the mine driveway are hypothesized to play a role in attracting wildlife towards the roadway. The proposed gates will eliminate these access points from wildlife use and fencing will lead wildlife to the safe underpass crossing location. The recommended location, design and fence alternative including costs are summarized in Table 3 below.

Table 3 Recommended Alternatives and Total Cost

Alternative	Cost
Location 2	*
SR 29 Design Alternative 2	$1,371,832
Barron Canal Crossing 2*	$66,166
Fence Alternative 3	$841,070
Total Cost	**$2,279,068**

*right-of-way cost is not included

Further coordination that should take place include power company representatives and property owners for either right-of-way or easements related to the canal crossing and post-fencing access proposed wildlife gates. Coordination with Sunniland Farms/Vulcan Materials will be needed for the proposed wildlife gate at the mine driveway. Power line maintenance crews will need to access the overhead lines on the west of SR 29, and the access points from SR 29 also provide access to the private property to the west of the roadway. The property owner for both sides of the road south of the mine is listed as Barron Collier Partnership, LLC by the Collier County Property Appraisers website. The power line is within an easement on private property.

The total cost of the recommended alternatives is about $2.3M. The SR 29 structure, canal crossing, and roadway reconstruction is approximately $1.4M with the fence alternative representing $840K. The alternatives were recommended by balancing ecological need with cost. The fence and elimination of access points, although costly, are integral features to the overall success of any underpass and canal crossing design considered.

9 REFERENCES

FDOT. (2011). *Final As Built Plans FPID 425219-1-52-01; SR 29 Collier County.* Bartow: FDOT.

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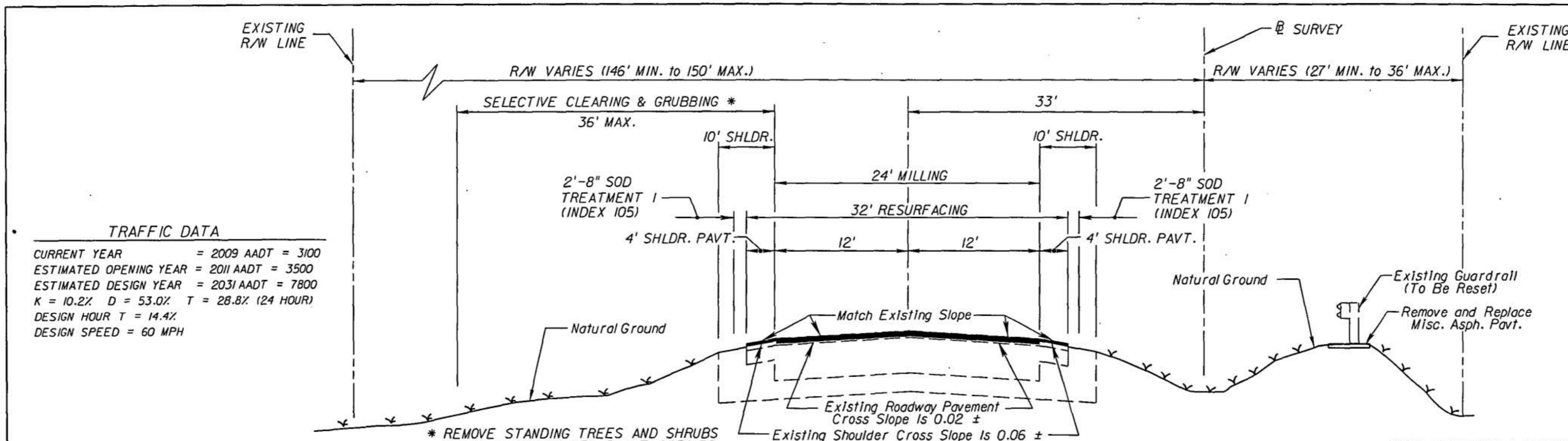
Appendix A

SR 29 Typical Section and

Straight-Line Diagram



TRAFFIC DATA

CURRENT YEAR = 2009 AADT = 3100
ESTIMATED OPENING YEAR = 2011 AADT = 3500
ESTIMATED DESIGN YEAR = 2031 AADT = 7800
K = 10.2% D = 53.0% T = 28.8% (24 HOUR)
DESIGN HOUR T = 14.4%
DESIGN SPEED = 60 MPH

* REMOVE STANDING TREES AND SHRUBS ONLY. ANY PROTECTED PLANT SPECIES IN THIS AREA TO REMAIN UNDISTURBED. SEE SUMMARY TABLE FOR LOCATIONS.

TYPICAL SECTION No. 1
SR 29

STA. 1056+25.00 TO STA. 1073+73.52
STA. 1075+49.77 TO STA. 1106+95.51
STA. 1113+25.33 TO STA. 1121+74.00
STA. 1149+32.00 TO STA. 1216+55.56
STA. 1244+79.00 TO STA. 1517+50.00

PAVEMENT DESIGN - THROUGH LANES AND TURN LANES

MILLING

MILL EXISTING ASPHALT PAVEMENT (1.5" AVG. DEPTH)

RESURFACING

CONST. TYPE SP STRUCTURAL COURSE (TRAFFIC C)(1.5") AND FRICTION COURSE FC-12.5 (TRAFFIC C)(1.5")(RUBBER)

WIDENING

CONST. OPTIONAL BASE GROUP 9 WITH TYPE SP STRUCTURAL COURSE (TRAFFIC C)(1.5") AND FRICTION COURSE FC-12.5 (TRAFFIC C)(1.5") RUBBER

PAVEMENT DESIGN - PAVED SHOULDERS

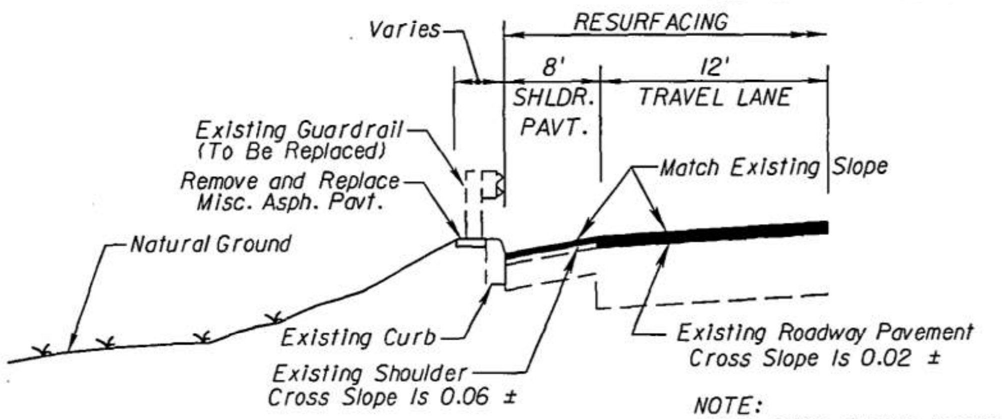
NO MILLING

RESURFACING

CONST. FRICTION COURSE FC-12.5 (TRAFFIC C)(1.5") RUBBER

WIDENING

CONST. OPTIONAL BASE GROUP 1 WITH FRICTION COURSE FC-12.5 (TRAFFIC C)(1.5") RUBBER



NOTE:
LEFT SIDE SHOWN, MIRROR IMAGE FOR RIGHT SIDE.

SHOULDER DETAIL AT BRIDGE APPROACHES

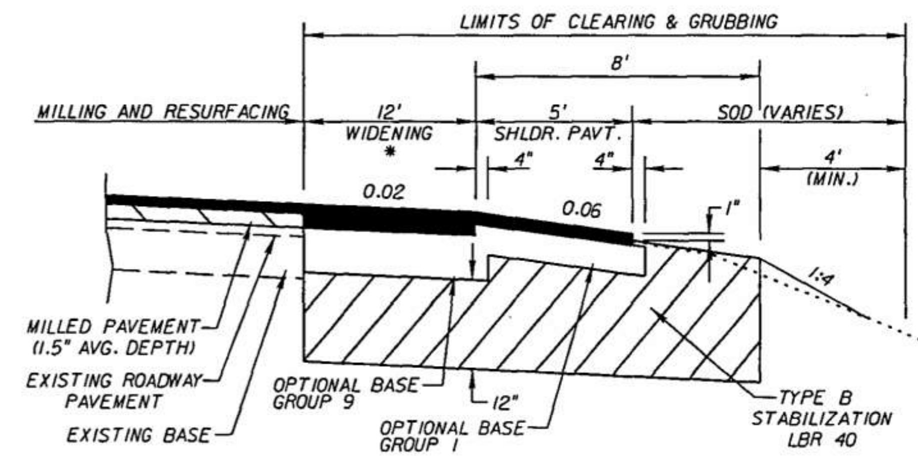
LEFT SHOULDER	RIGHT SHOULDER
STA. 1072+67.60 TO STA. 1073+73.52	STA. 1072+89.08 TO STA. 1073+73.52
STA. 1075+49.77 TO STA. 1076+36.15	STA. 1075+49.77 TO STA. 1076+51.33
STA. 1105+89.61 TO STA. 1106+95.51	STA. 1106+07.70 TO STA. 1106+95.51
STA. 1113+25.33 TO STA. 1114+13.77	STA. 1113+25.33 TO STA. 1114+30.44
STA. 1215+48.20 TO STA. 1216+55.56	STA. 1215+61.38 TO STA. 1216+55.56
STA. 1218+87.23 TO STA. 1219+73.85	STA. 1218+87.23 TO STA. 1219+89.12

PAVEMENT DESIGN - PAVED SHOULDERS

NO MILLING

RESURFACING

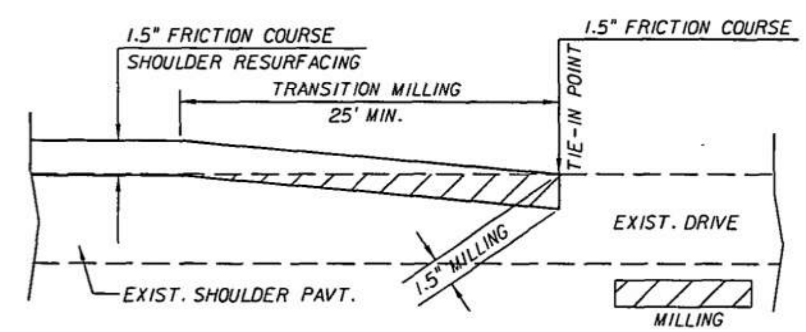
CONST. FRICTION COURSE FC-12.5 (TRAFFIC C)(1.5") RUBBER



RIGHT TURN LANE WIDENING AND SHOULDER PAVEMENT DETAIL

STA. 1432+27.62 TO STA. 1435+46.39 RT.
STA. 1439+15.90 TO STA. 1442+46.97 LT.

* NOTE: ACTUAL WIDTH OF BASE WIDENING MAY VARY DUE TO ACTUAL PAVEMENT WIDTH. CONTRACTOR MAY ELECT TO PLACE UNIFORM BASE WIDENING AT NO ADDITIONAL COST.



RESURFACING TRANSITION AT EXISTING DRIVEWAYS

STA. 1313+59 RT., 1364+95 RT., 1364+97 LT, 1516+60 RT.

REVISIONS			
DATE	DESCRIPTION	DATE	DESCRIPTION

ENGINEER OF RECORD:
EDUARDO A. PONCE, P.E.
P.E. LICENSE NUMBER 56818
FLORIDA DEPARTMENT OF TRANSPORTATION
801 N. BROADWAY AVENUE
BARTOW, FL 33830-3809

STATE OF FLORIDA
DEPARTMENT OF TRANSPORTATION

ROAD NO.	COUNTY	FINANCIAL PROJECT ID
29	COLLIER	425219-1-52-01

TYPICAL SECTION

SHEET NO. 3

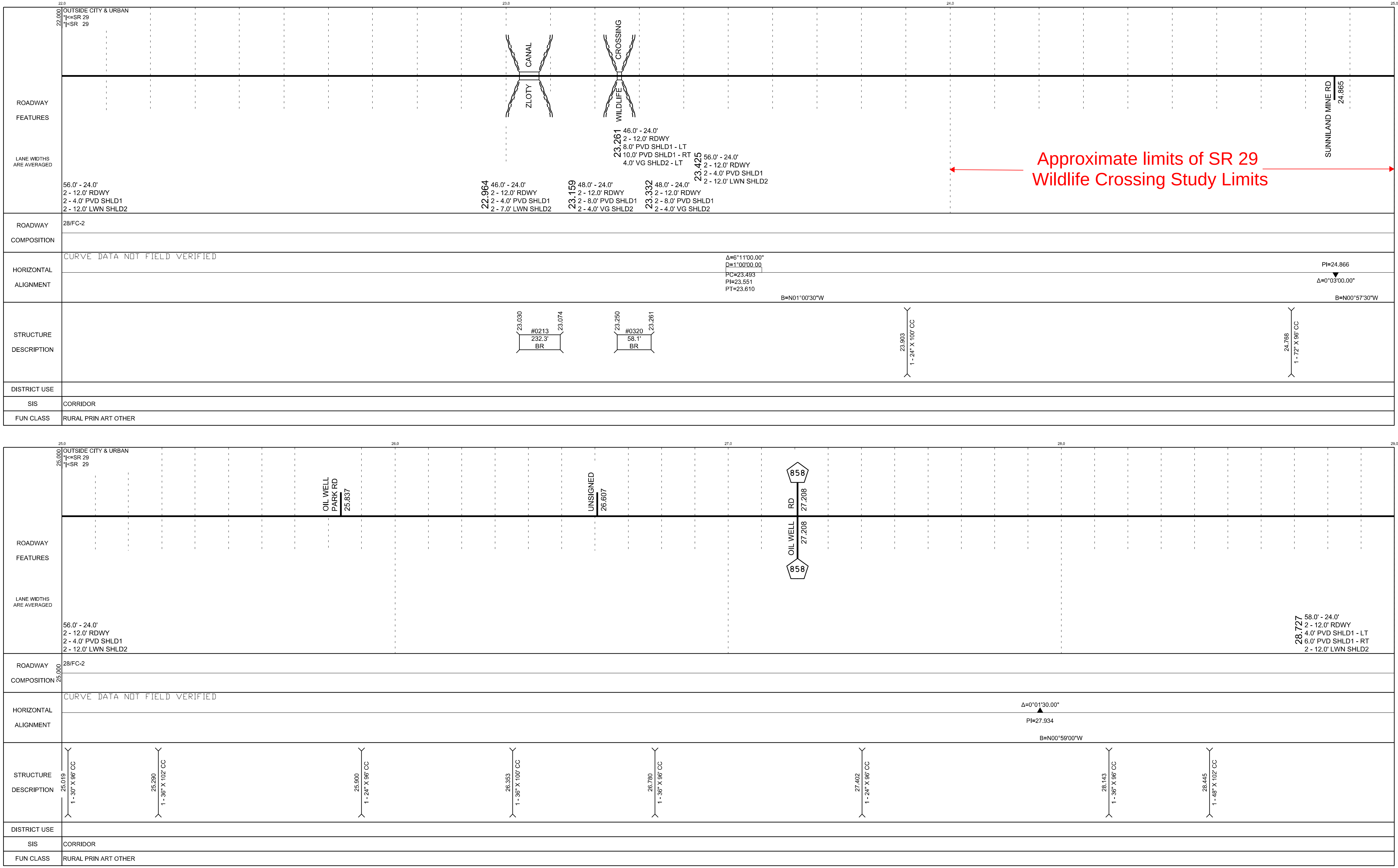
kn43rr 7/22/2010 11:58:09 AM C:\e\projects\42521915201\roadway\typrd01.dgn

	5 YR INV	SLD REV	BMP	EMP	INV	SLD REV
DATE	09/27/2017	10/15/2017			06/25/2019 06/25/2019 06/27/2018 FDOT	06/25/2019 FTE 06/25/2019 FTE 07/02/2018 FTE
BY	FTE	FTE				

FLORIDA DEPARTMENT OF TRANSPORTATION

STRAIGHT LINE DIAGRAM OF ROAD INVENTORY

SECTION STATUS	INT. or US ROUTE NO.	STATE ROAD NO.	COUNTY	DISTRICT	ROADWAY ID	SHEET NO:
02		SR 29	COLLIER	01	03080000	4 OF 7



Version: 1.4.2.27 09/09/2019

Appendix B

Photo Pages

Wildlife Crossing Feasibility Study
SR 29 North of Florida Panther National Wildlife Refuge; FPID 449143-1
Photo Pages

Photograph 1 Typical view of SR 29; view is to north from west side of SR 29. Power line is to the left of vegetation on the left side.

Photograph 2 Typical view of SR 29; view is to north from east side of SR 29. Barron Canal is beyond the guardrail on the right side of photograph.

Photograph 3 Typical view of the Barron Canal within study segment. The canal is approximately 65-70 feet wide.

Wildlife Crossing Feasibility Study
SR 29 North of Florida Panther National Wildlife Refuge; FPID 449143-1
Photo Pages

Photograph 4 Sunniland Farms/Vulcan Aggregates Mine entrance and driveway.

Photograph 5 Double utility gate at access point for power line corridor and adjacent private property.

Photograph 6 View of power line corridor.

Photograph 7 View towards SR 29 from within power line corridor. Example of an access point having a single utility gate. This gate is adjacent to Alternative Location 1.

Photograph 8 View inside vegetation between SR 29 and power line. The water is within the shallow, wide ditch inside the strip of vegetation.

Photograph 9 View to the north from east side of canal; view represents habitat type approaching the canal and future canal crossing in vicinity of Alternative Location 1.

Photograph 10 View to the south in the vicinity of Alternative Location 1. Driveway in center left of photo is referenced in Photograph 7.

Wildlife Crossing Feasibility Study
SR 29 North of Florida Panther National Wildlife Refuge; FPID 449143-1
Photo Pages

Photograph 11 View to east in vicinity of Alternative Location 2.

Photograph 12 View to the west in vicinity of Alternative Location 2.

Photograph 13 View to the north from east side of canal; view represents habitat type approaching the canal and future canal crossing in vicinity of Alternative Location 2.

Photograph 14 Same location as Photo 11; view to east in vicinity of Alternative Location 2.

Wildlife Crossing Feasibility Study
SR 29 North of Florida Panther National Wildlife Refuge; FPID 449143-1
Photo Pages

Photograph 15 Same location as Photo 11; view to south in vicinity of Alternative Location 2.

Photograph 16 Same location as Photo 11; view to west towards canal in vicinity of Alternative Location 2.

Appendix C

Meeting Minutes

Florida Department of Transportation
RON DESANTIS
GOVERNOR
801 North Broadway
Bartow, FL 33830
KEVIN J THIBAULT
SECRETARY

MEETING MINIUTES

DATE/TIME: 10/26/2021, 9:30 AM

LOCATION: Microsoft Teams

ATTENDEES: Brent Setchell, (FDOT), Nicole Monies (FDOT), Ryan Molloy (FDOT), Nicole Cribbs (FDA), Tia Norman (FDA), Leisa Priddy, Russel Priddy

SUBJECT: SR 29 Wildlife Crossing Meeting

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1) **Beginning of Meeting:**
   (a) Introductions by Brent

2) **Purpose of Meeting:**
   (a) The Florida Department of Transportation (FDOT) has tasked Faller Davis & Associates (FDA) to prepare a feasibility study for a potential new wildlife crossing along SR 29
   (b) Limits of the study area are from north of the Florida Panther National Wildlife Refuge boundary to north of the Vulcan Mine entrance *(Figure 1).*
   (c) Brent shared his screen and with historical panther and bear vehicle collision data and was identified as a hotspot by the Panther Recovery Implementation Transportation Subteam.
      i. The Panther Vehicle Collision (PVC) data included records since PVC record keeping began in the early 1980's to present day.
      ii. Brent did a quick review of the data points with the earliest PVC being 1987 and the most recent occurring in 2018.
      iii. Property Owners expressed concerns that data set being used was too large and should be limited to more recent data.
      iv. Brent inquired if the Property Owners were aware of any changes within the area which might be attributable to apparent less frequent PVCs.
      v. The Property Owners were not aware of any recent changes.
   (d) It was noted that the Priddys' own the Vulcan Mine entrance, but are not adjacent land-owner through most of study segment south of the mine entrance driveway.
      i. The Priddys' stated that Tom Jones would be the person to contact as the adjacent landowner.
   (e) Brent noted that the lands adjacent to SR 29 within this study segment are included in the proposed Eastern Collier Habitat Conservation Plan which include Preserve Area and Very Low-Density Use *(Figure 2)* which would conducive with the proposed wildlife crossing.

General Discussion:

3) Crossing Locations

(a) 2 locations were selected for the study segment

(b) Location 1 is located at the southern end of the study area, near a driveway heading west into Barron Collier property

(c) Location 2 is located midway in the study area approximately 0.5 miles south of the Vulcan Mine entrance driveway

4) Structure Types Being Considered

(a) Box Culvert – Option 1

(b) Slab Bridge – Option 2

(c) Both options would require the existing roadway profile of SR 29 to be raised

(d) A temporary detour parallel to SR 29 would be required to maintain traffic on SR 29 while the profile is raised.

5) Barron Canal Crossing

(a) Bridge similar to existing SR 29 canal crossings– Option 1

(b) Pile Bridge – Option 2

  i. 2 -30" piles laid horizontally side by side for a total width of 5'

(c) FDA believes the reason for the cluster of collisions near the mine driveway was due to having dry area to cross the canal. Adding another canal crossing with fencing to funnel wildlife to a new crossing could deter the animals from using the mine driveway.

6) Right-of-Way

(a) Right-of-way acquisition or easement will be needed to construct the canal crossing

7) Funding and Timeline

(a) This project is currently not funded for right-of-way acquisition or construction

(b) Design is funded

(c) Crossing would not likely be constructed for at least 5 years

(d) A proposed crossing near Owl's Hammock is a higher priority for FDOT than this location.

8) Fencing

(a) Multiple options to fence either the entire study area or just area around crossing are being considered.

(b) Fencing would be placed on both sides of SR 29

(c) Longest option would go from the mine entrance south to connect into existing fencing of the panther refuge.

9) Roadside Animal Detection System (RADS)

(a) FDOT has advertised a Request for Proposal for this section of SR 29 to provide a RADS

(b) RADS tentatively scheduled to be installed in mid 2022

(c) System requires a maintenance period of 3 years

(d) Older system installed by FDOT along US 41 had some issues with false detections

(e) Hoping to get newer technology which may use radar or thermal imaging to help improve accuracy when detecting animals

(f) This system would be constructed completely within existing FDOT Right-of-Way

10) Conclusions

(a) The Priddys' expressed concerns with calf depredations caused by panthers and lack of reimbursement resources.

(b) The Priddys' weren't in favor of opening new corridors which would allow for more panthers to enter their property and kill their livestock.

(c) They noted that home ranges of panthers limit the carrying capacity of the land and weren't sure how much the proposed crossing would get used since the adjacent lands are already occupied by panthers.

FIGURE 1

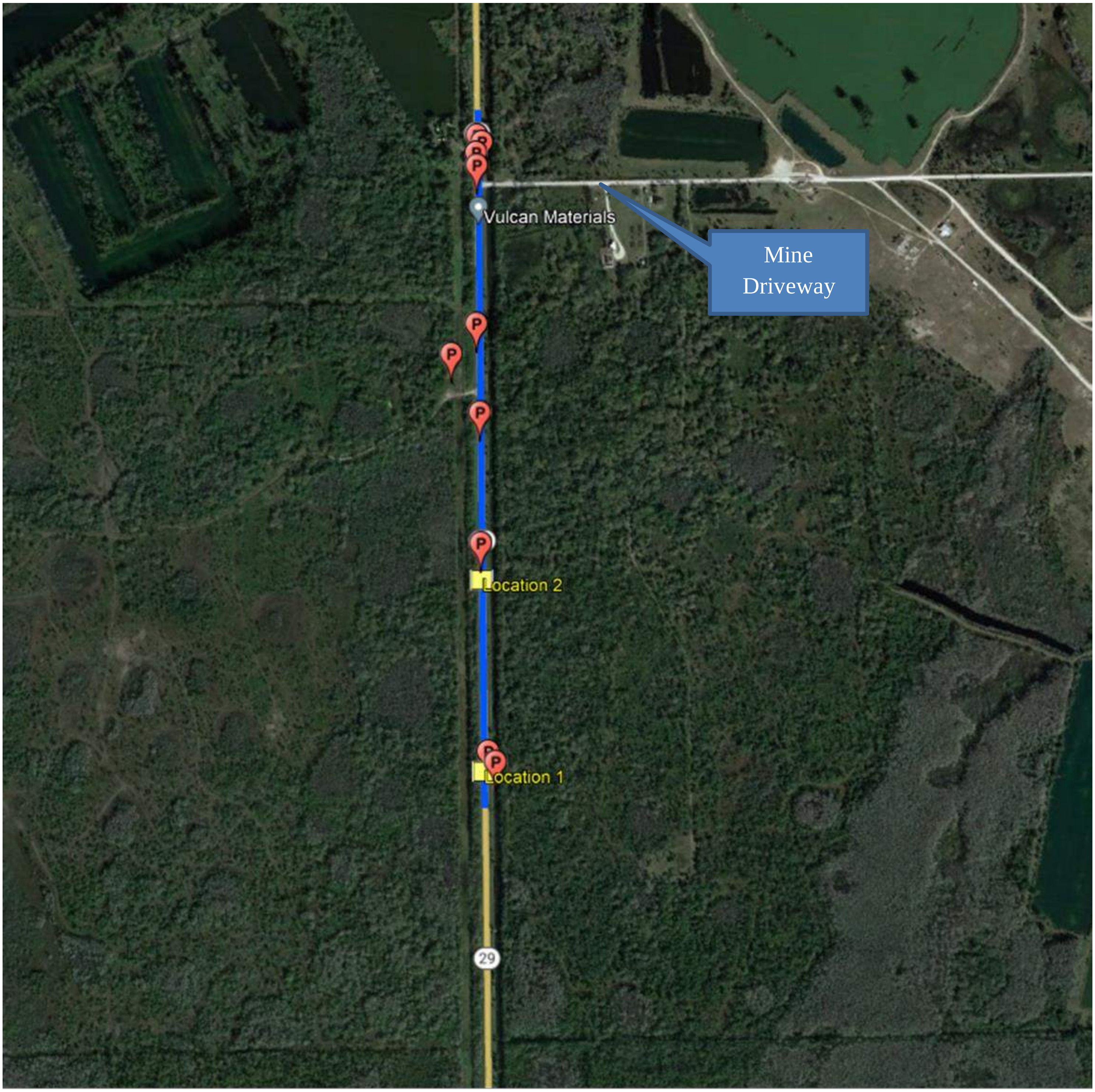

FIGURE 2


ECHCP Very Low Density Use
Vulcan Materials
Location 2
Location 1
ECHCP Preserve Area
29

RON DESANTIS
GOVERNOR

Florida Department of Transportation
801 North Broadway
Bartow, FL 33830

KEVIN J THIBAULT
SECRETARY

MEETING MINIUTES

DATE/TIME: 11/1/2021, 2:00 PM

LOCATION: Microsoft Teams

ATTENDEES: Brent Setchell, (FDOT), Nicole Monies (FDOT), Ryan Molloy (FDOT), Nicole Cribbs (FDA), Tia Norman (FDA), Samantha Szatyari (FDA), Tom Jones (Barron Collier)

SUBJECT: SR 29 Wildlife Crossing Meeting with Adjacent Property Owner

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1) **Beginning of Meeting:**
   (a) Introductions by Brent

2) **Purpose of Meeting:**
   (a) Faller Davis & Associates (FDA) and Florida Department of Transportation (FDOT) have an on-going feasibility study for a potential new wildlife crossing along SR 29
   (b) Limits of the study area are from north of the Florida Panther National Wildlife Refuge boundary to north of the Vulcan Mine entrance *(Figure 1).*
   (c) Brent shared his screen with historical panther and bear vehicle collision data which are the major motive for considering a crossing here
      i. Data for this is from beginning of collection in the early 1980's to present day.
   (d) Barron Collier is the adjacent landowner of this study segment
   (e) Brent noted that the lands adjacent to SR 29 within this study segment are included in the proposed Eastern Collier Habitat Conservation Plan which include Preserve Area and Very Low-Density Use *(Figure 2)* which would be conducive with the proposed wildlife crossing.

General Discussion:

3) **Crossing Locations**
   (a) 2 locations were selected for the study segment
   (b) Location 2 is in the north section of the study area, near a Barron Collier driveway
      i. This driveway is heavily used and is the main access point for the west property per Tom Jones
   (c) Location 1 is in the south section of study area near a Barron Collier driveway
      i. This driveway is not regularly used and has not been used in many years by Tom Jones

4) Structure Types being considered (Main Crossing)

(a) Box Culvert – Option 1
(b) Slab Bridge – Option 2
(c) Both options would require the existing roadway profile of SR 29 to be raised
(d) A temporary detour parallel to SR 29 would be required to maintain traffic on SR 29 while the profile is raised.

5) Barron Canal Crossing

(a) Bridge – similar to existing SR 29 canal crossings– Option 1
(b) Pile Bridge – Option 2 (lower-cost)
  i. 2 -30" piles laid horizontally side-by-side for a total width of 5'
(c) FDA believes the reason for the cluster of collisions near the mine driveway (at the northeast end of the study area) was due to having dry area to cross the canal. Adding another canal crossing with fencing could deter the animals from using the mine driveway

6) Right-of-Way

(a) A Right-of-way or easement will be needed to construct the canal crossing
(b) Power lines on west side of SR 29 are in an easement per Tom Jones on the Barron Collier property.

7) Funding and Timeline

(a) This project is currently not funded for construction or right-of-way
(b) Design is funded
(c) Crossing would not be constructed for at least 5 years
(d) A proposed crossing near Owl's Hammock is a higher priority for FDOT than this location.

8) Fencing

(a) Multiple options to fence either the entire study area or just area around crossing are being considered.
(b) Fencing would be placed on both sides of SR 29 similar to the existing wildlife fencing south of the study area.
(c) Longest option would go from the mine entrance south to connect into existing fencing of the panther refuge.
(d) Current fencing estimate is very high at around $100 per linear foot. This will be re-evaluated.
(e) Per question from Tom Jones – the animals would be able to just walk around the fence at the north end
(f) Gate would need to be added to the west driveway just north of location 1. Tom Jones said he has had these on his properties before and would need to review the gate options

9) Roadside Animal Detection System (RADS)

(a) FDOT has advertised a Request for Proposal for this section of SR 29 to provide a RADS
(b) RADS tentatively scheduled to be installed in mid 2022
(c) System requires a maintenance period of 3 years
(d) Older system installed by FDOT along US 41 had some issues with false detections
(e) Hoping to get newer technology which may use radar or thermal imaging to help improve accuracy when detecting animals
(f) This system would be constructed completely within FDOT Right-of-Way

10) Miscellaneous

(a) fSTOP foundation has camera near location 1 west driveway. FDOT sign is being stollen, but the camera seems to be left alone

11) Conclusions

(a) Tom Jones said that he would need to take 2-3 weeks to review the proposal
(b) Tom asked if the spacing was long enough between crossings, but Brent pointed out that it was similar spacing to crossings just south of the study segment

FIGURE 1

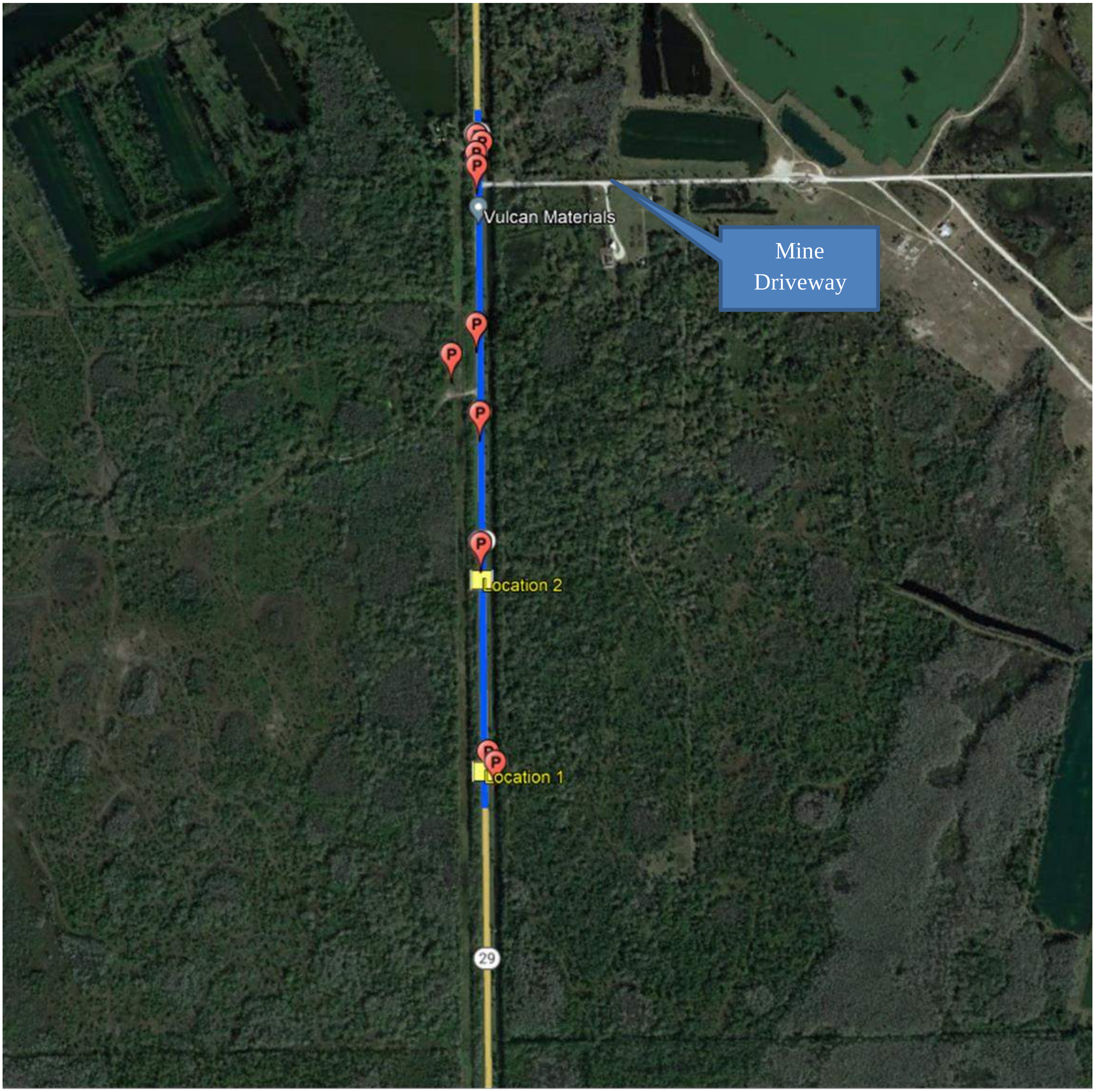
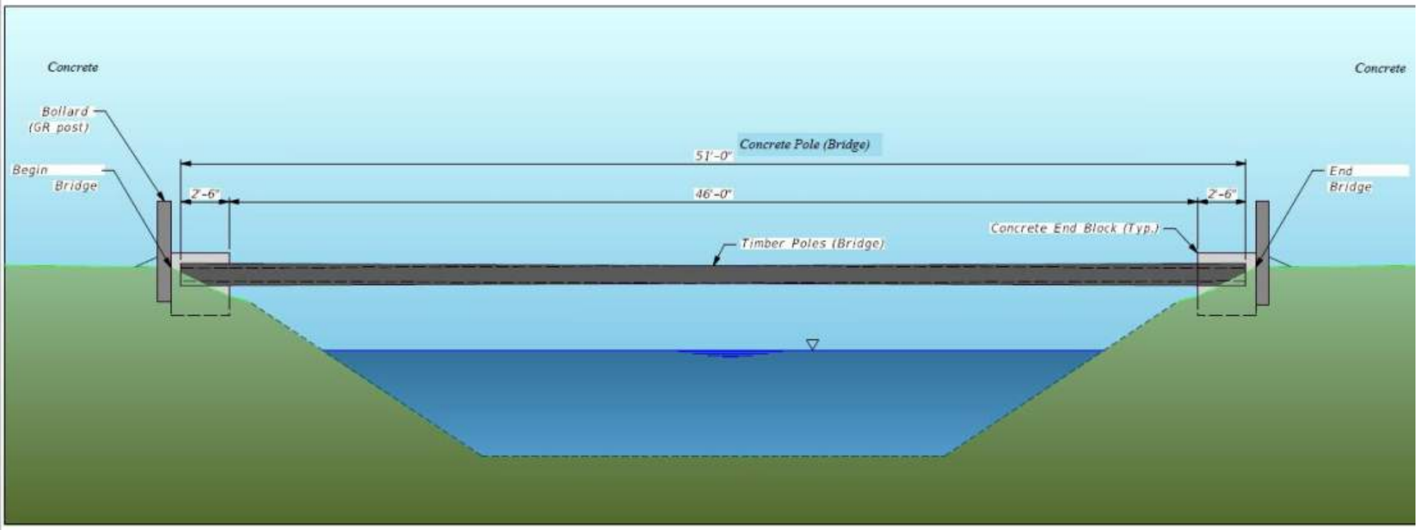


FIGURE 2


HCP Very
Density Use
Vulcan Materials
Location 2
Location 1
CP
erve
a
29

FIGURE 3



Concrete
Concrete
Bollard
(GR post)
Concrete Pole (Bridge)
51'-0"
Begin
Bridge
2'-6"
46'-0"
2'-6"
End
Bridge
Concrete End Block (Typ.)
Timber Poles (Bridge)

Appendix D

Structures, Roadway, and Fencing Cost Estimates

			SR 29 Alternative 1	SR 29 Alternative 2	Canal Alternative 1	Canal Alternative 2
			Bridge	Box Culvert	Bridge Canal	Conc. Piles Canal
Structures*			$548,645	$204,806	$258,034	$64,467
Roadway	**UNIT**	**UNIT COST**				
Clearing & Grubbing	AC	$19,052.45	$77,543.47	$67,446	$1,905.25	$952.62
Embankment	CY	$8.37	$167,720.57	$141,545	$1,422.90	$234.36
Type B Stabilization	SY	$5.40	$43,369.56	$41,284	----	----
Optional Base, Base Group 01	SY	$14.97	$27,029.83	$25,729	----	----
Optional Base, Base Group 10	SY	$22.92	$105,597.02	$100,518	----	----
Superpave Asph Conc, Traffic C	TN	$97.90	$105,606.20	$100,520.00	----	----
Asph Conc FC, FC-12.5, PG 76-22	TN	$117.23	$80,890.28	$78,023.66	----	----
Milling Exist Asph Pavt , 1 1/2" Avg Depth	SY	$3.34	$7,348.67	$7,348.67	----	----
Miscellaneous Asphalt Pavement	TN	$197.94	$11,474.58	$11,249.59	----	----
Concrete Shoulder Gutter	LF	$30.85	$48,773.85	$47,818	----	----
Guardrail- Roadway, Gen TL-3	LF	$18.37	$29,042.97	$28,474	----	----
Guardrail- Bridge Anchorage Assem, F&I	EA	$2,651.68	$10,606.72	----	----	----
Guardrail End Anch Assy/End Trea- Flared/Parallel	EA	$1,416.12	$5,664.48	$5,664.48	----	----
Pipe Culvert Optional Material, Round, 18"	LF	$121.59	$29,181.60	$29,181.60		
U-Endwall, 1:2 Slope, 18"	EA	$3,613.80	$28,910.40	$28,910.40		
Inlets, Gutter, Type S, <10	EA	$4,782.58	$38,260.64	$38,260.64		
Performance Turf, Sod	SY	$2.69	$34,797.84	$30,338	$820.45	$228.65
Temporary Pavement	SY	$16.78	$143,189.33	$131,256.89	----	----
Temporary Base/ Embankment	CY	$11.67	$64,314.67	$58,955	----	----
Roadway Subtotal			**$1,059,323**	**$972,522**	**$4,148.60**	**$1,415.63**
Maintenance of Traffic		5%	$52,966.13	$48,626.08	$207.43	$70.78
Mobilization		5%	$52,966.13	$48,626.08	$207.43	$70.78
Project Unknowns		10%	$105,932.27	$97,252.16	$414.86	$141.56
ROADWAY TOTAL			**$1,271,187.23**	**$1,167,025.88**	**$4,978.31**	**$1,698.76**
STRUCTURE + ROADWAY TOTAL**			**$1,819,832.23**	**$1,371,831.88**	**$263,012.31**	**$66,165.76**

*see structures construction cost estimate in Appendix

** Wildlife fencing is additional. See Fencing and Gates Cost Estimate Table; right-of-way costs or easements is not included

Fencing and Gates	**UNIT**	**UNIT COST**	**Fence Alternative 1**	**Fence Alternative 2**	**Fence Alternative 3**
Fencing, Type B, 10.0', w/ barbed wire*	LF	$60.00	$240,000.00	$558,000.00	$828,000.00
Fencing, Type B, Gate, Double	EA	$1,500.00	----	$3,000.00	$3,000.00
Fencing, Type B, Gate, Single**	EA	$1,258.71	$3,776.13	$10,069.68	$10,069.68
TOTAL			**$243,776.13**	**$571,069.68**	**$841,069.68**

*engineer's estimate

Recommended	
SR 29 Alternative 2	$1,371,832
Barron Canal Alternative 2	$66,166
Fence Alternative 3	$841,070
RECOMMENDED TOTAL	**$2,279,068**

KISINGER CAMPO & ASSOCIATES

Districtwide Environmental Permits Design Support
Task Work Order No. 10
SR 29 Wildlife Crossing Analysis

DESIGNED BY: SKB 09/21
CHECKED BY: BAH 10/21

Description: Alternative Estimates Summary

	Alternative No.	Alternative Description	Cost Estimate
Structure Cost	SR 29 - 1	SR 29 prestressed concrete bridge providing a wildlife crossing underpass.	$548,645
	SR 29 - 2	SR 29 single 10' x 8' box culvert providing a wildlife crossing underpass.	$204,806
	Barron Canal - 1	Barron Canal crossing consisting of a prestressed concrete bridge.	$258,034
	Barron Canal - 2	Barron Canal crossing consisting of horizontally lain 30" prestressed concrete piles.	$64,467

KISINGER CAMPO & ASSOCIATES

Districtwide Environmental Permits Design Support
Task Work Order No. 10
SR 29 Wildlife Crossing Analysis

DESIGNED BY: SKB 09/21
CHECKED BY: BAH 10/21

Description: Alternative Cost Estimates

The cost estimates developed herein utilizes a combination of the FDOT BDR Cost Estimate Spreadsheet and the FDOT Historic Cost Information, 12 Month Statewide Moving Averages from August 2021, adjusted per engineering judgement. The culvert is quantified in accordance with FDOT standard Pay Item Nos. 400-4-1 Concrete Class IV, Culvert and 415-1-1 Reinforcing Steel-Roadway (per specifications). Slope protection quantities are quantified in accordance with FDOT standard Pay Item Nos. 530-1 Riprap Sand-Cement, 530-3-3 Riprap Rubble Bank and Shore, and 530-74 Bedding Stone. Multipliers have been included in accordance with SDG Section 9.2.3 (Step 2).

SR 29 - Alternative 1

Pay Item Description	Quantity	Unit	Unit Cost ($/Unit)	Total Cost
Bridge (See BDR Cost Estimating Sheet)	1	EA	457204.25	$457,204.25
			Sub-total	**$457,204.25**
			Multiplier	20%
			Sub-total	**$548,645.10**

SR 29 - Alternative 2

Pay Item Description	Quantity	Unit	Unit Cost ($/Unit)	Total Cost
400-4-1 Conc Class IV, Culvert	144.1	CY	990.00	$142,659.00
415-1-1 Reinforcing Steel - Roadway	28,013	LB	1.00	$28,013.00
			Sub-total	**$170,672.00**
			Multiplier	20%
			Total	**$204,806.40**

Barron Canal - Alternative 1

Pay Item Description	Quantity	Unit	Unit Cost ($/Unit)	Total Cost
Bridge (See BDR Cost Estimating Sheet)	1	EA	184113.80	$184,113.80
530-1-100 Riprap, Sand-Cement Bags	10.3	CY	850.00	$8,755.00
530-3-3 Riprap- Rubble, Bank and Shore	424.2	TN	110.00	$46,662.00
530-74 Bedding Stone	150.3	TN	116.00	$17,434.80
142-70 Fill Sand(1)	71.2	CY	15.00	$1,068.00
			Sub-total	**$258,033.60**

(1) Fill Sand quantities reflect the fill on top of the bridge shown in the typical section.

Barron Canal - Alternative 2

Pay Item Description	Quantity	Unit	Unit Cost ($/Unit)	Total Cost
455-34-6 Prestressed Concrete Piling, 30" Sq(1)	158	LF	120.00	$18,960.00
400-4-5 Conc Class IV, Bridge Substructure	4.8	CY	950.00	$4,560.00
415-1-5 Reinforcing Steel - Substructure	648	LF	1.00	$648.00
530-1-100 Riprap, Sand-Cement Bags	5.5	CY	850.00	$4,675.00
530-3-3 Riprap- Rubble, Bank and Shore	235.8	TN	110.00	$25,938.00
530-74 Bedding Stone	83.5	TN	116.00	$9,686.00
			Sub-total	**$64,467.00**

(1) Cost reduced from BDR spreadsheet since no driving is required.

SR 29 Alternative 1

WILDLIFE UNDERPASS - PRESTRESSED CONCRETE BRIDGE

SR 29 WILDLIFE CROSSING ANALYSIS

KISINGER CAMPO & ASSOCIATES

Districtwide Environmental Permits Design Support — DESIGNED BY: SKB 09/21
Task Work Order No. 10 — CHECKED BY:
SR 29 Wildlife Crossing Analysis

Foundation Quantities

SR 29 Alternative 1

0455 34 3 PRESTRESSED CONCRETE PILING, 18" SQ

Location	No. Piles	Pile Length *(ft.)*		Total Length *(ft.)*
END BENT 1	4	75.00		300.00
END BENT 2	4	75.00		300.00

PAY ITEM TOTAL 600 LF

0455143 3 TEST PILES-PRESTRESSED CONCRETE, 18" SQ

Location	No. Piles	Pile Length *(ft.)*	Additional Length *(ft.)*	Total Length *(ft.)*
END BENT 1	1	75.00	15.00	90.00
END BENT 2	1	75.00	15.00	90.00

`

PAY ITEM TOTAL 180 LF

KISINGER CAMPO & ASSOCIATES

Districtwide Environmental Permits Design Support
Task Work Order No. 10
SR 29 Wildlife Crossing Analysis

DESIGNED BY: SKB 09/21
CHECKED BY:

Substructure Quantities

SR 29 Alternative 1

0400 4 5 CONCRETE CLASS IV, BRIDGE SUBSTRUCTURE

END BENTS 1 & 2					
Location	Length *(ft.)*	Width *(ft.)*	Height *(ft.)*	Quantity	Volume *(CY)*
Cap	46.67	3.00	2.50	1	12.96
Backwall	46.67	1.00	3.83	1	6.63
Cheekwall	2.00	1.00	4.17	2	0.62
Pedestals	3.00	2.00	0.50	6	0.67
Lug	9.83	0.46	0.50	2	0.17
				TOTAL	21.1

Applicable Equation: Volume = Quantity x (Length x Width x Height) / (27 ft^3/CY)
Reduction for pile embedment conservatively excluded.

SUMMARY	
Location	Volume *(CY)*
END BENT 1	21.1
END BENT 2	21.1

PAY ITEM TOTAL 42.2 CY

0415 1 5 REINFORCING STEEL - BRIDGE SUBSTRUCTURE

Location	Volume Concrete *(CY)*	BDR Estimate Value *(lb./CY)*	Weight *(lb.)*
END BENT 1	21.10	135	2849
END BENT 2	21.10	135	2849

PAY ITEM TOTAL 5697 LB

KISINGER CAMPO & ASSOCIATES

Districtwide Environmental Permits Design Support — DESIGNED BY: SKB 09/21
Task Work Order No. 10 — CHECKED BY:
SR 29 Wildlife Crossing Analysis

Superstructure Quantities

SR 29 Alternative 1

0400 4 4 CONCRETE CLASS IV, BRIDGE SUPERSTRUCTURE

BRIDGE DECK				
Location	Length *(ft.)*	Width *(ft.)*	Deck Depth *(ft.)*	Volume *(CY)*
SPAN 1	59.17	46.67	0.67	68.18

BUILD-UP						
Location	No. Beams	Beam Length *(ft.)*	Flange Width *(ft.)*	'B' & 'D' * *(in.)*	'C' * *(in.)*	Volume *(CY)*
SPAN 1	5	58.67	1.00	2.00	1.00	1.21

* See SPI Index 450-199, Case 3.

THICKENED DECK END						
Location	Depth *(in.)*	Buildup *(in.)*	Added Depth *(ft.)*	Length* *(ft.)*	Width *(ft.)*	Volume *(CY)*
SPAN 1 (BEGIN)	4.00	2.00	0.50	35.00	2.50	1.78
SPAN 1 (END)	4.00	2.00	0.50	35.00	2.50	1.78

* Length = Total distance between beam flanges.

Location	Deck *(CY)*	Build-Up *(CY)*	Deck End *(CY)*	Volume *(CY)*
SPAN 1	68.18	1.21	3.56	73.00

PAY ITEM TOTAL 73.0 CY

Applicable Equations:

Bridge Deck — Volume = (Length x Width x Depth) / (27 ft^3/CY)

Build-Up — Volume = (Beam Length x Flange Width x (C + ((B + D - 2C)/6))) / (27 ft^3/CY)

Thickened Slab End — Volume = Length * (Width x Added Depth + 0.5 x (Added Depth)2) / (27 ft3/CY)

0400 7 1 BRIDGE DECK GROOVING

Location	Length *(ft.)*	Width *(ft.)*	Area *(SY)*
BRIDGE	59.17	44.00	290.00

PAY ITEM TOTAL 290 SY

Applicable Equation: Area = Length x Width / (9 ft^2/SY)

KISINGER CAMPO & ASSOCIATES

Districtwide Environmental Permits Design Support — DESIGNED BY: SKB 09/21
Task Work Order No. 10 — CHECKED BY:
SR 29 Wildlife Crossing Analysis

Superstructure Quantities

SR 29 Alternative 1

0400147 COMPOSITE NEOPRENE PADS

Location	No. Pads per Location	Pad Type*	L *(in.)*	W *(ft.)*	Thickness *(in.)*	Volume *(CF)*
END BENT 1	6	AA	10	1.17	1.91	1.00
END BENT 2	6	AA	10	1.17	1.91	1.00

* See Index 400-510 for dimensions.

PAY ITEM TOTAL 2.0 CF

Applicable Equation: Volume = No. Pads x (L / 12 in/ft) x W x (Thickness / 12 in/ft)

0415 1 4 REINFORCING STEEL - BRIDGE SUPERSTRUCTURE

Location	Volume Concrete *(CY)*	BDR Estimate Value *(lb./CY)*	Weight *(lb.)*
BRIDGE	73.00	205	14965

14965 LB

0450 1 1 PRESTRESSED BEAMS, TYPE II

Location	Beam Length *(ft.)*	Quantity	Length *(ft.)*
BEAMS 1-6	58.67	6	352.00

PAY ITEM TOTAL 352 LF

0458 1 11 BRIDGE DECK EXPANSION JOINT, NEW CONSTRUCTION,
F&I POURED JOINT WITH BACKER ROD

Location	Width* *(ft.)*		Length *(ft.)*
END BENT 1	44.00		45.00
END BENT 2	44.00		45.00

* Measured along skew between inside face of rails/parapets.

PAY ITEM TOTAL 90 LF

Applicable Equation: Length = Width + 2in. + $\sqrt{[(6in.)^2 + (5in.)^2]}$

KISINGER CAMPO & ASSOCIATES

Districtwide Environmental Permits Design Support — DESIGNED BY: SKB 09/21
Task Work Order No. 10 — CHECKED BY:
SR 29 Wildlife Crossing Analysis

Approach Slab Quantities

SR 29 Alternative 1

0400 2 10 CLASS II CONCRETE, APPROACH SLABS

Location	Length *(ft.)*	Width *(ft.)*	Depth - Slab *(ft.)*	Depth - Topping* *(ft.)*	Depth - To Backwall *(ft.)*	Volume *(CY)*
APPROACH SLAB 1	30.00	46.67	1.00	0.17	0.35	53.20
APPROACH SLAB 2	30.00	46.67	1.00	0.17	0.35	53.20

* Asphalt overlay + 1/4" when deck planing is required.

PAY ITEM TOTAL 106.4 CY

Applicable Equation: Volume = (Length x Width x Depth Slab + 2-ft x Width x Depth Topping
+ Width x Depth To Backwall x (1-ft + 0.5 x Depth To Backwall)) / (27 ft^3/CY)

0415 1 9 REINFORCING STEEL - APPROACH SLABS

Location	Volume Concrete *(CY)*	BDR Estimate Value *(lb./CY)*	Weight *(lb.)*
APPROACH SLAB 1	53.2	200	10640
APPROACH SLAB 2	53.2	200	10640

PAY ITEM TOTAL 21280 LB

KISINGER CAMPO & ASSOCIATES

Districtwide Environmental Permits Design Support — DESIGNED BY: SKB 09/21
Task Work Order No. 10 — CHECKED BY:
SR 29 Wildlife Crossing Analysis

Barrier Quantities

SR 29 Alternative 1

0521 5 13 CONCRETE TRAFFIC RAILING - BRIDGE, 36" SINGLE-SLOPE

Location	Length *(ft.)*	No. Railings	Length *(ft.)*
APP SLAB 1	30.00	2	60.00
Bridge	59.17	2	119.00
APP SLAB 2	30.00	2	60.00

PAY ITEM TOTAL 239 LF

KISINGER CAMPO & ASSOCIATES

Districtwide Environmental Permits Design Support DESIGNED BY: SKB 09/21
Task Work Order No. 10 CHECKED BY:
SR 29 Wildlife Crossing Analysis

Wall Quantities

SR 29 Alternative 1

0548 12 RETAINING WALL SYSTEM, PERMANENT, EXCLUDING BARRIER

Location	Length *(ft.)*	Height *(ft.)*	Area *(SF)*
Begin Bridge - Left	28.00	12	336
Begin Bridge - Front	45.67	8.5	389
Begin Bridge - Right	28.00	12	336
End Bridge - Left	28.00	12	336
End Bridge - Front	45.67	8.5	389
End Bridge - Right	28.00	12	336

PAY ITEM TOTAL 2122 SF

Bridge Development Report Cost Estimating - SR 29 Alternative 1 - AASHTO Type II

Effective 01/01/2021

Step One: Estimate Component Items

Utilizing the cost provided herein, develop the cost estimate for each bridge type under consideration.

A. Bridge Substructure

1. Prestressed Concrete Piling, (furnished and installed)			
Size of Piling	**Cost per Lin. Foot [1]**	**Quantity**	**Cost**
18" (Driven Plumb or 1" Batter) [2]	$100	780	$78,000
18" (Driven Battered) [2]	$140		
24" (Driven Plumb or 1" Batter) [2]	$140		
24" (Driven Battered) [2]	$200		
30" (Driven Plumb or 1" Batter) [2]	$170		
30" (Driven Battered) [2]	$240		
18" w/CFRP or Stainless Steel Strand (Driven Plumb or 1" Batter)	$135		
18" w/CFRP or Stainless Steel Strand (Driven Battered)	$160		
24" w/CFRP or Stainless Steel Strand (Driven Plumb or 1" Batter)	$150		
24" w/CFRP or Stainless Steel Strand (Driven Battered)	$210		
30" w/CFRP or Stainless Steel Strand (Driven Plumb or 1" Batter)	$225		
30" w/CFRP or Stainless Steel Strand (Driven Battered)	$280		
Heavy mild steel reinforcing in pile head (each)[2]	$250		
		Subtotal	$78,000

[1] When silica fume, metakaolin or ultrafine fly ash is used add $6/LF to the piling cost.

[2] When heavy mild steel reinforcing is used in the pile head, add $250.

2. Steel Piling, (furnished and installed)			
Size of Piling	**Cost per Lin. Foot**	**Quantity**	**Cost**
14 x 73 H Section	$90		
14 x 89 H Section	$100		
18" Pipe Pile	$100		
20" Pipe Pile	$125		
24" Pipe Pile	$145		
30" Pipe Pile	$200		
		Subtotal	

3. Drilled Shaft (not including Excavation)			
Dia. (On land with casing salvaged)	**Cost per Lin. Foot**	**Quantity**	**Cost**
3.5 ft	$500		
4 ft	$550		
5 ft	$600		
6 ft	$680		
7 ft	$825		
8 ft	$1,550		
9 ft	$1,800		
Dia. (In water with casing salvaged)	**Cost per Lin. Foot**	**Quantity**	**Cost**
3.5 ft	$550		
4 ft	$625		
5 ft	$700		
6 ft	$825		
7 ft	$950		
8 ft	$1,650		
9 ft	$1,900		
Dia. (In water with permanent casing)	**Cost per Lin. Foot**	**Quantity**	**Cost**
3.5 ft	$700		
4 ft	$750		
5 ft	$850		
6 ft	$990		
7 ft	$1,250		
8 ft	$2,200		
9 ft	$2,400		
		Subtotal	

A. Bridge Substructure (continued)

4. Drilled Shaft Excavation

Dia.	Cost per Lin. Foot	Quantity	Cost
3.5 ft	**$250**		
4 ft	**$280**		
5 ft	**$300**		
6 ft	**$340**		
7 ft	**$420**		
8 ft	**$780**		
9 ft	**$900**		
		Subtotal	

5. Cofferdam Footing (Cofferdam and Seal Concrete[1])

Prorate the cost provided herein based on area and depth of water. A cofferdam footing having the following attributes cost $600,000: Area 63 ft x 37.25 ft; Depth of seal 5 ft; Depth of water over footing 16 ft

Type	Cost per Footing	Quantity	Cost
Cofferdam Footing			
		Subtotal	

[1] Cost of seal concrete included in pay item 400-3-20 or 400-4-200.

6. Substructure Concrete

Type	Cost per Cubic Yard	Quantity	Cost
Concrete [1]	**$950**	**42.2**	**$40,090**
Mass Concrete [1]	**$625**		
Seal Concrete [1]	**$650**		
Bulkhead Concrete [1]	**$1,000**		
Shell Fill [1]	**$30**		
		Subtotal	$40,090

[1] Admixtures: For Calcium Nitrite add $40/cy (@4.5 gal/cy) and for highly reactive pozzolans add $40/cy (@ 60 lb./cy)

7. Substructure Reinforcing and Post-tensioning Steel

Type	Cost per Pound	Quantity	Cost
Carbon Reinforcing Steel	**$1.00**	**5697**	**$5,697**
Low-Carbon Chromium Reinforcing Steel	**$1.25**		
Stainless Reinforcing Steel	**$4.00**		
Post-tensioning Steel, Strand - Grout Filler	**$8.00**		
Post-tensioning Steel, Bar - Grout Filler	**$10.00**		
Post-tensioning Steel, Strand - Flexible Filler	**$24.00**		
Post-tensioning Steel, Bar - Flexible Filler	**$30.00**		
		Subtotal	**$5,697**

Substructure Subtotal **$123,787**

B. Walls

1. Retaining Walls			
MSE Walls	**Cost per Sq. Foot**	**Quantity**	**Cost**
Permanent	$30	2122	$63,660
Temporary	$15		
Sheet Pile Walls, Prestressed Concrete	**Cost per Lin. Foot**	**Quantity**	**Cost**
10" x 30"	$150		
12" x 30"	$185		
12" x 30" with FRP	$265		
Sheet Pile Walls, Steel	**Cost per Sq. Foot**	**Quantity**	**Cost**
Permanent Cantilever Wall	$30		
Permanent Anchored Wall [1]	$55		
Temporary Cantilever Wall	$16		
Temporary Anchored Wall [1]	$35		
Soil Nail Wall with Permanent Facing	**Cost per Sq. Foot**	**Quantity**	**Cost**
Soil Nail Wall with Permanent Facing	$110		
Traffic Railings with Junction Slabs	**Cost per Lin. Foot**	**Quantity**	**Cost**
32" Vertical Face	$260		
42" Vertical Face	$280		
36" Single-Slope	$255		
42" Single-Slope	$275		
		Subtotal	$63,660

[1] Includes the cost of anchors, waler steel, miscellaneous steel for permanent/temporary walls and concrete face for permanent walls.

2. Noise Wall			
Type	**Cost per Sq. Foot**	**Quantity**	**Cost**
Noise Wall	$30		
		Subtotal	

Walls Subtotal	**$63,660**

C. Box Culverts

1. Box Culverts			
Concrete	**Cost per Cubic Yard**	**Quantity**	**Cost**
Class II Concrete	**$950**		
Class IV Concrete	**$990**		
Reinforcing Steel	**Cost per Pound**	**Quantity**	**Cost**
Carbon Reinforcing Steel	**$1.00**		
		Subtotal	

Box Culvert Subtotal

D. Bridge Superstructure

1. Bearing Type			
Neoprene Bearing Pads	**Cost per Cubic Foot**	**Quantity**	**Cost**
Neoprene Bearing Pads	**$1,000**	**2**	**$2,000**
Multirotational Bearings (Capacity in kips)	**Cost per Each**	**Quantity**	**Cost**
1- 250	**$6,000**		
251- 500	**$8,000**		
501- 750	**$8,750**		
751-1000	**$9,500**		
1001-1250	**$10,000**		
1251-1500	**$11,000**		
1501-1750	**$13,000**		
1751-2000	**$15,000**		
>2000	**$17,000**		
		Subtotal	$2,000

2. Bridge Girders			
Structural Steel (includes coating costs)	**Cost per Pound**	**Quantity**	**Cost**
Plate Girders, Straight [1]	**$1.65**		
Plate Girders, Curved [1]	**$1.95**		
Box Girders, Straight [1]	**$1.95**		
Box Girders, Curved [1]	**$2.15**		

[1] When weathering steel (uncoated) is used, reduce the price by $0.04 per pound.
Inorganic zinc coating systems have an expected life cycle of 20 years.

Prestressed Concrete Girders and Slabs	**Cost per Lin. Foot**	**Quantity**	**Cost**
Florida U-Beam; 48" [1]	**$750**		
Florida U-Beam; 54"	**$800**		
Florida U-Beam; 63"	**$850**		
Florida U-Beam; 72"	**$900**		
Florida Slab Beam 12" x 48" [2]	**$230**		
Florida Slab Beam 12" x 60" [2]	**$280**		
Florida Slab Beam 15" x 48" [2]	**$280**		
Florida Slab Beam 15" x 60" [2]	**$370**		
Florida Slab Beam 18" x 48" [2]	**$340**		
Florida Slab Beam 18" x 60" [2]	**$440**		
AASHTO Type II Beam	**$190**	**352**	**$66,880**
Florida-I Beam; 36	**$240**		
Florida-I Beam; 45	**$260**		
Florida-I Beam; 54	**$280**		
Florida-I Beam; 63	**$300**		
Florida-I Beam; 72	**$320**		
Florida-I Beam; 78	**$330**		
Florida-I Beam; 84	**$340**		
Florida-I Beam; 96	**$370**		
		Subtotal	**$66,880**

[1] Price is based on ability to furnish products without any conversions of casting beds and without purchasing of forms. If these conditions do not exist, add the following cost: $450,000

[2] Interpolate between given prices for intermediate width FSBs.

D. Bridge Superstructure (continued)

3. Cast-in-Place Superstructure Concrete			
Type	**Cost per Cubic Yard**	**Quantity**	**Cost**
Box Girder Concrete, Straight	$950		
Box Girder Concrete, Curved	$1,200		
Deck Concrete Class II	$750		
Deck Concrete Class IV	$1,200	73	$87,600
Precast Deck Overlay Concrete Class IV	$1,000		
Topping Concrete for slab beams and units[1]	$800		
[1] Including cost of shrinkage reducing admixture.		Subtotal	$87,600

4. Concrete for Precast Segmental Box Girders, Cantilever Construction			
Concrete Cost by Deck Area	**Cost per Cubic Yard**	**Quantity**	**Cost**
≤ 300,000 SF	$1,250		
> 300,000 SF AND ≤ 500,000 SF	$1,200		
> 500,000 SF	$1,150		
		Subtotal	

5. Reinforcing and Post-Tensioning Steel			
Type	**Cost per Pound**	**Quantity**	**Cost**
Carbon Reinforcing Steel	$1.05	14965	$15,713
Low-Carbon Chromium Reinforcing Steel	$1.30		
Stainless Reinforcing Steel	$4.05		
Post-tensioning Steel, Strand; longitudinal - Grout Filler	$8.00		
Post-tensioning Steel, Strand; transverse - Grout Filler	$10.00		
Post-tensioning Steel, Bar - Grout Filler	$10.00		
Post-tensioning Steel, Strand; longitudinal - Flexible Filler	$24.00		
Post-tensioning Steel, Bars - Flexible Filler	$30.00		
		Subtotal	$15,713

6. Railings and Barriers			
Traffic Railings [1]	**Cost per Lin. Foot**	**Quantity**	**Cost**
32" Vertical Face	$90		
42" Vertical Face	$100		
36" Single-Slope Median	$100		
36" Single-Slope	$110	119.00	$13,090
42" Single-Slope	$140		
Thrie Beam Retrofit	$180		
Thrie Beam Panel Retrofit	$110		
Vertical Face Retrofit	$125		
Rectangular Tube Retrofit	$100		
Pedestrian/Bicycle Railings:	**Cost per Lin. Foot**	**Quantity**	**Cost**
Concrete Parapet (27") [1]	$65		
Single Bullet Railing [1]	$40		
Double Bullet Railing [1]	$50		
Panel/Picket Railing (42") steel (Type 1 & 2)	$95		
Panel/Picket Railing (42") steel (Type 3-5)	$130		
Panel/Picket Railing (42") aluminum (Type 1 & 2)	$70		
Panel/Picket Railing (42") aluminum (Type 3-5)	$105		
Panel/Picket Railing (48") steel (Type 1 & 2)	$115		
Panel/Picket Railing (48") steel (Type 3-5)	$145		
Panel/Picket Railing (48") aluminum (Type 1 & 2)	$85		
Panel/Picket Railing (48") aluminum (Type 3-5)	$120		
[1] Combine cost of Bullet Railings with Concrete Parapet or Traffic Railing, as appropriate.		Subtotal	$13,090

7. Expansion Joints			
Type	**Cost per Lin. Foot**	**Quantity**	**Cost**
Poured Joint With Backer Rod	$45	90	$4,050
Strip Seal	$250		
Finger Joint <6"	$850		
Finger Joint >6"	$1,500		
Modular 6"	$500		
Modular 8"	$700		
Modular 12"	$900		
		Subtotal	$4,050

Superstructure Subtotal **$189,333**

E. Miscellaneous Items

1. Bridge Deck Grooving and Planing

Type	Cost per Sq. Yard	Quantity	Cost
Bridge Deck Planing	$6.00		
Bridge Deck Grooving for Short Bridge	$8.00	290	$2,320
Bridge Deck Grooving for Long Bridge	$5.00		
		Grooving and Planing Subtotal	$2,320

2. Detour Bridges

Type	Cost per Sq. Foot	Quantity	Cost
Acrow Detour Bridge [1]	$55		
		Detour Bridge Subtotal	

[1] Using FDOT supplied components. The cost is for the bridge proper (measured out-to-out) and does not include approach work, surfacing, or guardrail.

3. Approach Slab

Approach Slab Material	Cost per Unit	Quantity	Cost
Cast-in-Place Concrete (per Sq. Yard)	$400	106.4	$42,560
Reinforcing Steel (per Pound)	$1.05	21280	$22,344
36" Single-Slope	110	120.00	$13,200
		Approach Slab Subtotal	$78,104

Unadjusted Total $457,204

Step Two: Estimate Conditional Variables and Cost per Square Foot

After developing the total cost estimate utilizing the unit cost, modify the cost to account for site condition variables. If appropriate, the cost will be modified by the following variables:

** Phased construction is defined as construction over traffic or construction requiring multiple phases to complete the construction of the entire cross section of the bridge. The 20 percent premium is applied to the effected units of the superstructure and/or substructure.

Conditional Variables	% Increase/ Decrease	Cost (+/-)
For construction over open water, floodplains that flood frequently or other similar areas, increase cost by 3 %.		
For construction over traffic and/or phased construction, increase by 20 %. [1]	20%	$91,441
	20%	$91,441

[1] Phased construction is defined as construction requiring multiple phases to complete the construction of the entire cross section of the bridge. The 20 percent premium is applied to the affected units of the superstructure and/or substructure.

Substructure Subtotal	$123,787
Superstructure Subtotal	$189,333
Walls Subtotal	$63,660
Box Culverts Subtotal	
Grooving and Planing Subtotal	$2,320
Detour Bridge Subtotal	
Approach Slab Subtotal	$78,104
Conditional Variables	$91,441
Total Cost	$548,645
Total Square Feet of Deck	2761.1
Cost per Square Foot (not including Approach Slab)	$170

Design Aid for Determination of Reinforcing Steel

In the absence of better information, use the following quantities of reinforcing steel pounds per cubic yard of concrete.

Location	Pounds of Steel per Cubic Yard	Cubic Yds.	Tot. Pounds
Pile Abutments	**135**		
Pile Bents	**145**		
Single Column Piers >25'	**210**		
Single Column Piers <25'	**150**		
Multiple Column Piers >25'	**215**		
Multiple Column Piers <25'	**195**		
Bascule Piers	**110**		
Standard Deck Slabs	**205**		
Isotropic Deck Slabs	**125**		
Concrete Box Girders, Pier Seg	**225**		
Concrete Box Girders, Typ. Seg	**165**		
C.I.P. Flat Slabs @ 30ft & 15" Deep	**220**		
Approach Slab	**200**		

Step Three: Cost Estimate Comparison to Historical Bridge Cost

The final step is a comparison of the cost estimate by comparison with historic bridge cost based on a cost per square foot. These total cost numbers are calculated exclusively for the bridge cost as defined in the General Section of this chapter. Price computed by Steps 1 and 2 should be generally within the range of cost as supplied herein. If the cost falls outside the provided range, good justification must be provided.

Bridge Superstructure Type	Total Cost per Square Foot Low	Total Cost per Square Foot High
Short Span Bridges:		
Reinforced Concrete Flat Slab- Simple Span [1]	$115	$160
Pre-cast Concrete Slab - Simple Span [1]	$110	$200
Medium Span Bridges:		
Concrete Deck / Steel Girder - Simple Span [1]	$125	$142
Concrete Deck / Steel Girder - Continuous Span [1]	$135	$170
Concrete Deck / Prestressed Girder - Simple Span [1]	$90	$145
Concrete Deck / Prestressed Girder - Continuous Span [1]	$95	$211
Concrete Deck / Steel Box Girder [1] -	$140	$180
Span range from 150' to 280' (for curvature, add 15% premium)		
Segmental Concrete Box Girders - Cantilever Construction	$140	$160
Span range from 150' to 280'		
Movable Bridge - Bascule Spans & Piers	$1,800	$2,000
Demolition Costs:		
Typical	$35	$60
Bascule	$60	$70
Project Type		
Widening (Construction Only)	$85	$160

[1] Increase the cost by twenty percent for phased construction

Estimated Cost per Square Foot | **$170**

SR 29 Alternative 2

WILDLIFE UNDERPASS – CONCRETE BOX CULVERT

SR 29 WILDLIFE CROSSING ANALYSIS

KISINGER CAMPO & ASSOCIATES

Districtwide Environmental Permits Design Support — DESIGNED BY: SKB 09/21
Task Work Order No. 10 — CHECKED BY:
SR 29 Wildlife Crossing Analysis

Substructure Quantities

SR 29 Alternative 2

0400 4 1 CONCRETE CLASS IV, CULVERT

10'x8' Wildlife Crossing					
Location	Volume *(CY)*			Quantity	Volume *(CY)*
Box	72.92			1	72.92
Wing Wall	17.79			4	71.16
				TOTAL	144.1 CY

0415 1 1 REINFORCING STEEL - ROADWAY

10'x8' Wildlife Crossing					
Location	Weight *(LB)*			Units	Weight *(LB)*
Main Box	17261.00			1	17261.00
Left End Wingwall	2578.00			1	2578.00
Left Begin Wingwall	2578.00			1	2578.00
Right End Wingwall	2578.00			1	2578.00
Right Begin Wingwall	2578.00			1	2578.00
Left Headwall	151.00			1	151.00
Right Headwall	151.00			1	151.00
Left Cutoff wall	69.00			1	69.00
Right Cutoff Wall	69.00			1	69.00

PAY ITEM TOTAL 28013 LB

Box Culvert Analysis:
Estimate of Quantities

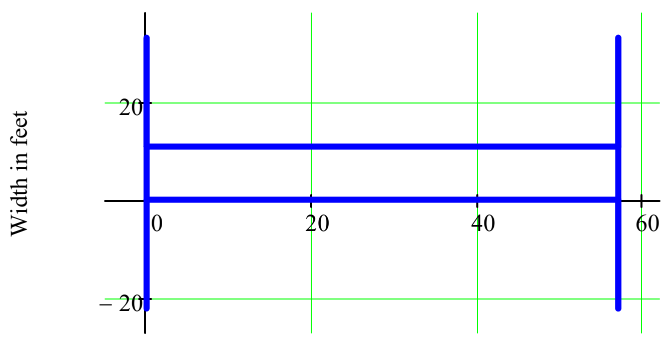
Project = "SR29 Wildlife Crossing Analysis"

DesignedBy = "SKB"

CheckedBy = "____"

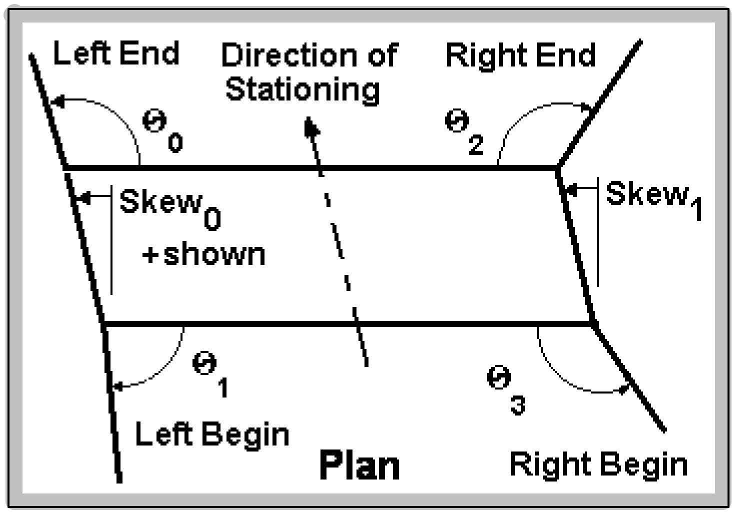
CurrentDataFile = "\Data Files CIP\10'x8' Wildlife Culvert.dat"

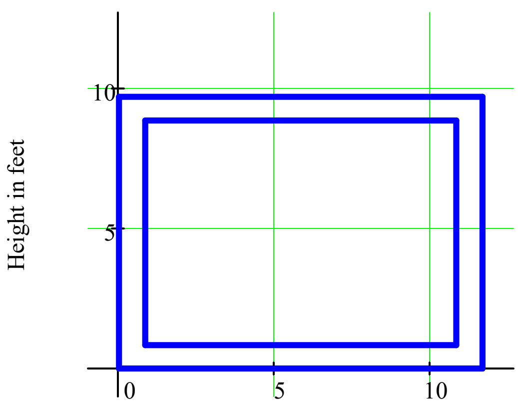
Comment = "Single cell, no box skew, wingwalls parallel to traffic"



Length in feet

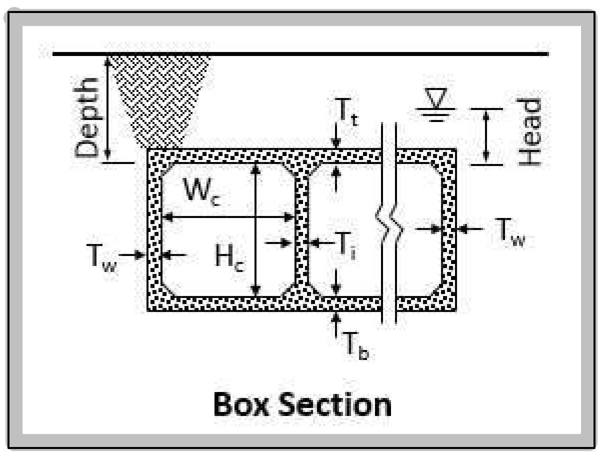
Plan - Box Culvert





Width in feet

Cross Section - Box Culvert



Box Dimensions

$HydraulicOpening := W_c \cdot H_c \cdot NoOfCells$

$HydraulicOpening = 80\ ft^2$

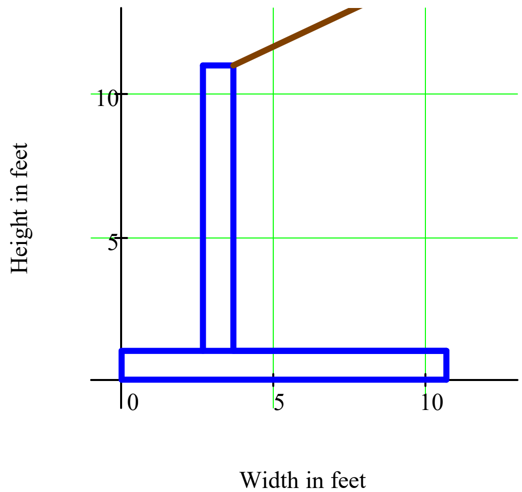
$SoilHeight = 2\ ft$

$NoOfCells = 1$	$W_c = 10\ ft$	$H_c = 8\ ft$	$L_c = 57\ ft$	$\theta^T = (90\ \ 90\ \ 90\ \ 90)\cdot deg$	$Head = 0\ ft$
$T_t = 10\cdot in$	$T_b = 10\cdot in$	$T_w = 10\cdot in$	$T_i = 10\cdot in$	$Cover = 2\cdot in$	$Depth = 2.833\ ft$

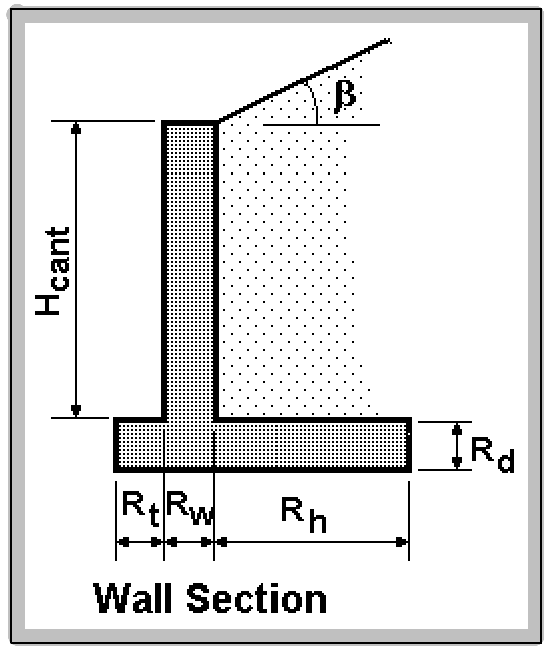
Cutoff wall and Headwall Dimensions

$Skew_{left} = 0\cdot deg$	$B_{lhw} = 18\cdot in$	$H_{lhw} = 24\cdot in$	$B_{lcw} = 12\cdot in$	$H_{lcw} = 24\cdot in$
$Skew_{right} = 0\cdot deg$	$B_{rhw} = 18\cdot in$	$H_{rhw} = 24\cdot in$	$B_{rcw} = 12\cdot in$	$H_{rcw} = 24\cdot in$

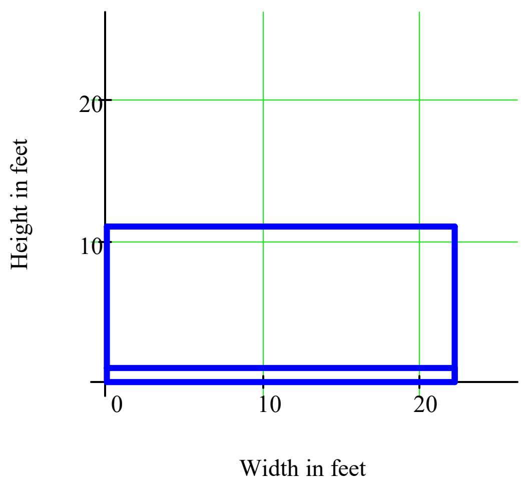
Wingwall Dimensions



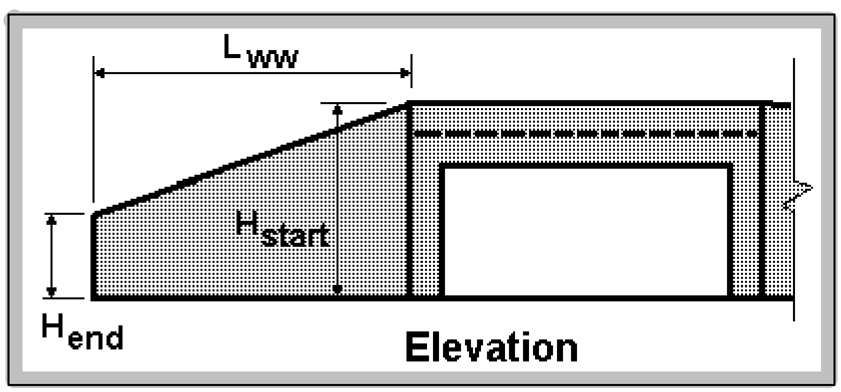
Cross Section - First Wingwall



$R_t = \begin{pmatrix} 32 \\ 32 \\ 32 \\ 32 \end{pmatrix} \cdot in$ $R_w = \begin{pmatrix} 12 \\ 12 \\ 12 \\ 12 \end{pmatrix} \cdot in$ $R_h = \begin{pmatrix} 84 \\ 84 \\ 84 \\ 84 \end{pmatrix} \cdot in$ $R_d = \begin{pmatrix} 12 \\ 12 \\ 12 \\ 12 \end{pmatrix} \cdot in$ $\beta = \begin{pmatrix} 26.57 \\ 26.57 \\ 26.57 \\ 26.57 \end{pmatrix} \cdot deg$



Elevation - First Wingwall



$H_{end} = \begin{pmatrix} 10 \\ 10 \\ 10 \\ 10 \end{pmatrix} ft$ $H_{start} = \begin{pmatrix} 10 \\ 10 \\ 10 \\ 10 \end{pmatrix} ft$ $L_{ww} = \begin{pmatrix} 22.17 \\ 22.17 \\ 22.17 \\ 22.17 \end{pmatrix} ft$ $\theta = \begin{pmatrix} 90 \\ 90 \\ 90 \\ 90 \end{pmatrix} \cdot deg$

Summary of Concrete Quantities

$Vol_{cw.left} = 0.5 \cdot yd^3$ $Vol_{cw.right} = 0.5 \cdot yd^3$

$Vol_{bot.slab} = 21.6 \cdot yd^3$ $Vol_{walls} = 28.15 \cdot yd^3$ $Vol_{top.slab} = 20.52 \cdot yd^3$

$Vol_{hw.left} = 0.76 \cdot yd^3$ $Vol_{hw.right} = 0.76 \cdot yd^3$

$Vol_{wall} = \begin{pmatrix} 8.21 \\ 8.21 \\ 8.21 \\ 8.21 \end{pmatrix} \cdot yd^3$ $Vol_{ww.cowall} = \begin{pmatrix} 0.8211 \\ 0.8211 \\ 0.8211 \\ 0.8211 \end{pmatrix} \cdot yd^3$ $Vol_{footing} = \begin{pmatrix} 8.76 \\ 8.76 \\ 8.76 \\ 8.76 \end{pmatrix} \cdot yd^3$ $TotalVol_{wingwall} = \begin{pmatrix} 17.79 \\ 17.79 \\ 17.79 \\ 17.79 \end{pmatrix} \cdot yd^3$

$Vol_{box} = 72.92 \cdot yd^3$ $\sum Vol_{wall} = 32.84 \cdot yd^3$ $\sum TotalVol_{footing} = 38.32 \cdot yd^3$ $TotalVolume = 144.08 \cdot yd^3$

Summary of Soil and Miscellaneous Values

$E = 4388 \cdot ksi$ $f_c = 5.5 \cdot ksi$ $Extension = 0$ $Env = 2$

0 - *new box (no extension)*
1- *left extension*
2 - *right extension*

Environmental Class
1 - slightly aggressive
2 - moderately aggressive
3 - extremely aggressive

$F_y = 60 \cdot ksi$ $n_{mod} = 6.609$

$ConsiderLLSurcharge_{ww} = 1$ *0 - No* *1 - Yes*

$ConsiderLL_{hw} = 1$ *0 - No* *1 - Yes*

$BarrierDL_{hw} = 0 \cdot \frac{kip}{ft}$

$\gamma_{soil} = 120 \cdot \frac{lbf}{ft^3}$ $k_s = 100000 \cdot \frac{lbf}{ft^3}$ $\phi = 30 \cdot deg$ $q_{nom} = 5000 \cdot \frac{lbf}{ft^2}$

Summary of Reinforcement Check Values

$Check_{box} = \text{"OK"}$ $Check_{cw} = \text{"OK"}$ $Check_{hw} = \text{"OK"}$ $Check_{ww} = \text{"OK"}$ $TotalCheck = \text{"OK"}$

$BarSize_{slabs} = \begin{pmatrix} 6 \\ 6 \\ 6 \\ 6 \end{pmatrix}$ $S_{slabs} = \begin{pmatrix} 6 \\ 6 \\ 6 \\ 6 \end{pmatrix} \cdot in$

top slab, top mat
top slab, bot mat
bot slab, top mat
bot slab, bot mat

$BarSize_{long} = \begin{pmatrix} 4 \\ 4 \\ 4 \\ 4 \\ 4 \end{pmatrix}$ $S_{long} = \begin{pmatrix} 12 \\ 12 \\ 12 \\ 12 \\ 12 \end{pmatrix} \cdot in$

top slab, top mat
top slab, bot mat
interior wall(s)
exterior walls
bot slab, both m.

$BarSize_{walls} = \begin{pmatrix} 4 \\ 4 \end{pmatrix}$ $S_{walls} = \begin{pmatrix} 16 \\ 16 \end{pmatrix} \cdot in$

interior wall(s)
exterior walls

$BarSize_{corners} = \begin{pmatrix} 6 \\ 6 \end{pmatrix}$ $S_{corners} = \begin{pmatrix} 6 \\ 6 \end{pmatrix} \cdot in$

top corner
bot corner

$BarSize_{cw} = \begin{pmatrix} 4 \\ 4 \\ 4 \\ 4 \end{pmatrix}$ $Num_{cw} = \begin{pmatrix} 2 \\ 2 \\ 2 \\ 2 \end{pmatrix}$

top bar, left cw
bot bar, left cw
top bar, right cw
bot bar, right cw

$StirSize_{cw} = \begin{pmatrix} 4 \\ 4 \end{pmatrix}$ $S_{stirrup.cw} = \begin{pmatrix} 12 \\ 12 \end{pmatrix} \cdot in$

$BarSize_{hw} = \begin{pmatrix} 6 \\ 6 \\ 6 \\ 6 \end{pmatrix}$ $Num_{hw} = \begin{pmatrix} 3 \\ 3 \\ 3 \\ 3 \end{pmatrix}$

top bar, left hw
bot bar, left hw
top bar, right hw
bot bar, right hw

$StirSize_{hw} = \begin{pmatrix} 4 \\ 4 \end{pmatrix}$ $S_{stirrup.hw} = \begin{pmatrix} 12 \\ 12 \end{pmatrix} \cdot in$

Reinforcement List - Main Box *click table below to reveal scroll bar...*

$Reinf_{box}$ =

	0	1	2	3	4
0	"Bar Location"	"Size"	"Desig"	"Len"	"Num"
1	"top face, top slab"	6	101	11.33	115
2	"bot face, top slab"	6	102	11.33	115
3	"top face, bot slab"	6	103	11.33	121
4	"bot face, bot slab"	6	104	11.33	121
5	"top ext corner"	6	105	7.76	228
6	"bot ext corner"	6	106	7.76	228
7	"inside face, ext wall"	4	108	9.33	86
8	long top face, bot slab"	4	109	59.67	13
9	long top face, top slab"	4	110	56.67	13
10	long bot face, top slab"	4	111	56.02	13
11	long bot face, bot slab"	4	112	59.67	13
12	ng each face, ext wall"	4	113	56.67	18
13	ng each face, ext wall"	4	114	56.67	...
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					

Reinforcement Lists - Left Begin and Left End Wingwalls

$Rw_0 =$

"Bar Location"	"Size"	"Desig"	"Len"	"Num"	"Type"	"A"	"G"	"B"	"C"	"D"	"E"	"F"	"H"	"J"	"K"	"N
"wall vert, soil side"	6	401	9.75	45	1	0	0	9.75	0	0	0	0	0	0	0	(
"wall horiz, front side"	4	402	21.84	11	1	0	0	21.84	0	0	0	0	0	0	0	(
"wall horiz, soil side"	4	404	21.84	11	1	0	0	21.84	0	0	0	0	0	0	0	(
"wall vert, front side"	4	406	9.75	23	1	0	0	9.75	0	0	0	0	0	0	0	(
"wall vert, soil side"	6	407	6.22	45	10	0	0	3.33	2.89	0	0	0	0	0	0	(
"top footing heel"	5	409	10.33	45	1	0	0	10.33	0	0	0	0	0	0	0	(
"bot footing toe"	4	410	10.33	23	1	0	0	10.33	0	0	0	0	0	0	0	(
"temp footing"	4	411	21.84	24	1	0	0	21.84	0	0	0	0	0	0	0	(
"wall to box ties"	5	412	2	16	1	0	0	2	0	0	0	0	0	0	0	(

$Rw_1 =$

"Bar Location"	"Size"	"Desig"	"Len"	"Num"	"Type"	"A"	"G"	"B"	"C"	"D"	"E"	"F"	"H"	"J"	"K"	"N
"wall vert, soil side"	6	501	9.75	45	1	0	0	9.75	0	0	0	0	0	0	0	(
"wall horiz, front side"	4	502	21.84	11	1	0	0	21.84	0	0	0	0	0	0	0	(
"wall horiz, soil side"	4	504	21.84	11	1	0	0	21.84	0	0	0	0	0	0	0	(
"wall vert, front side"	4	506	9.75	23	1	0	0	9.75	0	0	0	0	0	0	0	(
"wall vert, soil side"	6	507	6.22	45	10	0	0	3.33	2.89	0	0	0	0	0	0	(
"top footing heel"	5	509	10.33	45	1	0	0	10.33	0	0	0	0	0	0	0	(
"bot footing toe"	4	510	10.33	23	1	0	0	10.33	0	0	0	0	0	0	0	(
"temp footing"	4	511	21.84	24	1	0	0	21.84	0	0	0	0	0	0	0	(
"wall to box ties"	5	512	2	16	1	0	0	2	0	0	0	0	0	0	0	(

Reinforcement Lists - Right Begin and Right End Wingwalls

$Rw_2 =$

"Bar Location"	"Size"	"Desig"	"Len"	"Num"	"Type"	"A"	"G"	"B"	"C"	"D"	"E"	"F"	"H"	"J"	"K"	"N
"wall vert, soil side"	6	601	9.75	45	1	0	0	9.75	0	0	0	0	0	0	0	(
"wall horiz, front side"	4	602	21.84	11	1	0	0	21.84	0	0	0	0	0	0	0	(
"wall horiz, soil side"	4	604	21.84	11	1	0	0	21.84	0	0	0	0	0	0	0	(
"wall vert, front side"	4	606	9.75	23	1	0	0	9.75	0	0	0	0	0	0	0	(
"wall vert, soil side"	6	607	6.22	45	10	0	0	3.33	2.89	0	0	0	0	0	0	(
"top footing heel"	5	609	10.33	45	1	0	0	10.33	0	0	0	0	0	0	0	(
"bot footing toe"	4	610	10.33	23	1	0	0	10.33	0	0	0	0	0	0	0	(
"temp footing"	4	611	21.84	24	1	0	0	21.84	0	0	0	0	0	0	0	(
"wall to box ties"	5	612	2	16	1	0	0	2	0	0	0	0	0	0	0	(

$Rw_3 =$

"Bar Location"	"Size"	"Desig"	"Len"	"Num"	"Type"	"A"	"G"	"B"	"C"	"D"	"E"	"F"	"H"	"J"	"K"	"N
"wall vert, soil side"	6	701	9.75	45	1	0	0	9.75	0	0	0	0	0	0	0	(
"wall horiz, front side"	4	702	21.84	11	1	0	0	21.84	0	0	0	0	0	0	0	(
"wall horiz, soil side"	4	704	21.84	11	1	0	0	21.84	0	0	0	0	0	0	0	(
"wall vert, front side"	4	706	9.75	23	1	0	0	9.75	0	0	0	0	0	0	0	(
"wall vert, soil side"	6	707	6.22	45	10	0	0	3.33	2.89	0	0	0	0	0	0	(
"top footing heel"	5	709	10.33	45	1	0	0	10.33	0	0	0	0	0	0	0	(
"bot footing toe"	4	710	10.33	23	1	0	0	10.33	0	0	0	0	0	0	0	(
"temp footing"	4	711	21.84	24	1	0	0	21.84	0	0	0	0	0	0	0	(
"wall to box ties"	5	712	2	16	1	0	0	2	0	0	0	0	0	0	0	(

Reinforcement Lists - Headwalls and Cutoff Walls

Rh_1 =

"Bar Location"	"Size"	"Desig"	"Len"	"Num"	"Type"	"A"	"G"	"B"	"C"	"D"	"E"	"F"	"H"	"J"	"K"	"N"
"top"	6	801	11.33	3	1	0	0	11.33	0	0	0	0	0	0	0	0
"bottom"	6	802	11.33	3	1	0	0	11.33	0	0	0	0	0	0	0	0
"stirrups"	4	803	6.11	12	27	0	0	1.6	0.5	0.67	0.42	1.19	1	1	0	0

Rh_2 =

"Bar Location"	"Size"	"Desig"	"Len"	"Num"	"Type"	"A"	"G"	"B"	"C"	"D"	"E"	"F"	"H"	"J"	"K"	"N"
"top"	6	804	11.33	3	1	0	0	11.33	0	0	0	0	0	0	0	0
"bottom"	6	805	11.33	3	1	0	0	11.33	0	0	0	0	0	0	0	0
"stirrups"	4	806	6.11	12	27	0	0	1.6	0.5	0.67	0.42	1.19	1	1	0	0

Rc_1 =

"Bar Location"	"Size"	"Desig"	"Len"	"Num"	"Type"	"A"	"G"	"B"	"C"	"D"	"E"	"F"	"H"	"J"	"K"	"N"
"top"	4	807	11.33	2	1	0	0	11.33	0	0	0	0	0	0	0	0
"bottom"	4	808	11.33	2	1	0	0	11.33	0	0	0	0	0	0	0	0
"stirrups"	4	809	4.88	12	7	0	0	1.6	0.67	0.5	0.5	0	0	0	0	0

Rc_2 =

"Bar Location"	"Size"	"Desig"	"Len"	"Num"	"Type"	"A"	"G"	"B"	"C"	"D"	"E"	"F"	"H"	"J"	"K"	"N"
"top"	4	810	11.33	2	1	0	0	11.33	0	0	0	0	0	0	0	0
"bottom"	4	811	11.33	2	1	0	0	11.33	0	0	0	0	0	0	0	0
"stirrups"	4	812	4.88	12	7	0	0	1.6	0.67	0.5	0.5	0	0	0	0	0

No variables are modified in this file: CurrentDataFile = "\Data Files CIP\10'x8' Wildlife Culvert.dat"

REINFORCING STEEL QUANTITIES

DATE RAN: FRI NOV 19 09:00:57 2021

NAME OF UNIT	QUANTITY/UNIT		NO. UNITS		TOTAL-QUANTITY	COST/LB	TOTAL-COST
MAIN BOX	17261 LBS	X	1	=	17261 LBS AT	0.000 = $	0.00
LEFT END WINGWALL	2578 LBS	X	1	=	2578 LBS AT	0.000 = $	0.00
LEFT BEGIN WINGWALL	2578 LBS	X	1	=	2578 LBS AT	0.000 = $	0.00
RIGHT END WINGWALL	2578 LBS	X	1	=	2578 LBS AT	0.000 = $	0.00
RIGHT BEGIN WINGWALL	2578 LBS	X	1	=	2578 LBS AT	0.000 = $	0.00
LEFT HEADWALL	151 LBS	X	1	=	151 LBS AT	0.000 = $	0.00
RIGHT HEADWALL	151 LBS	X	1	=	151 LBS AT	0.000 = $	0.00
LEFT CUTOFF WALL	69 LBS	X	1	=	69 LBS AT	0.000 = $	0.00
RIGHT CUTOFF WALL	69 LBS	X	1	=	69 LBS AT	0.000 = $	0.00
			GRAND TOTAL	=	28013 LBS	$	0.00

LOCATION MAIN BOX NO. REQUIRED = 1 LBS/MARK

							LBS/MARK
6	101	11- 4	115	1	11- 4		1957.03
6	102	11- 4	115	1	11- 4		1957.03
6	103	11- 4	121	1	11- 4		2059.14
6	104	11- 4	121	1	11- 4		2059.14
6	105	7- 9	228	10	2- 0 3/4	5- 8 1/2	2657.46
6	106	7- 9	228	10	2- 0 3/4	5- 8 1/2	2657.46
4	108	9- 4	86	1	9- 4		535.99
4	109	59- 8	13	1	59- 8		518.17
4	110	56- 8	13	1	56- 8		492.12
4	111	56- 1	13	1	56- 0 1/4		486.48
4	112	59- 8	13	1	59- 8		518.17
4	113	56- 8	18	1	56- 8		681.40
4	114	56- 8	18	1	56- 8		681.40

LOCATION LEFT END WINGWALL NO. REQUIRED = 1 LBS/MARK

							LBS/MARK
6	401	9- 9	45	1	9- 9		659.00
4	402	21-10	11	1	21-10		160.48
4	404	21-10	11	1	21-10		160.48
4	406	9- 9	23	1	9- 9		149.80
6	407	6- 3	45	10	3- 4	2-10 3/4	420.75
5	409	10- 4	45	1	10- 4		484.84
4	410	10- 4	23	1	10- 4		158.71
4	411	21-10	24	1	21-10		350.14
5	412	2- 0	16	1	2- 0		33.38

LOCATION LEFT BEGIN WINGWALL NO. REQUIRED = 1 LBS/MARK

							LBS/MARK
6	501	9- 9	45	1	9- 9		659.00
4	502	21-10	11	1	21-10		160.48
4	504	21-10	11	1	21-10		160.48
4	506	9- 9	23	1	9- 9		149.80
6	507	6- 3	45	10	3- 4	2-10 3/4	420.75
5	509	10- 4	45	1	10- 4		484.84
4	510	10- 4	23	1	10- 4		158.71
4	511	21-10	24	1	21-10		350.14
5	512	2- 0	16	1	2- 0		33.38

LOCATION RIGHT END WINGWALL NO. REQUIRED = 1 LBS/MARK

							LBS/MARK
6	601	9- 9	45	1	9- 9		659.00
4	602	21-10	11	1	21-10		160.48
4	604	21-10	11	1	21-10		160.48
4	606	9- 9	23	1	9- 9		149.80
6	607	6- 3	45	10	3- 4	2-10 3/4	420.75
5	609	10- 4	45	1	10- 4		484.84

4	610	10- 4	23	1	10- 4							158.71
4	611	21-10	24	1	21-10							350.14
5	612	2- 0	16	1	2- 0							33.38

LOCATION RIGHT BEGIN WINGWALL NO. REQUIRED = 1 LBS/MARK

6	701	9- 9	45	1	9- 9							659.00
4	702	21-10	11	1	21-10							160.48
4	704	21-10	11	1	21-10							160.48
4	706	9- 9	23	1	9- 9							149.80
6	707	6- 3	45	10	3- 4	2-10 3/4						420.75
5	709	10- 4	45	1	10- 4							484.84
4	710	10- 4	23	1	10- 4							158.71
4	711	21-10	24	1	21-10							350.14
5	712	2- 0	16	1	2- 0							33.38

LOCATION LEFT HEADWALL NO. REQUIRED = 1 LBS/MARK

6	801	11- 4	3	1	11- 4							51.05
6	802	11- 4	3	1	11- 4							51.05
4	803	6- 2	12	27	1- 7 1/4	0- 6	0- 8	0- 5	1- 2 1/4	1- 0	1- 0	48.97
10	0	0- 0	0	0								

LOCATION RIGHT HEADWALL NO. REQUIRED = 1 LBS/MARK

6	804	11- 4	3	1	11- 4							51.05
6	805	11- 4	3	1	11- 4							51.05
4	806	6- 2	12	27	1- 7 1/4	0- 6	0- 8	0- 5	1- 2 1/4	1- 0	1- 0	48.97
10	0	0- 0	0	0								

LOCATION LEFT CUTOFF WALL NO. REQUIRED = 1 LBS/MARK

4	807	11- 4	2	1	11- 4							15.14
4	808	11- 4	2	1	11- 4							15.14
4	809	4-11	12	7	1- 7 1/4	0- 8	0- 6	0- 6				39.09
10	0	0- 0	0	0								

LOCATION RIGHT CUTOFF WALL NO. REQUIRED = 1 LBS/MARK

4	810	11- 4	2	1	11- 4							15.14
4	811	11- 4	2	1	11- 4							15.14
4	812	4-11	12	7	1- 7 1/4	0- 8	0- 6	0- 6				39.09
10	0	0- 0	0	0								

Barron Canal Alternative 1

WILDLIFE CROSSING - BRIDGE

SR 29 WILDLIFE CROSSING ANALYSIS

KISINGER CAMPO & ASSOCIATES

Districtwide Environmental Permits Design Support — DESIGNED BY: SKB 09/21
Task Work Order No. 10 — CHECKED BY:
SR 29 Wildlife Crossing Analysis

Animal Crossing Fixtures Quantities

Barron Canal Alternative 1

0142 70 FILL SAND

Location	Length *(ft.)*	Width *(ft.)*	Depth *(ft.)*	Volume *(CY)*
Bridge	82.00	10.42	2.25	71.18

71.2 CY

KISINGER CAMPO & ASSOCIATES

Districtwide Environmental Permits Design Support — DESIGNED BY: SKB 09/21
Task Work Order No. 10 — CHECKED BY:
SR 29 Wildlife Crossing Analysis

Foundation Quantities

Barron Canal Alternative 1

0455 34 3 PRESTRESSED CONCRETE PILING, 18" SQ

Location	No. Piles	Pile Length *(ft.)*		Total Length *(ft.)*
END BENT 1	3	75.00		225.00
END BENT 2	3	75.00		225.00

PAY ITEM TOTAL 450 LF

0455143 3 TEST PILES-PRESTRESSED CONCRETE, 18" SQ

Location	No. Piles	Pile Length *(ft.)*	Additional Length *(ft.)*	Total Length *(ft.)*
END BENT 1	1	75.00	15.00	90.00
END BENT 2	1	75.00	15.00	90.00

`

PAY ITEM TOTAL 180 LF

0530 1100 RIPRAP, SAND-CEMENT BAGS

Location	Sand Cement Height	Bedding Stone Height	Trench	Sand Cement Width	Total Length	Volume
	(ft.)	*(ft.)*	*(ft.)*	*(ft.)*	*(ft.)*	*(CY)*
END BENT 1	2.50	1.00	1.00	1.00	34.69	5.14
END BENT 2	2.50	1.00	1.00	1.00	34.69	5.14

PAY ITEM TOTAL 10.3 CY

KISINGER CAMPO & ASSOCIATES

Districtwide Environmental Permits Design Support — DESIGNED BY: SKB 09/21
Task Work Order No. 10 — CHECKED BY:
SR 29 Wildlife Crossing Analysis

Foundation Quantities

Barron Canal Alternative 1

0530 3 3 RIPRAP- RUBBLE, BANK AND SHORE

Rip-Rap Properties				
Specific Gravity	Water Weight *(PCF)*	Void Factor	'T' *(ft.)*	Rip-Rap Weight *(PSF)*
2.30	62.40	0.90	2.50	322.92

Location	Plan Area of Riprap *(SF)*	Weight of riprap *(PSF)*	Weight *(Ton)*
END BENT 1	1341.36	322.92	212.10
END BENT 2	1341.36	322.92	212.10

PAY ITEM TOTAL 424.2 TN

0530 74 BEDDING STONE

Location	Plan Area of Bedding Stone *(SF)*	Unit Weight of bedding stone *(PCF)*	Thickness *(ft.)*	Weight *(Ton)*
END BENT 1	1306.67	115.00	1.00	75.13
END BENT 2	1306.67	115.00	1.00	75.13

PAY ITEM TOTAL 150.3 TN

KISINGER CAMPO & ASSOCIATES

Districtwide Environmental Permits Design Support
Task Work Order No. 10
SR 29 Wildlife Crossing Analysis

DESIGNED BY: SKB 09/21
CHECKED BY:

Substructure Quantities

Barron Canal Alternative 1

0400 4 5 CONCRETE CLASS IV, BRIDGE SUBSTRUCTURE

END BENTS 1 & 2					
Location	Length *(ft.)*	Width *(ft.)*	Height *(ft.)*	Quantity	Volume *(CY)*
Cap	12.00	3.00	2.50	1	3.33
Backwall	9.92	1.00	3.83	1	1.41
Pedestals	3.00	2.00	0.50	2	0.22
Wingwall cap	9.00	3.00	2.50	2	5.00
Wingwall Backwall	12.00	1.00	5.30	2	4.71
				TOTAL	14.7

Applicable Equation: Volume = Quantity x (Length x Width x Height) / (27 ft^3/CY)
Reduction for pile embedment conservatively excluded.

SUMMARY	
Location	Volume *(CY)*
END BENT 1	14.7
END BENT 2	14.7

PAY ITEM TOTAL 29.4 CY

0415 1 5 REINFORCING STEEL - BRIDGE SUBSTRUCTURE

Location	Volume Concrete *(CY)*	BDR Estimate Value *(lb./CY)*	Weight *(lb.)*
END BENT 1	14.70	135	1985
END BENT 2	14.70	135	1985

PAY ITEM TOTAL 3969 LB

KISINGER CAMPO & ASSOCIATES

Districtwide Environmental Permits Design Support — DESIGNED BY: SKB 09/21
Task Work Order No. 10 — CHECKED BY:
SR 29 Wildlife Crossing Analysis

Superstructure Quantities

Barron Canal Alternative 1

0400 4 4 CONCRETE CLASS IV, BRIDGE SUPERSTRUCTURE

BRIDGE DECK				
Location	Length *(ft.)*	Width *(ft.)*	Deck Depth *(ft.)*	Volume *(CY)*
SPAN 1	82.00	12.00	0.67	24.30

BUILD-UP						
Location	No. Beams	Beam Length *(ft.)*	Flange Width *(ft.)*	'B' & 'D' * *(in.)*	'C' * *(in.)*	Volume *(CY)*
SPAN 1	2	79.50	4.00	2.00	1.00	2.62

* See SPI Index 450-199, Case 3.

THICKENED DECK END						
Location	Depth *(in.)*	Buildup *(in.)*	Added Depth *(ft.)*	Length* *(ft.)*	Width *(ft.)*	Volume *(CY)*
SPAN 1 (BEGIN)	3.50	2.00	0.46	3.00	2.50	0.14
SPAN 1 (END)	3.50	2.00	0.46	3.00	2.50	0.14

* Length = Total distance between beam flanges.

Location	Deck *(CY)*	Build-Up *(CY)*	Deck End *(CY)*	Volume *(CY)*
SPAN 1	24.30	2.62	0.28	27.20

PAY ITEM TOTAL 27.2 CY

Applicable Equations:

Bridge Deck — Volume = (Length x Width x Depth) / (27 ft^3/CY)

Build-Up — Volume = (Beam Length x Flange Width x (C + ((B + D - 2C)/6))) / (27 ft^3/CY)

Thickened Slab End — Volume = Length * (Width x Added Depth + 0.5 x (Added Depth)2) / (27 ft3/CY)

KISINGER CAMPO & ASSOCIATES

Districtwide Environmental Permits Design Support
Task Work Order No. 10
SR 29 Wildlife Crossing Analysis

DESIGNED BY: SKB 09/21
CHECKED BY:

Superstructure Quantities

Barron Canal Alternative 1

0400147 COMPOSITE NEOPRENE PADS

Location	No. Pads per Location	Pad Type*	L *(in.)*	W *(ft.)*	Thickness *(in.)*	Volume *(CF)*
END BENT 1	2	E	10	2.67	1.91	0.80
END BENT 2	2	E	10	2.67	1.91	0.80

* See Index 400-510 for dimensions.

PAY ITEM TOTAL 1.6 CF

Applicable Equation: Volume = No. Pads x (L / 12 in/ft) x W x (Thickness / 12 in/ft)

0415 1 4 REINFORCING STEEL - BRIDGE SUPERSTRUCTURE

Location	Volume Concrete *(CY)*	BDR Estimate Value *(lb./CY)*	Weight *(lb.)*
BRIDGE	27.20	205	5576

5576 LB

0450 2 36 PREST BEAMS: FLORIDA-I BEAM 36"

Location	Beam Length *(ft.)*	Quantity	Length *(ft.)*
BEAMS 1 & 2	79.50	2	159.00

PAY ITEM TOTAL 159 LF

0458 1 11 BRIDGE DECK EXPANSION JOINT, NEW CONSTRUCTION,
F&I POURED JOINT WITH BACKER ROD

Location	Width* *(ft.)*		Length *(ft.)*
END BENT 1	10.42		12.00
END BENT 2	10.42		12.00

* Measured along skew between inside face of rails/parapets.

PAY ITEM TOTAL 24 LF

Applicable Equation: Length = Width + 2in. + $\sqrt{[(6in.)^2 + (5in.)^2]}$

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SR 29 Wildlife Crossing Analysis

Barrier Quantities

Barron Canal Alternative 1

0521 6 11 CONCRETE PARAPET, PEDESTRIAN/BICYCLE, 27" HEIGHT

Location	Length *(ft.)*	No. Railings	Length *(ft.)*
Bridge	76.00	2	152.00

PAY ITEM TOTAL 152 LF

Bridge Development Report Cost Estimating - Canal Alternative 1 - FIB-36
Effective 01/01/2021

Step One: Estimate Component Items

Utilizing the cost provided herein, develop the cost estimate for each bridge type under consideration.

A. Bridge Substructure

1. Prestressed Concrete Piling, (furnished and installed)			
Size of Piling	**Cost per Lin. Foot [1]**	**Quantity**	**Cost**
18" (Driven Plumb or 1" Batter) [2]	$100	630	$63,000
18" (Driven Battered) [2]	$140		
24" (Driven Plumb or 1" Batter) [2]	$140		
24" (Driven Battered) [2]	$200		
30" (Driven Plumb or 1" Batter) [2]	$170		
30" (Driven Battered) [2]	$240		
18" w/CFRP or Stainless Steel Strand (Driven Plumb or 1" Batter)	$135		
18" w/CFRP or Stainless Steel Strand (Driven Battered)	$160		
24" w/CFRP or Stainless Steel Strand (Driven Plumb or 1" Batter)	$150		
24" w/CFRP or Stainless Steel Strand (Driven Battered)	$210		
30" w/CFRP or Stainless Steel Strand (Driven Plumb or 1" Batter)	$225		
30" w/CFRP or Stainless Steel Strand (Driven Battered)	$280		
Heavy mild steel reinforcing in pile head (each)[2]	$250		
		Subtotal	$63,000

[1] When silica fume, metakaolin or ultrafine fly ash is used add $6/LF to the piling cost.

[2] When heavy mild steel reinforcing is used in the pile head, add $250.

2. Steel Piling, (furnished and installed)			
Size of Piling	**Cost per Lin. Foot**	**Quantity**	**Cost**
14 x 73 H Section	$90		
14 x 89 H Section	$100		
18" Pipe Pile	$100		
20" Pipe Pile	$125		
24" Pipe Pile	$145		
30" Pipe Pile	$200		
		Subtotal	

3. Drilled Shaft (not including Excavation)			
Dia. (On land with casing salvaged)	**Cost per Lin. Foot**	**Quantity**	**Cost**
3.5 ft	$500		
4 ft	$550		
5 ft	$600		
6 ft	$680		
7 ft	$825		
8 ft	$1,550		
9 ft	$1,800		
Dia. (In water with casing salvaged)	**Cost per Lin. Foot**	**Quantity**	**Cost**
3.5 ft	$550		
4 ft	$625		
5 ft	$700		
6 ft	$825		
7 ft	$950		
8 ft	$1,650		
9 ft	$1,900		
Dia. (In water with permanent casing)	**Cost per Lin. Foot**	**Quantity**	**Cost**
3.5 ft	$700		
4 ft	$750		
5 ft	$850		
6 ft	$990		
7 ft	$1,250		
8 ft	$2,200		
9 ft	$2,400		
		Subtotal	

A. Bridge Substructure (continued)

4. Drilled Shaft Excavation

Dia.	Cost per Lin. Foot	Quantity	Cost
3.5 ft	**$250**		
4 ft	**$280**		
5 ft	**$300**		
6 ft	**$340**		
7 ft	**$420**		
8 ft	**$780**		
9 ft	**$900**		
		Subtotal	

5. Cofferdam Footing (Cofferdam and Seal Concrete[1])

Prorate the cost provided herein based on area and depth of water. A cofferdam footing having the following attributes cost $600,000: Area 63 ft x 37.25 ft; Depth of seal 5 ft; Depth of water over footing 16 ft

Type	Cost per Footing	Quantity	Cost
Cofferdam Footing			
		Subtotal	

[1] Cost of seal concrete included in pay item 400-3-20 or 400-4-200.

6. Substructure Concrete

Type	Cost per Cubic Yard	Quantity	Cost
Concrete [1]	**$950**	**29.4**	**$27,930**
Mass Concrete [1]	**$625**		
Seal Concrete [1]	**$650**		
Bulkhead Concrete [1]	**$1,000**		
Shell Fill [1]	**$30**		
		Subtotal	$27,930

[1] Admixtures: For Calcium Nitrite add $40/cy (@4.5 gal/cy) and for highly reactive pozzolans add $40/cy (@ 60 lb./cy)

7. Substructure Reinforcing and Post-tensioning Steel

Type	Cost per Pound	Quantity	Cost
Carbon Reinforcing Steel	**$1.00**	**3969**	**$3,969**
Low-Carbon Chromium Reinforcing Steel	**$1.25**		
Stainless Reinforcing Steel	**$4.00**		
Post-tensioning Steel, Strand - Grout Filler	**$8.00**		
Post-tensioning Steel, Bar - Grout Filler	**$10.00**		
Post-tensioning Steel, Strand - Flexible Filler	**$24.00**		
Post-tensioning Steel, Bar - Flexible Filler	**$30.00**		
		Subtotal	**$3,969**

Substructure Subtotal **$94,899**

B. Walls

1. Retaining Walls			
MSE Walls	**Cost per Sq. Foot**	**Quantity**	**Cost**
Permanent	**$30**		
Temporary	**$15**		
Sheet Pile Walls, Prestressed Concrete	**Cost per Lin. Foot**	**Quantity**	**Cost**
10" x 30"	**$150**		
12" x 30"	**$185**		
12" x 30" with FRP	**$265**		
Sheet Pile Walls, Steel	**Cost per Sq. Foot**	**Quantity**	**Cost**
Permanent Cantilever Wall	**$30**		
Permanent Anchored Wall [1]	**$55**		
Temporary Cantilever Wall	**$16**		
Temporary Anchored Wall [1]	**$35**		
Soil Nail Wall with Permanent Facing	**Cost per Sq. Foot**	**Quantity**	**Cost**
Soil Nail Wall with Permanent Facing	**$110**		
Traffic Railings with Junction Slabs	**Cost per Lin. Foot**	**Quantity**	**Cost**
32" Vertical Face	**$260**		
42" Vertical Face	**$280**		
36" Single-Slope	**$255**		
42" Single-Slope	**$275**		
		Subtotal	

[1] Includes the cost of anchors, waler steel, miscellaneous steel for permanent/temporary walls and concrete face for permanent walls.

2. Noise Wall			
Type	**Cost per Sq. Foot**	**Quantity**	**Cost**
Noise Wall	**$30**		
		Subtotal	

Walls Subtotal

C. Box Culverts

1. Box Culverts			
Concrete	**Cost per Cubic Yard**	**Quantity**	**Cost**
Class II Concrete	**$950**		
Class IV Concrete	**$990**		
Reinforcing Steel	**Cost per Pound**	**Quantity**	**Cost**
Carbon Reinforcing Steel	**$1.00**		
		Subtotal	

	Box Culvert Subtotal	

D. Bridge Superstructure

1. Bearing Type			
Neoprene Bearing Pads	**Cost per Cubic Foot**	**Quantity**	**Cost**
Neoprene Bearing Pads	**$1,000**	**1.6**	**$1,600**
Multirotational Bearings (Capacity in kips)	**Cost per Each**	**Quantity**	**Cost**
1- 250	**$6,000**		
251- 500	**$8,000**		
501- 750	**$8,750**		
751-1000	**$9,500**		
1001-1250	**$10,000**		
1251-1500	**$11,000**		
1501-1750	**$13,000**		
1751-2000	**$15,000**		
>2000	**$17,000**		
		Subtotal	$1,600

2. Bridge Girders			
Structural Steel (includes coating costs)	**Cost per Pound**	**Quantity**	**Cost**
Plate Girders, Straight [1]	**$1.65**		
Plate Girders, Curved [1]	**$1.95**		
Box Girders, Straight [1]	**$1.95**		
Box Girders, Curved [1]	**$2.15**		

[1] When weathering steel (uncoated) is used, reduce the price by $0.04 per pound.
Inorganic zinc coating systems have an expected life cycle of 20 years.

Prestressed Concrete Girders and Slabs	**Cost per Lin. Foot**	**Quantity**	**Cost**
Florida U-Beam; 48" [1]	**$750**		
Florida U-Beam; 54"	**$800**		
Florida U-Beam; 63"	**$850**		
Florida U-Beam; 72"	**$900**		
Florida Slab Beam 12" x 48" [2]	**$230**		
Florida Slab Beam 12" x 60" [2]	**$280**		
Florida Slab Beam 15" x 48" [2]	**$280**		
Florida Slab Beam 15" x 60" [2]	**$370**		
Florida Slab Beam 18" x 48" [2]	**$340**		
Florida Slab Beam 18" x 60" [2]	**$440**		
AASHTO Type II Beam	**$190**		
Florida-I Beam; 36	**$240**	**159**	**$38,160**
Florida-I Beam; 45	**$260**		
Florida-I Beam; 54	**$280**		
Florida-I Beam; 63	**$300**		
Florida-I Beam; 72	**$320**		
Florida-I Beam; 78	**$330**		
Florida-I Beam; 84	**$340**		
Florida-I Beam; 96	**$370**		
		Subtotal	**$38,160**

[1] Price is based on ability to furnish products without any conversions of casting beds and without purchasing of forms. If these conditions do not exist, add the following cost: $450,000

[2] Interpolate between given prices for intermediate width FSBs.

D. Bridge Superstructure (continued)

3. Cast-in-Place Superstructure Concrete			
Type	**Cost per Cubic Yard**	**Quantity**	**Cost**
Box Girder Concrete, Straight	$950		
Box Girder Concrete, Curved	$1,200		
Deck Concrete Class II	$750		
Deck Concrete Class IV	$1,200	27.2	$32,640
Precast Deck Overlay Concrete Class IV	$1,000		
Topping Concrete for slab beams and units[1]	$800		
[1] Including cost of shrinkage reducing admixture.		Subtotal	$32,640

4. Concrete for Precast Segmental Box Girders, Cantilever Construction			
Concrete Cost by Deck Area	**Cost per Cubic Yard**	**Quantity**	**Cost**
≤ 300,000 SF	$1,250		
> 300,000 SF AND ≤ 500,000 SF	$1,200		
> 500,000 SF	$1,150		
		Subtotal	

5. Reinforcing and Post-Tensioning Steel			
Type	**Cost per Pound**	**Quantity**	**Cost**
Carbon Reinforcing Steel	$1.05	5576	$5,855
Low-Carbon Chromium Reinforcing Steel	$1.30		
Stainless Reinforcing Steel	$4.05		
Post-tensioning Steel, Strand; longitudinal - Grout Filler	$8.00		
Post-tensioning Steel, Strand; transverse - Grout Filler	$10.00		
Post-tensioning Steel, Bar - Grout Filler	$10.00		
Post-tensioning Steel, Strand; longitudinal - Flexible Filler	$24.00		
Post-tensioning Steel, Bars - Flexible Filler	$30.00		
		Subtotal	$5,855

6. Railings and Barriers			
Traffic Railings [1]	**Cost per Lin. Foot**	**Quantity**	**Cost**
32" Vertical Face	$90		
42" Vertical Face	$100		
36" Single-Slope Median	$100		
36" Single-Slope	$110		
42" Single-Slope	$140		
Thrie Beam Retrofit	$180		
Thrie Beam Panel Retrofit	$110		
Vertical Face Retrofit	$125		
Rectangular Tube Retrofit	$100		
Pedestrian/Bicycle Railings:	**Cost per Lin. Foot**	**Quantity**	**Cost**
Concrete Parapet (27") [1]	$65	152	$9,880
Single Bullet Railing [1]	$40		
Double Bullet Railing [1]	$50		
Panel/Picket Railing (42") steel (Type 1 & 2)	$95		
Panel/Picket Railing (42") steel (Type 3-5)	$130		
Panel/Picket Railing (42") aluminum (Type 1 & 2)	$70		
Panel/Picket Railing (42") aluminum (Type 3-5)	$105		
Panel/Picket Railing (48") steel (Type 1 & 2)	$115		
Panel/Picket Railing (48") steel (Type 3-5)	$145		
Panel/Picket Railing (48") aluminum (Type 1 & 2)	$85		
Panel/Picket Railing (48") aluminum (Type 3-5)	$120		
[1] Combine cost of Bullet Railings with Concrete Parapet or Traffic Railing, as appropriate.		Subtotal	$9,880

7. Expansion Joints			
Type	**Cost per Lin. Foot**	**Quantity**	**Cost**
Poured Joint With Backer Rod	$45	24	$1,080
Strip Seal	$250		
Finger Joint <6"	$850		
Finger Joint >6"	$1,500		
Modular 6"	$500		
Modular 8"	$700		
Modular 12"	$900		
		Subtotal	$1,080

Superstructure Subtotal	**$89,215**

E. Miscellaneous Items

1. Bridge Deck Grooving and Planing

Type	Cost per Sq. Yard	Quantity	Cost
Bridge Deck Planing	$6.00		
Bridge Deck Grooving for Short Bridge	$8.00		
Bridge Deck Grooving for Long Bridge	$5.00		
	Grooving and Planing Subtotal		

2. Detour Bridges

Type	Cost per Sq. Foot	Quantity	Cost
Acrow Detour Bridge [1]	$55		
	Detour Bridge Subtotal		

[1] Using FDOT supplied components. The cost is for the bridge proper (measured out-to-out) and does not include approach work, surfacing, or guardrail.

3. Approach Slab

Approach Slab Material	Cost per Unit	Quantity	Cost
Cast-in-Place Concrete (per Sq. Yard)	$400		
Reinforcing Steel (per Pound)	$1.05		
36" Single-Slope	110		
	Approach Slab Subtotal		

Unadjusted Total **$184,114**

Step Two: Estimate Conditional Variables and Cost per Square Foot

After developing the total cost estimate utilizing the unit cost, modify the cost to account for site condition variables. If appropriate, the cost will be modified by the following variables:

** Phased construction is defined as construction over traffic or construction requiring multiple phases to complete the construction of the entire cross section of the bridge. The 20 percent premium is applied to the effected units of the superstructure and/or substructure.

Conditional Variables	% Increase/ Decrease	Cost (+/-)
For construction over open water, floodplains that flood frequently or other similar areas, increase cost by 3 %.		
For construction over traffic and/or phased construction, increase by 20 %. [1]		

[1] Phased construction is defined as construction requiring multiple phases to complete the construction of the entire cross section of the bridge. The 20 percent premium is applied to the affected units of the superstructure and/or substructure.

Substructure Subtotal	**$94,899**
Superstructure Subtotal	**$89,215**
Walls Subtotal	
Box Culverts Subtotal	
Grooving and Planing Subtotal	
Detour Bridge Subtotal	
Approach Slab Subtotal	
Conditional Variables	
Total Cost	**$184,114**
Total Square Feet of Deck	**960.0**
Cost per Square Foot (not including Approach Slab)	**$192**

Design Aid for Determination of Reinforcing Steel

In the absence of better information, use the following quantities of reinforcing steel pounds per cubic yard of concrete.

Location	Pounds of Steel per Cubic Yard	Cubic Yds.	Tot. Pounds
Pile Abutments	**135**		
Pile Bents	**145**		
Single Column Piers >25'	**210**		
Single Column Piers <25'	**150**		
Multiple Column Piers >25'	**215**		
Multiple Column Piers <25'	**195**		
Bascule Piers	**110**		
Standard Deck Slabs	**205**		
Isotropic Deck Slabs	**125**		
Concrete Box Girders, Pier Seg	**225**		
Concrete Box Girders, Typ. Seg	**165**		
C.I.P. Flat Slabs @ 30ft & 15" Deep	**220**		
Approach Slab	**200**		

Step Three: Cost Estimate Comparison to Historical Bridge Cost

The final step is a comparison of the cost estimate by comparison with historic bridge cost based on a cost per square foot. These total cost numbers are calculated exclusively for the bridge cost as defined in the General Section of this chapter. Price computed by Steps 1 and 2 should be generally within the range of cost as supplied herein. If the cost falls outside the provided range, good justification must be provided.

Bridge Superstructure Type	Total Cost per Square Foot Low	High
Short Span Bridges:		
Reinforced Concrete Flat Slab- Simple Span [1]	$115	$160
Pre-cast Concrete Slab - Simple Span [1]	$110	$200
Medium Span Bridges:		
Concrete Deck / Steel Girder - Simple Span [1]	$125	$142
Concrete Deck / Steel Girder - Continuous Span [1]	$135	$170
Concrete Deck / Prestressed Girder - Simple Span [1]	$90	$145
Concrete Deck / Prestressed Girder - Continuous Span [1]	$95	$211
Concrete Deck / Steel Box Girder [1] -	$140	$180
Span range from 150' to 280' (for curvature, add 15% premium)		
Segmental Concrete Box Girders - Cantilever Construction	$140	$160
Span range from 150' to 280'		
Movable Bridge - Bascule Spans & Piers	$1,800	$2,000
Demolition Costs:		
Typical	$35	$60
Bascule	$60	$70
Project Type		
Widening (Construction Only)	$85	$160

[1] Increase the cost by twenty percent for phased construction

Estimated Cost per Square Foot **$192**

Barron Canal Alternative 2

WILDLIFE CROSSING – HORIZONTALLY PLACED PILES

SR 29 WILDLIFE CROSSING ANALYSIS

KISINGER CAMPO & ASSOCIATES

Districtwide Environmental Permits Design Support — DESIGNED BY: SKB 09/21
Task Work Order No. 10 — CHECKED BY:
SR 29 Wildlife Crossing Analysis

Foundation Quantities

Barron Canal Alternative 2

0455 34 6 PRESTRESSED CONCRETE PILING, 30" SQ

Location	No. Piles	Pile Length *(ft.)*		Total Length *(ft.)*
Bridge	2	79.00		158.00

PAY ITEM TOTAL 158 LF

0530 1100 RIPRAP, SAND-CEMENT BAGS

Location	Sand Cement Height	Bedding Stone Height	Trench	Sand Cement Width	Total Length	Volume
	(ft.)	*(ft.)*	*(ft.)*	*(ft.)*	*(ft.)*	*(CY)*
END BENT 1	2.50	1.00	1.00	1.00	18.59	2.75
END BENT 2	2.50	1.00	1.00	1.00	18.59	2.75

PAY ITEM TOTAL 5.5 CY

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Foundation Quantities

Barron Canal Alternative 2

0530 3 3 RIPRAP- RUBBLE, BANK AND SHORE

Rip-Rap Properties				
Specific Gravity	Water Weight *(PCF)*	Void Factor	'T' *(ft.)*	Rip-Rap Weight *(PSF)*
2.30	62.40	0.90	2.50	322.92

Location	Plan Area of Riprap *(SF)*	Weight of riprap *(PSF)*	Weight *(Ton)*
END BENT 1	745.06	322.92	117.90
END BENT 2	745.06	322.92	117.90

PAY ITEM TOTAL 235.8 TN

0530 74 BEDDING STONE

Location	Plan Area of Bedding Stone *(SF)*	Unit Weight of bedding stone *(PCF)*	Thickness *(ft.)*	Weight *(Ton)*
END BENT 1	726.47	115.00	1.00	41.77
END BENT 2	726.47	115.00	1.00	41.77

PAY ITEM TOTAL 83.5 TN

KISINGER CAMPO & ASSOCIATES

Districtwide Environmental Permits Design Support
Task Work Order No. 10
SR 29 Wildlife Crossing Analysis

DESIGNED BY: SKB 09/21
CHECKED BY:

Substructure Quantities

Barron Canal Alternative 2

0400 4 5 CONCRETE CLASS IV, BRIDGE SUBSTRUCTURE

END BENTS 1 & 2					
Location	Length *(ft.)*	Width *(ft.)*	Height *(ft.)*	Quantity	Volume *(CY)*
Cap	7.00	3.00	4.50	1	3.50
Pile Volume	-5.00	2.50	2.50	1	-1.16
				TOTAL	2.4

Applicable Equation: Volume = Quantity x (Length x Width x Height) / (27 ft^3/CY)
Reduction for pile embedment conservatively excluded.

SUMMARY	
Location	Volume *(CY)*
END BENT 1	2.4
END BENT 2	2.4

PAY ITEM TOTAL 4.8 CY

0415 1 5 REINFORCING STEEL - BRIDGE SUBSTRUCTURE

Location	Volume Concrete *(CY)*	BDR Estimate Value *(lb./CY)*	Weight *(lb.)*
END BENT 1	2.40	135	324
END BENT 2	2.40	135	324

PAY ITEM TOTAL 648 LB

Appendix E

SR 29 from Oil Well Road to I-75 PD&E

Draft Wildlife Connectivity Analysis

SR29 PD&E Oil Well Road to Interstate 75

Wildlife Connectivity Assessment and Recommendations (Draft 8/19-26, 11/26-7 and 12/11-12 - 2019)

Introduction/Background

The current segment of SR 29 from Oil Well Road (CR 858) to Interstate 75 (I75) negatively impacts habitat connectivity, wildlife mortality rate and highway safety. Significant impediments to wildlife movement include high speed traffic, the paved road itself, the "cleared" high-tension transmission line corridor adjacent to the west side of the roadway, and the Barron Collier Canal that runs the length of the project area along the east side of the roadway. These three linear features (the road, power lines, and canal) also act as a boundary that separates Florida Panther National Wildlife Refuge (FPNWR) and Big Cypress National Preserve (BCNP).

Traffic at high speeds, particularly with low driver visibility on rural roads at night creates a significant risk for collisions with wildlife. Collisions with large species like Florida black bears and panthers present significant concern for highway safety and population persistence. The pavement itself impedes slow moving species (e.g., turtles, snakes, alligators) increasing their risk for traffic-related mortality and safety risk for drivers that attempt to avoid striking these species when present on the pavement. The open right-of-way and powerline corridor expose smaller prey species that occur in adjacent forested habitats to increased predation. The canal significantly alters natural surface water flows in the area and acts as a significant barrier to east-west movement for many species.

For this assessment, the project area was divided into North and South sections (fig. 1). The north section is bordered by private lands, while the south section is bordered by Federally protected conservation lands. While the north section presently does not have any wildlife crossings or wildlife fencing, the south section has four wildlife crossings and continuous 10' high chain-link wildlife fencing.

North Section (Private Lands/ECPO HCP Area)

<u>Study site parameters</u>

The north section extends from CR 858 to the northern boundary of the FPNWR and BCNP, a length of 3.5 mi. Private lands occur on either side of the road. Land use/land cover generally consists of agricultural and mining lands, forested and unforested wetlands, and pine flatwoods. There are a few residential and agricultural related structures with 12 driveways/access roads.

<u>Data analysis</u>

The north section is within the NE Collier Rural Lands Stewardship Area and is being reviewed by the US Fish and Wildlife Service (FWS) for a Habitat Conservation Plan. The proposed designations under this plan in the SR 29 study area are shown in fig. 2. The upper 2/3 of North section of SR 29 is bordered on at least one side by proposed development areas. The lower 1/3 of the North section has contiguous (proposed) preservation areas and is the most suitable area for potential movement across SR 29 by panthers and other wildlife species.

To enhance this habitat connection and to provide more significant buffers between developed areas and conservation areas we recommend exchanging a node of very low density development (A) that increases fragmentation and negative edge effects with another area to the north (B) that is surrounded on three sides by proposed developed areas (fig. 3). This switch of proposed land use would benefit panthers through use of higher quality habitat and less exposure to development edges and conflict potential and keep development more compact and reduce potential human-wildlife conflicts. These areas are of similar size and under the same ownership. This also enhances opportunities for wildlife crossing structures on SR 29, by providing more alternative locations that match current data for panthers and bears.

Florida panther and black bear roadkill data are shown in figs. 2 and 3. Vehicle collisions with Florida panthers in the north section range from 1980 to 2018 (n=12). All but two of these are located from the Vulcan Mine Road south to the FPNWR/BCNP boundary. Black bear roadkills ranged from 1997 to 2014 (n=6). Like the panther roadkills all but one black bear was found near Vulcan Mine Road and further south. We've identified 4 significant clusters of roadkill data (fig. 4) that can be used in selecting potential locations for wildlife crossing structures. Interestingly, all four of these clusters coincide with access roads or trails that abut SR 29 and are likely travel routes for panthers (figs. 4 and 5). The cluster at Vulcan Mine Road is probably a result of the bridge over the Collier Canal that provides a dry crossing for panthers.

Land cover surrounding these roadkill clusters is shown in fig. 6. Roadkill cluster A exhibits high ground with low density residential to the west and mesic flatwoods to the east. Roadkill cluster B is primarily bounded on both sides of SR 29 by mixed wetland hardwoods. Roadkill clusters C and D are adjacent to mixed wetland hardwoods and mixed hardwood/coniferous swamps. These habitat types (excepting low density residential) are all highly preferred by panthers (USFWS 2012). Dates of roadkills in each cluster are shown below:

Cluster	Species	Sex	Age	Year
A	panther	male	adult	2001
A	panther	female	adult	2003
A	panther	female	unk	2016
A	panther	male	adult	2018
A	bear	female	juv	1997
B	panther	male	adult	1987
B	panther	female	juv	1992
B	panther	female	adult	1994
B	bear	male	juv	2004
C	panther	unk	unk	2006
C	bear	male	juv	2007
D	panther	male	adult	2000
D	panther	male	adult	2002
D	bear	female	cub	2000
D	bear	male	adult	2008

Data on general roadkill trends for all other vertebrates was also available from two previous studies (Smith et al. 2006, Spicer 2017). Spicer (2017) found nominal levels of roadkills (amphibians, reptiles, mammals and birds) of 0.15-0.2/day/km for the area between Vulcan Mine Road and the boundary of FPNWR/BCNP during 40 consecutive days of monitoring (by vehicle) from June-August of 2016. Smith et al. (2006) found a roadkill frequency distribution per km of 0.2 – 0.25 for all taxa from monitoring (driving) 3 days per week from 12/05 to 5/06. Notable species were American alligator, common snapping turtle, wading birds and scavenging raptors. Both studies likely underestimate levels of road-kills (in particular, amphibians) because of limitations in sampling frequency, time of day, study duration and weather. Scavenging and vehicle traffic are cited as causes for removal of carcasses prior to recording.

The only existing structures in the north section are five pipe culverts ranging in size from 12 in to 48 in (fig. 3). The two culverts south of Vulcan Mine Road may provide supplemental connectivity for smaller species of wetland dependent species. The one closest to Vulcan mine Road is a 48 in x 72 in oval concrete pipe, while the most southern culvert is a 30 in round pipe.

<u>Recommendations</u>

Two alternatives are provided as a result of this analysis. Alternative one is more viable when exercised in combination with the proposed HCP land exchange described previously and shown in fig. 3. Alternative two would be preferred if circumstances associated with the HCP land exchange was not an option.

Alternative one –

In this alternative we would recommend two wildlife crossing structures designed for Florida panther and other large wildlife. These structures would have clearance height and width of 6 ft x 16 ft, respectively. Recommended locations are C and D shown in figs. 4, 5 and 6. Although smaller structures than those existing on SR 29, they are still of sufficient size to accommodate the target species and this alternative provides greater, more enhanced habitat connectivity than in previous applications on SR 29 as the structures are approximately 0.5 km apart and 1 km from the current crossing structure at Pistol Pond. The other structures are multiple km apart. The lower profile should also reduce roadway construction costs.

Alternative two –

This alternative includes only one structure located at location D (see figs. 4, 5, and 6). In this case we would compensate by recommending a larger structure with a clearance height of 7 ft and width of 19 ft. This option would still provide greater habitat connectivity than current conditions due to a proximity of only 1 km from the Pistol Pond structure, which is a much shorter distance between structures than those south of Pistol Pond.

General considerations –

Even though the most recent panther roadkills have occurred at Vulcan Mine Road, we believe this is mostly due to convenience in that the existing bridge provides dry crossings over the canal. Provision of wildlife crossing structures with dry crossing shelves over the canal at the recommended location(s), with time for acclimation would redirect panthers to these safer crossing locations.

Given the uncertainty over the disposition of the Barron Collier Canal, we would recommend inclusion of dry shelves to be constructed over the canal, similar to the previous wildlife crossing structures north of I-75 on SR 29. Should the canal be reclaimed and the historic hydrology and flow patterns restored adjacent to SR 29, we would then recommend more standard approaches consisting of native local soils at grade with adjacent habitats. Design should include slight slopes to provide outward drainage from the structure to prevent pooling within.

Landscaping within the approaches should consist of native shrub and ground cover species for wildlife cover. Large animal wildlife fencing should be consistent in height with the current wildlife fencing on SR 29, though other more aesthetic materials should be considered. Consideration of herptile mesh or alternative materials that would prevent access to the road surface by these species is recommended.

The two existing culverts south of Vulcan Mine Road could provide seasonal passage by smaller terrestrial species in dry periods with minor modifications and directional fencing. However, these measures would be dependent on the reclamation of Barron Collier Canal and restoration of natural hydroperiods and flow patterns. In absence of the latter, we would not recommend any modifications to the existing culverts.

South Section (FL Panther NWR/Big Cypress NP)

<u>Study site parameters</u>

The south section extends from the north boundary of FPNWR/BCNP to I75, a length of 6.75 mi. Federally managed public conservation lands exists on both sides of the road. Land cover consists of a mosaic of native habitat types. There are 13 driveways/management access roads into FPNWR/BCNP and to private residences.

<u>Data analysis</u>

There are currently 4 wildlife crossing structures and 3 hydrologic bridges. The height and width of the wildlife crossings are 2 at 8 ft x 24 ft and 2 at 10 ft x 58 ft, respectively. The three hydrologic bridges were inspected in the field to assess their potential to serve as terrestrial wildlife crossings and were found to be low in clearance height (only 3-4 ft) relative to the water levels and therefore little to no dry shelves exist against the abutments. In addition, these three bridges are adjacent to open marsh areas, a habitat type unsuitable for more terrestrial-based species except in periods of drought or when water levels are minimal.

Only one adult male panther has been killed (2016) on the road since the wildlife crossings and fencing were constructed in the south section (fig. 7). This was likely due to a break in the fence or a gate left open. Seven black bears have been killed on the road within the fence enclosure between 2006 and 2017 (fig. 7). Intrusion into the fenced roadway could be as a result of fence-end runs, gates left open, breaks in the fence, and possibly climbing the fence. existing structures- wet and dry.

Spicer (2017) found one significant hotspot of roadkill within a 2 km section surrounding the second hydrologic bridge (fig. 1). The levels of combined roadkills (amphibians, reptiles, mammals and birds) ranged from 0.45-0.65/day/km. Given the brief duration of this study and the extent of wetlands adjacent to SR 29 in FPNWR/BCNP, numbers of aquatic turtles, snakes and amphibians killed on the road is likely much greater.

No small culverts were found in the south section of the project area.

Recommendations

While we do not recommend any new large wildlife crossing structures in the south section, we do recommend adding new culverts in the two extended sections within the current fence enclosure adjacent to FPNWR and BCNP (fig. 8). The two extended segments with no cross-drains or bridges are 1.55 mi and 1.85 mi each. We would recommend an approximate spacing of 0.25 mi which is similar to the spacing that would result from implementing Alternative One (new WC structures and existing culverts) for the north section. This equates to 4 culverts for segment A and 5 culverts for segment B (fig. 8). Keeping inline with the two existing culverts in the north section we would recommend installing concrete ellipticals (29 in rise/45 in span). This size would be suitable for movement by most aquatic turtles, snakes, amphibians and small alligators.

Adaptation of the existing hydrologic bridges or replacements is dependent on the eventual disposition of the Barron Collier Canal. If it is reclaimed and historic hydrology and flow patterns are restored, there would be an opportunity to adapt the existing bridges at least seasonal use by terrestrial-based species by installing shelves. Restoration of historic hydrology would also change the dynamics of the proposed culverts also, converting them to seasonal dry and wet passages.

Large animal wildlife fencing should be evaluated to identify trespass issues, particularly by bears. Consideration of herptile mesh or alternative materials that would prevent access to the road surface by these species is recommended, particularly in sections where herptile densities are high. Monitoring is recommended to determine where herptile mesh is most needed.

Contact:

Daniel J. Smith, Ph.D., A.I.C.P.,
Ecologist/Environmental Planner
2361 S Oak Park Dr
Deland, FL 32724
352-213-3833
djs.ursus@gmail.com

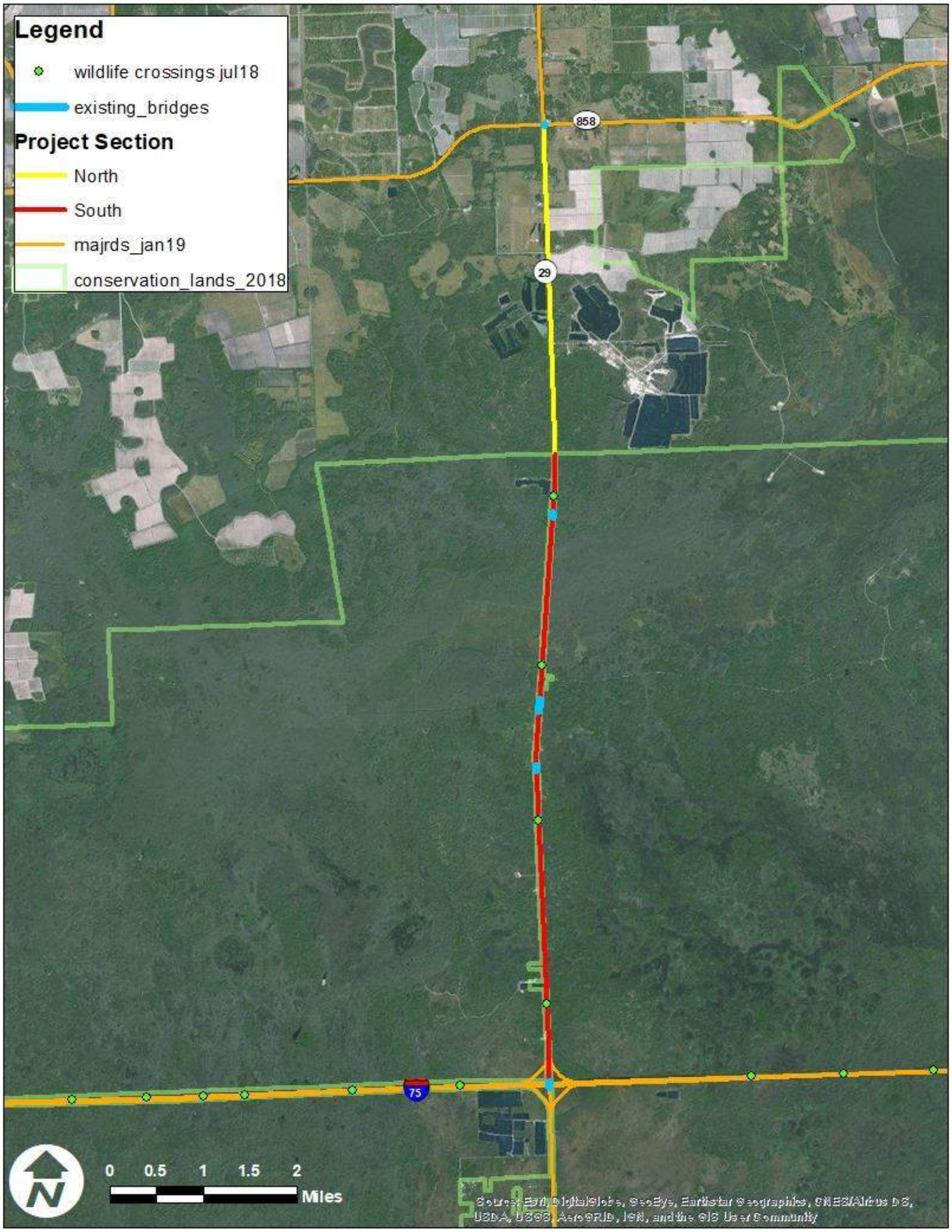

Figure 1. State Road 29 Study Area; subdivided into two sections for habitat connectivity assessment.

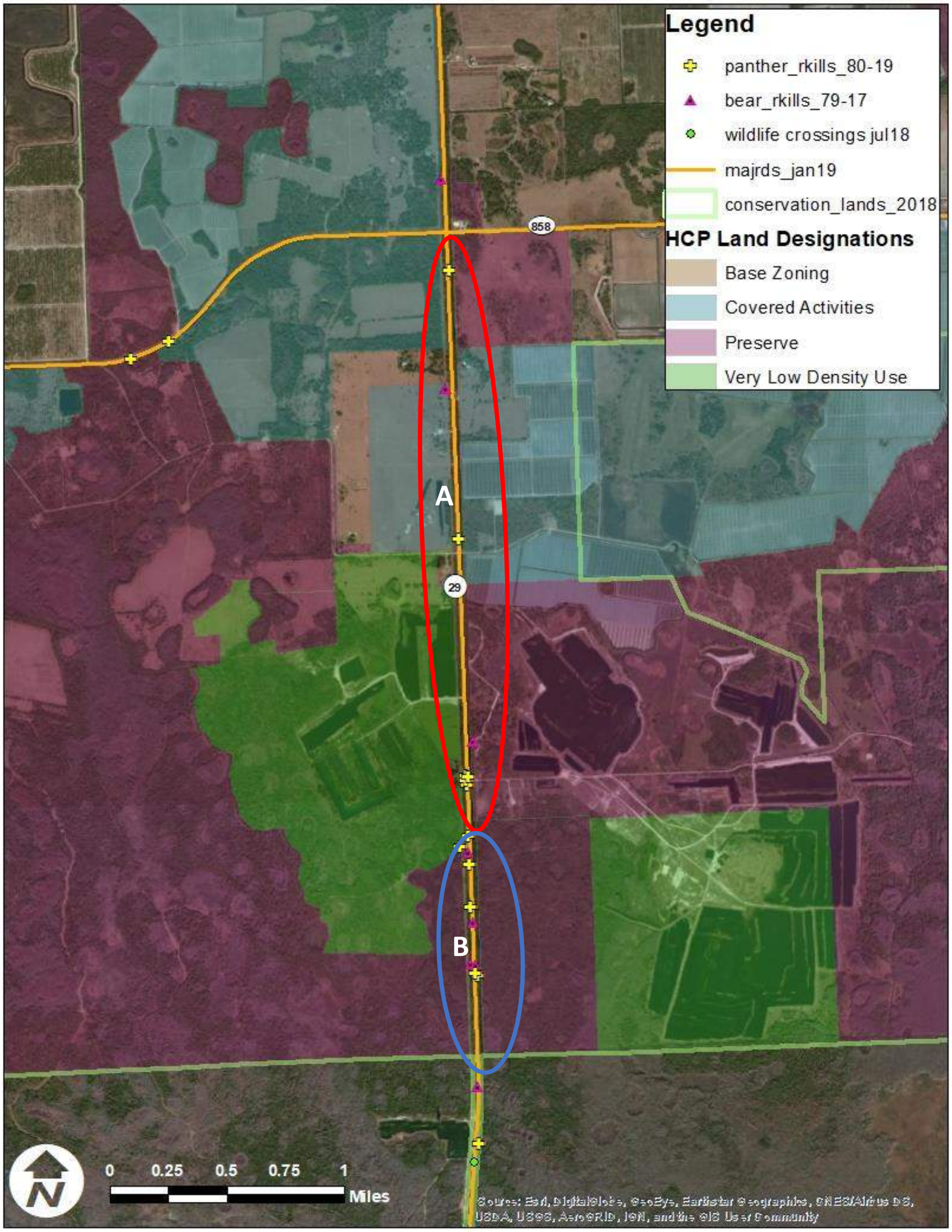

Figure 2. Habitat Conservation Plan designations for the North section of SR 29, including locations of Florida panther and black bear roadkills. Area A is primarily active agriculture and mining lands and is mostly designated in the HCP for development activities of varying densities on at least one side of SR 29. Area B is designated as preservation and represents the primary habitat connection across SR 29 within the HCP area.

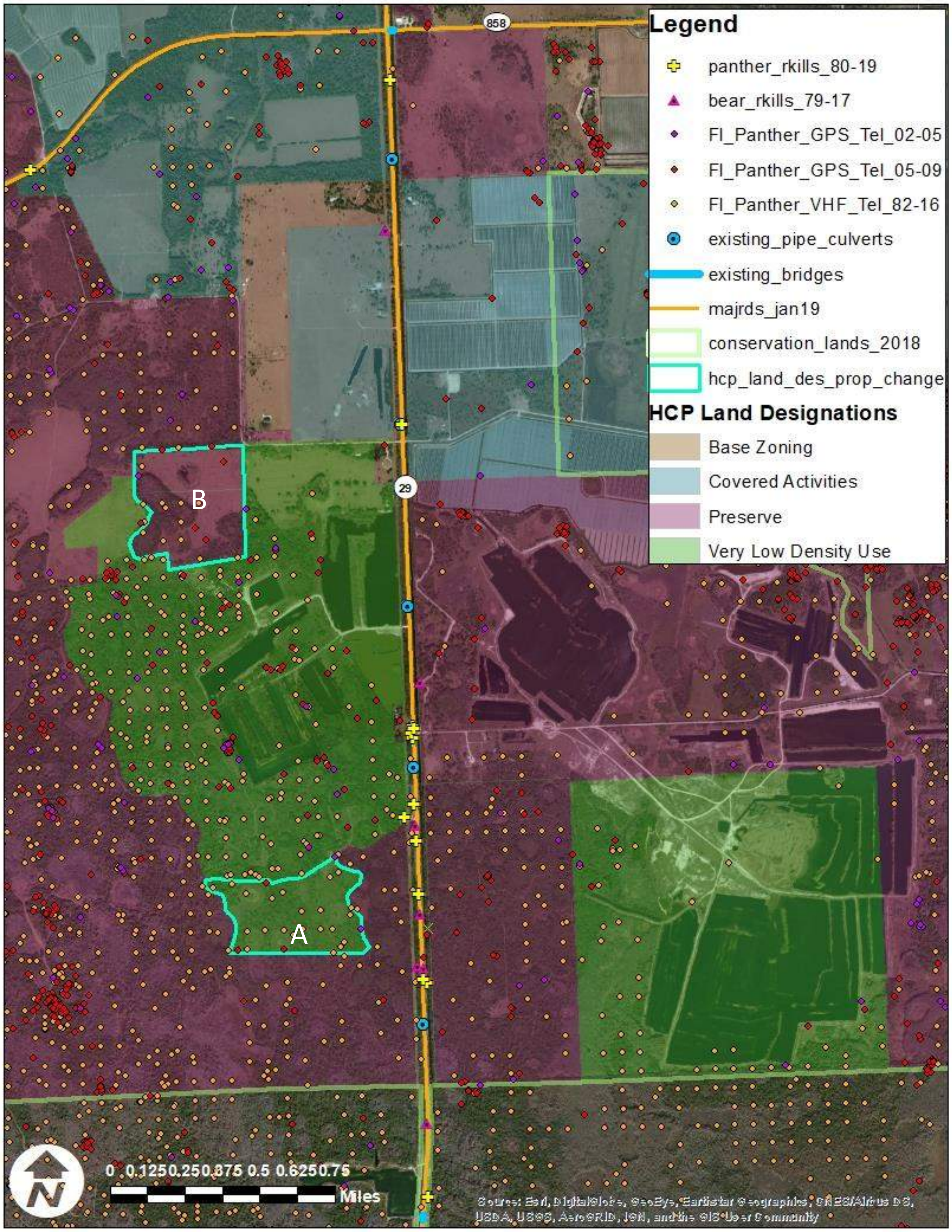

Figure 3. Proposed exchange of designated development area (A) with designated preservation area (B). These areas are of equal size and same land ownership. This proposal creates better functioning habitat connections across SR 29, with reduced negative edge effects and a much wider swath of habitat for planning wildlife crossing structure locations. This is also supported by and consistent with the majority of roadkill and telemetry locations of Florida panther.

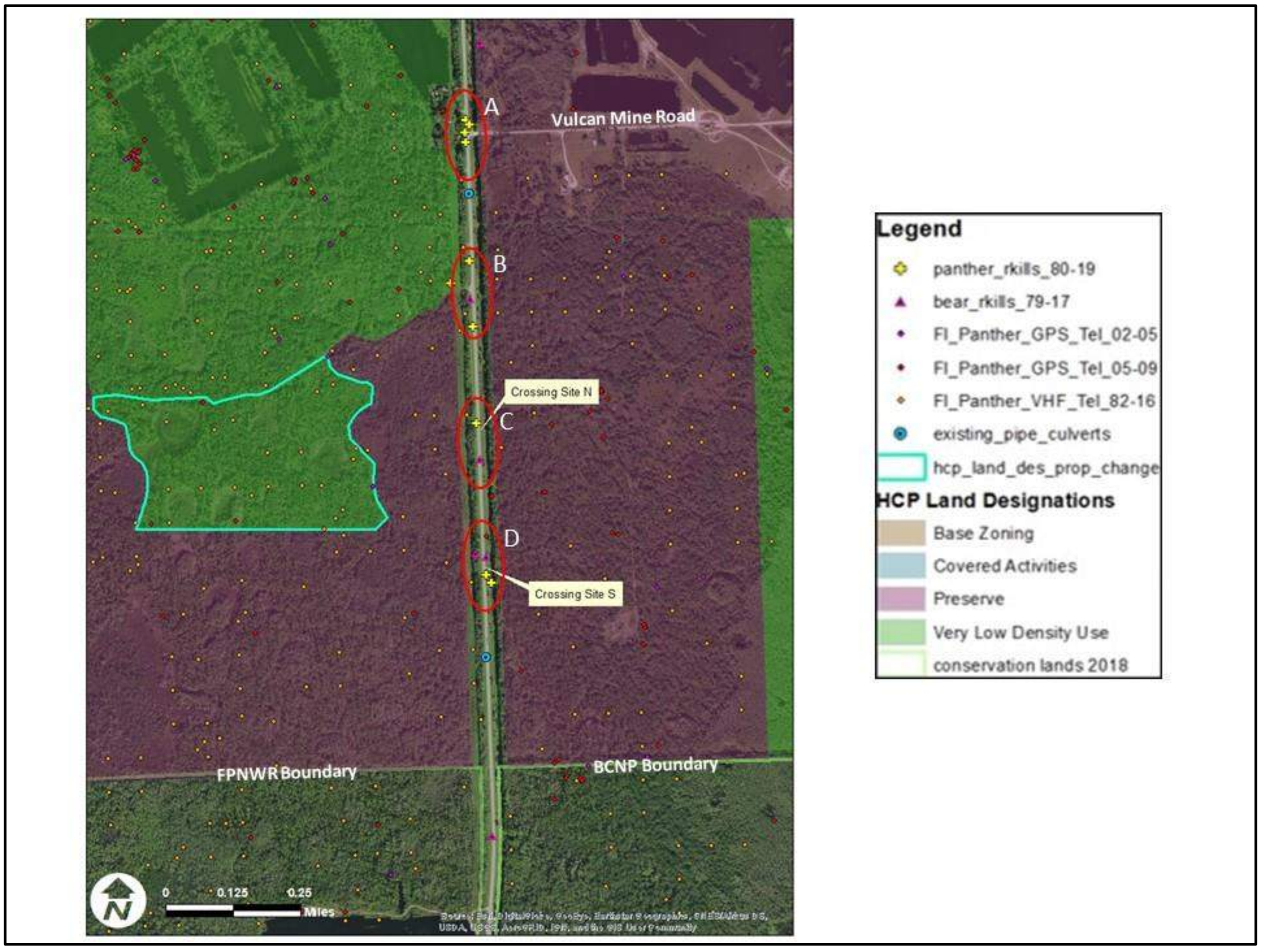

Figure 4. Four significant clusters of Florida panther/black bear roadkills and adjacent HCP designations. These occur from Vulcan Mine Road south to the FPNWR/BCNP boundary and are consistent with most telemetry locations near SR 29 in the North section of the study area. Labeled locations within clusters C and D represent areas of greatest potential for wildlife crossing structures and provide significant buffers/distance from development and access roads.

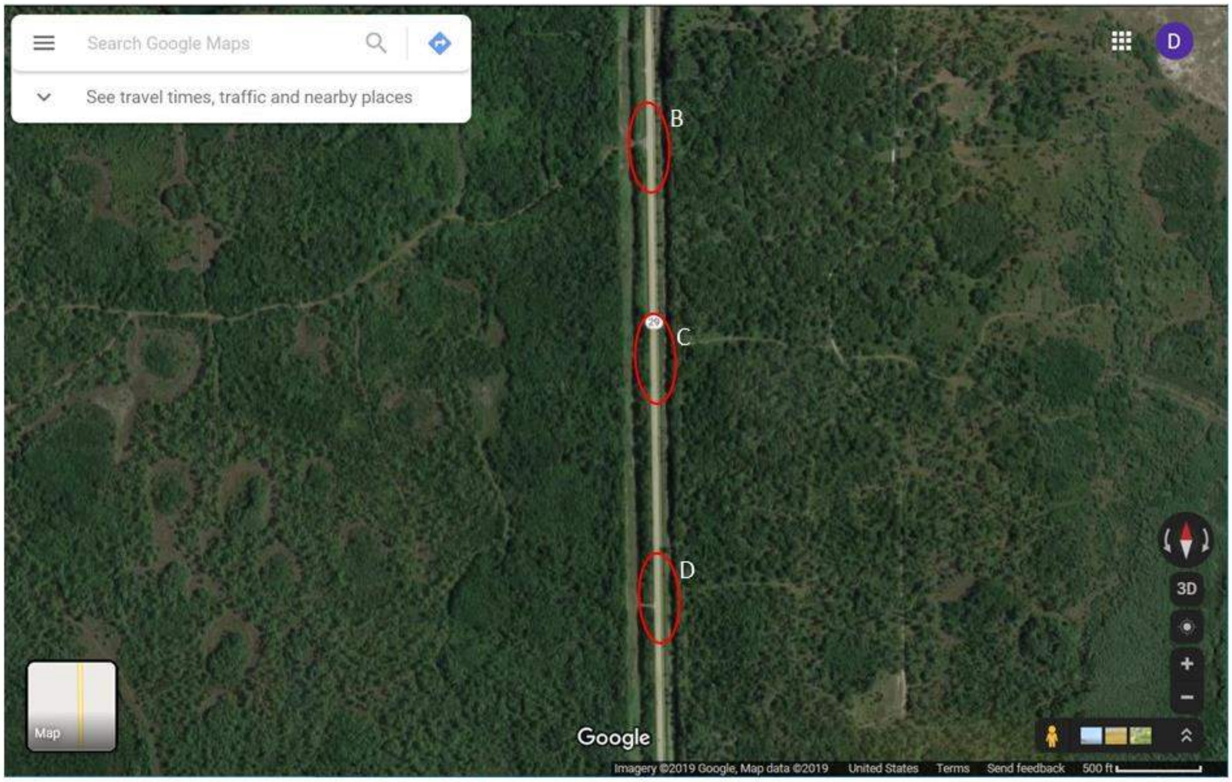

Figure 5. Aerial location of three roadkill clusters (B – D) within contiguous habitat preservation areas on both sides of SR 29 from the proposed HCP (also see fig. 4). Of significant note is that all three of these locations are coincide with trail roads abutting SR 29, likely used by panthers moving through these habitat areas.

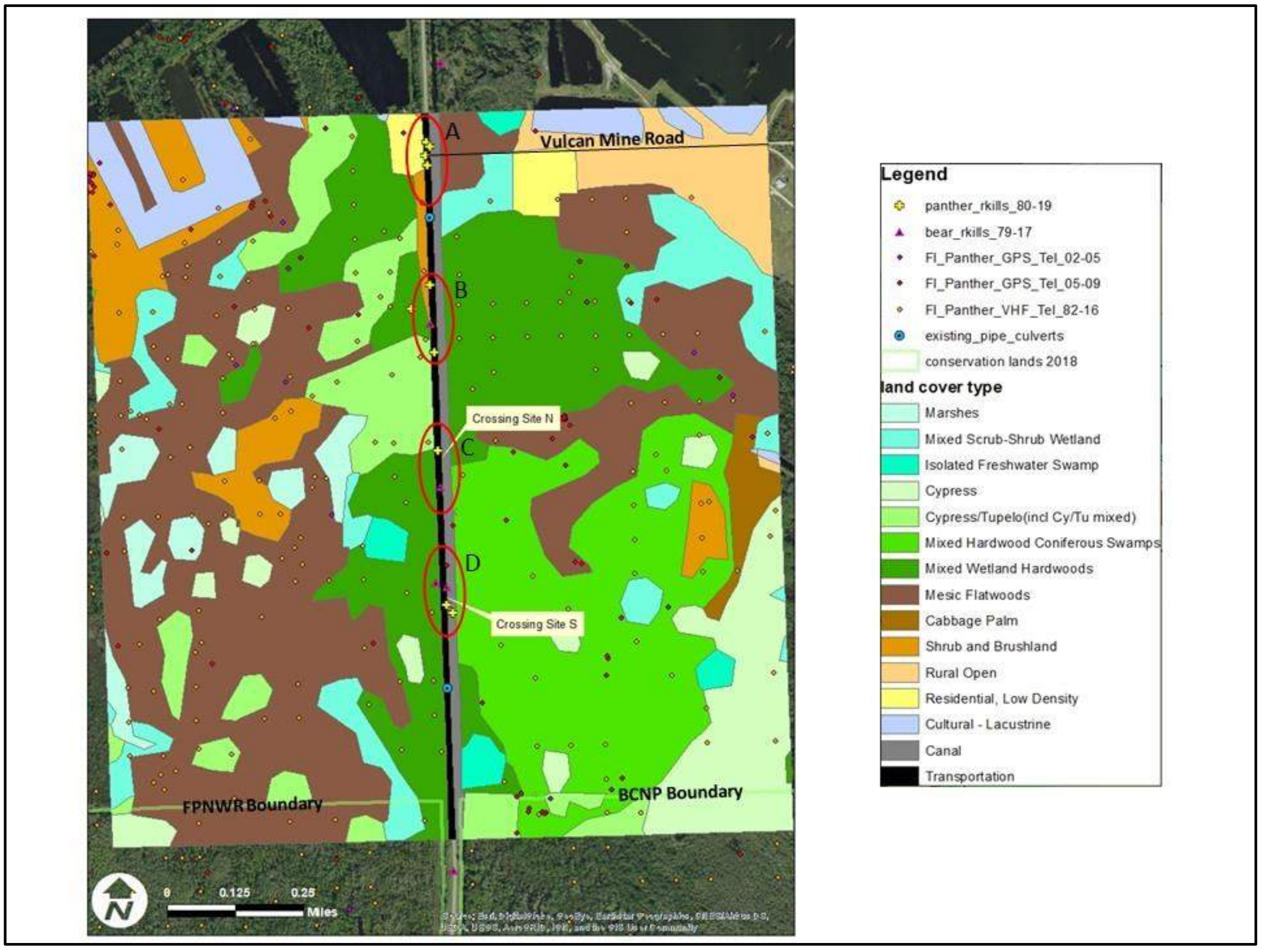

Figure 6. Four significant clusters of Florida panther/black bear roadkills and adjacent land cover (FWC 2018). Florida panther and black bear telemetry is also shown.

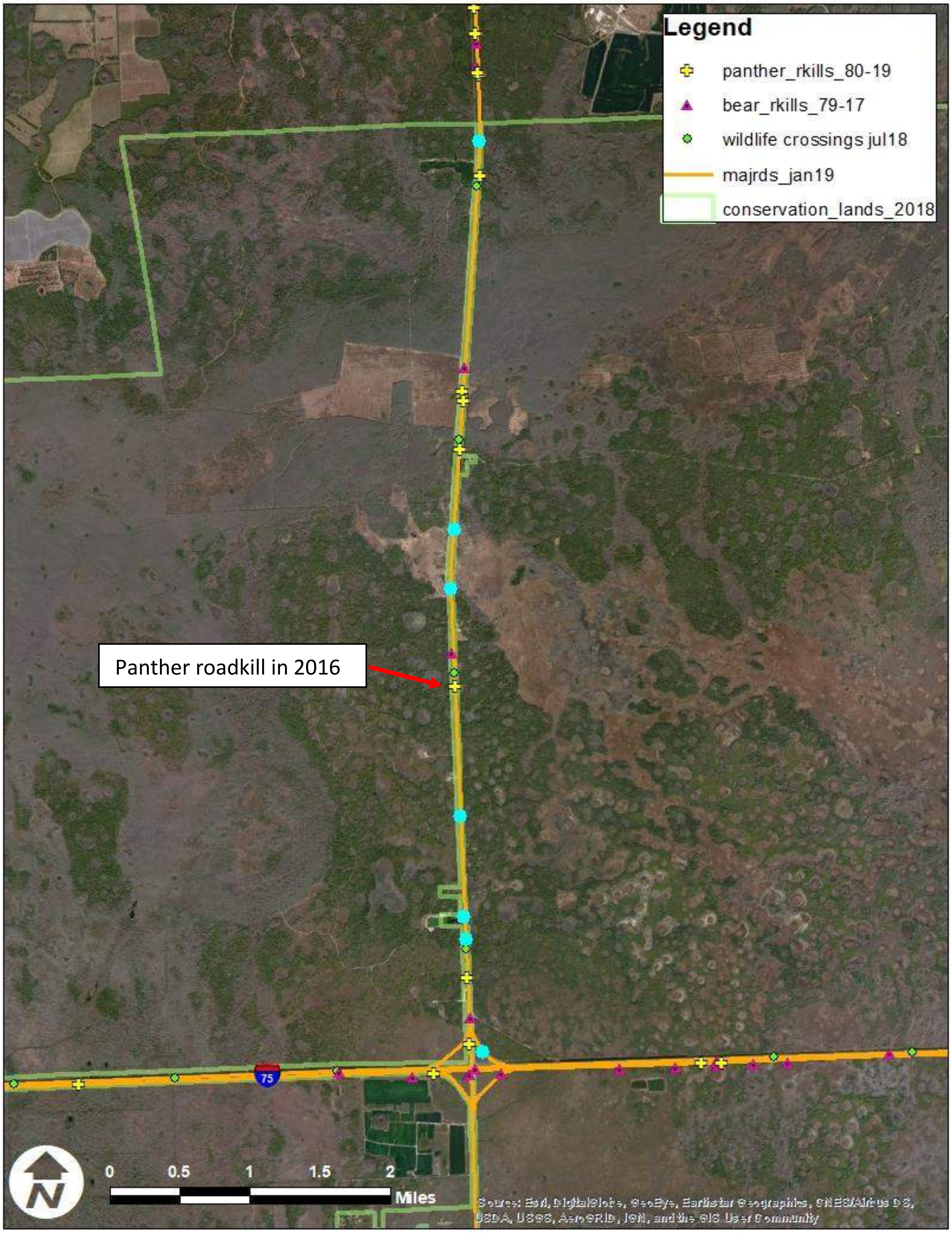

Figure 7. Road morality of Florida panther and blck bear since installation of wildlife fencing along SR 29 within the FPNWR/BCNP. One panther and seven black bears have been killed between 2006 and 2017 within the fenced roadway. Bear roadkills from 2006 – 2017 are shown as blue highlighted dots.

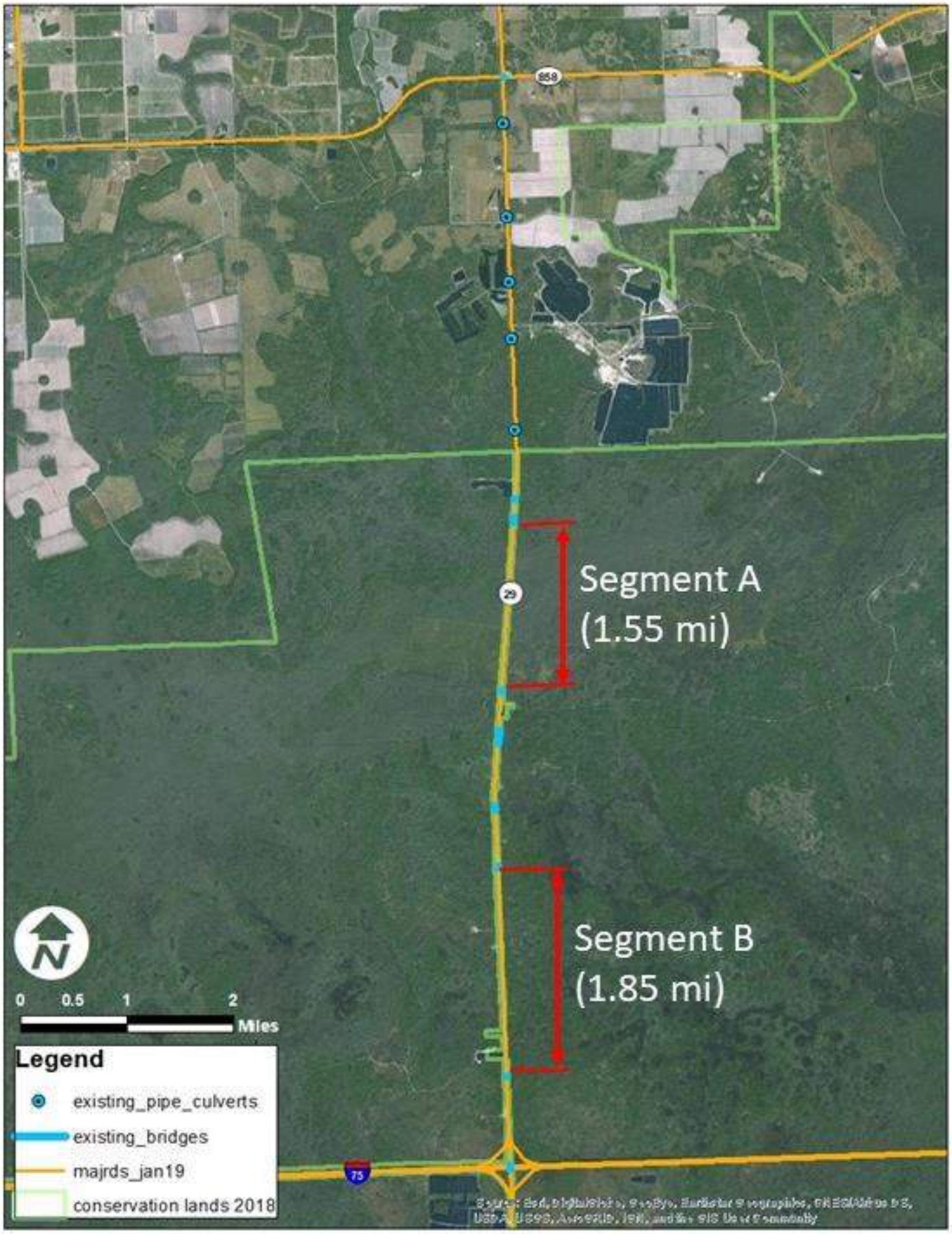

Figure 8. Extended gaps between wildlife crossing structures in the south section of the SR 29 project area. These segments should be considered for installation of smaller culvert crossings for wildlife.

4.4.4. Wildlife Crossing Analysis

A wildlife connectivity assessment was performed for the project area and is included in Appendix __. In general terms, the project area was divided into North and South sections (See Fig. 4-9 and Fig. 4-10). The north section is bordered by private lands, while the south section is bordered by Federally protected conservation lands. While the north section presently does not have any wildlife crossings or wildlife fencing, the south section has four wildlife crossings and continuous 10' high chain-link wildlife fencing

North Section (Private Lands/ECPO HCP Area)

The north section extends from CR 858 (Oil Well Rd) to the northern boundary of the FPNWR and BCNP, a length of 3.5 mi. Private lands occur on either side of the road. Land use/land cover generally consists of agricultural and mining lands, forested and unforested wetlands, and pine flatwoods. There are a few residential and agricultural related structures with 12 driveways/access roads.

The north section is within the NE Collier Rural Lands Stewardship Area and is being reviewed by the US Fish and Wildlife Service (FWS) for a Habitat Conservation Plan (HCP). The proposed designations under this plan in the SR 29 study area are shown in Fig. 4-9B.

To enhance this habitat connection and to provide more significant buffers between developed areas and conservation areas we recommend exchanging a node of very low density development (A) that increases fragmentation and negative edge effects with another area to the north (B) that is surrounded on three sides by proposed developed areas shown in Fig. 4-9C. This switch of proposed land use would benefit panthers through use of higher quality habitat and less exposure to development edges and conflict potential and keep development more compact and reduce potential human-wildlife conflicts.

Florida panther and black bear roadkill data are shown in Figs. 4-9B and C. Vehicle collisions with Florida panthers in the north section range from 1980 to 2018 (n=12). All but two of these are located from the Vulcan Mine Road south to the FPNWR/BCNP boundary. Black bear roadkills ranged from 1997 to 2014 (n=6). Like the panther roadkills all but one black bear was found near Vulcan Mine Road and further south. Four significant clusters of roadkill data (Fig. 4-9D) that can be used in selecting potential locations for wildlife crossing structures. Interestingly, all four of these clusters coincide with access roads or trails that abut SR 29 and are likely travel routes for panthers (Figs. 4-9D and E). The cluster at Vulcan Mine Road is probably a result of the bridge over the Collier Canal that provides a dry crossing for panthers.

Land cover surrounding these roadkill clusters is shown in Fig. 4-9F. Roadkill cluster A exhibits high ground with low density residential to the west and mesic flatwoods to the east. Roadkill cluster B is primarily bounded on both sides of SR 29 by mixed wetland hardwoods. Roadkill clusters C and D are adjacent to mixed wetland hardwoods and mixed hardwood/coniferous swamps.

<u>Recommendations</u>

Two alternatives are provided as a result of this analysis. Alternative one is more viable when exercised in combination with the proposed HCP land exchange described previously and shown in Fig. 4-9C. Alternative two would be preferred if circumstances associated with the HCP land exchange was not an option.

Alternative one –

This alternative would provide two wildlife crossing structures designed for Florida panther and other large wildlife. These structures would have clearance height and width of 6 ft x 16 ft, respectively. Recommended locations are C and D shown in Figs. 4-9D, E and F.

Alternative two –

This alternative includes only one structure located at location D (See Figs. 4-9D, E and F). In this case a larger structure with a clearance height of 7 ft and width of 19 ft, would be used as compensation.

South Section (FL Panther NWR/Big Cypress NP)

The south section extends from the north boundary of FPNWR/BCNP to I75, a length of 6.75 mi. Federally managed public conservation lands exists on both sides of the road. Land cover consists of a mosaic of native habitat types. There are 13 driveways/management access roads into FPNWR/BCNP and to private residences.

There are currently 4 wildlife crossing structures and 3 hydrologic bridges. The height and width of the wildlife crossings are 2 at 8 ft x 24 ft and 2 at 10 ft x 58 ft, respectively. The three hydrologic bridges were inspected in the field to assess their potential to serve as terrestrial wildlife crossings and were found to be low in clearance height (only 3-4 ft) relative to the water levels and therefore little to no dry shelves exist against the abutments. In addition, these three bridges are adjacent to open marsh areas, a habitat type unsuitable for more terrestrial-based species except in periods of drought or when water levels are minimal.

Only one adult male panther has been killed (2016) on the road since the wildlife crossings and fencing were constructed in the south section (Fig 4-10A). This was likely due to a break in the fence or a gate left open. Seven black bears have been killed on the road within the fence enclosure between 2006 and 2017 (Fig 4-10A). Intrusion into the fenced roadway could be as a result of fence-end runs, gates left open, breaks in the fence, and possibly climbing the fence. existing structures- wet and dry.

No small culverts were found in the south section of the project area.

<u>Recommendations</u>

No additional large wildlife crossing structures in the south section are recommended, but instead adding new culverts in the two extended sections within the current fence enclosure adjacent to FPNWR and BCNP (Fig 4-10B).

Adaptation of the existing hydrologic bridges or replacements is dependent on the eventual disposition of the Barron Collier Canal. If it is reclaimed and historic hydrology and flow patterns are restored, there would be an opportunity to adapt the existing bridges at least seasonal use by terrestrial-based species by installing shelves. Restoration of historic hydrology would also change the dynamics of the proposed culverts also, converting them to seasonal dry and wet passages. The other alternative proposed is that the existing bridges would be replaced by a much larger bridge that spans the entire flow-way of Okoalacoochee Slough. If this latter alternative was pursued, it would eliminate the need for some of the proposed crossing culverts.

Appendix A

Road-kill data collected on SR 29 south
Dec 2005 – Aug 2006

(data and figures from Smith et al 2006)

Smith, D.J., R.F. Noss, and M.B. Main. 2006. East Collier County wildlife movement study: SR 29, CR 846, and CR 858 wildlife crossing project. Unpublished report. University of Central Florida, Orlando, FL.

The frequency distribution for roadkills on SR 29 south is shown in fig. A-1. Despite only 47 total roadkills recorded, 68% of these are concentrated in three spatial clusters, at road segments 27-32 (16%), 35-39 (21%), and 53-61 (31%). All roadkills and respective 100-m segments for SR 29 south are shown in the 2004 digital ortho-photograph of the area (fig. A-2) and listed in Table A-1.

Aside from Florida panther and black bear, significant roadkills included alligator (road segments 11, 27, 29, 35, and 60), snapping turtle (road segment 32 x 2), great egret (road segment 39), and raptors including barred owl and red-shouldered hawk (road segments 20, 35, and 58).

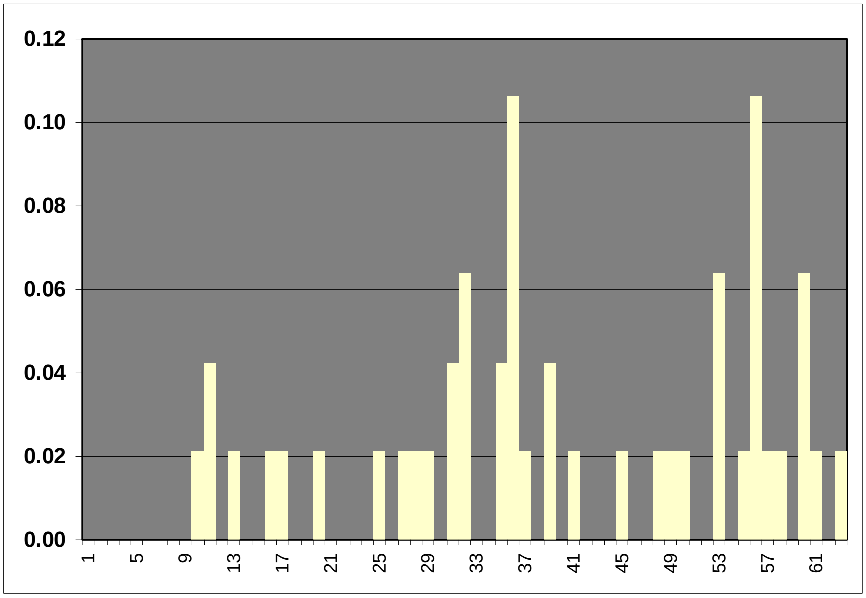

Figure A-1. Frequency distribution for roadkills recorded on SR 29 south (numbers on x-axis represent 100-m road segments, see Fig. A2).

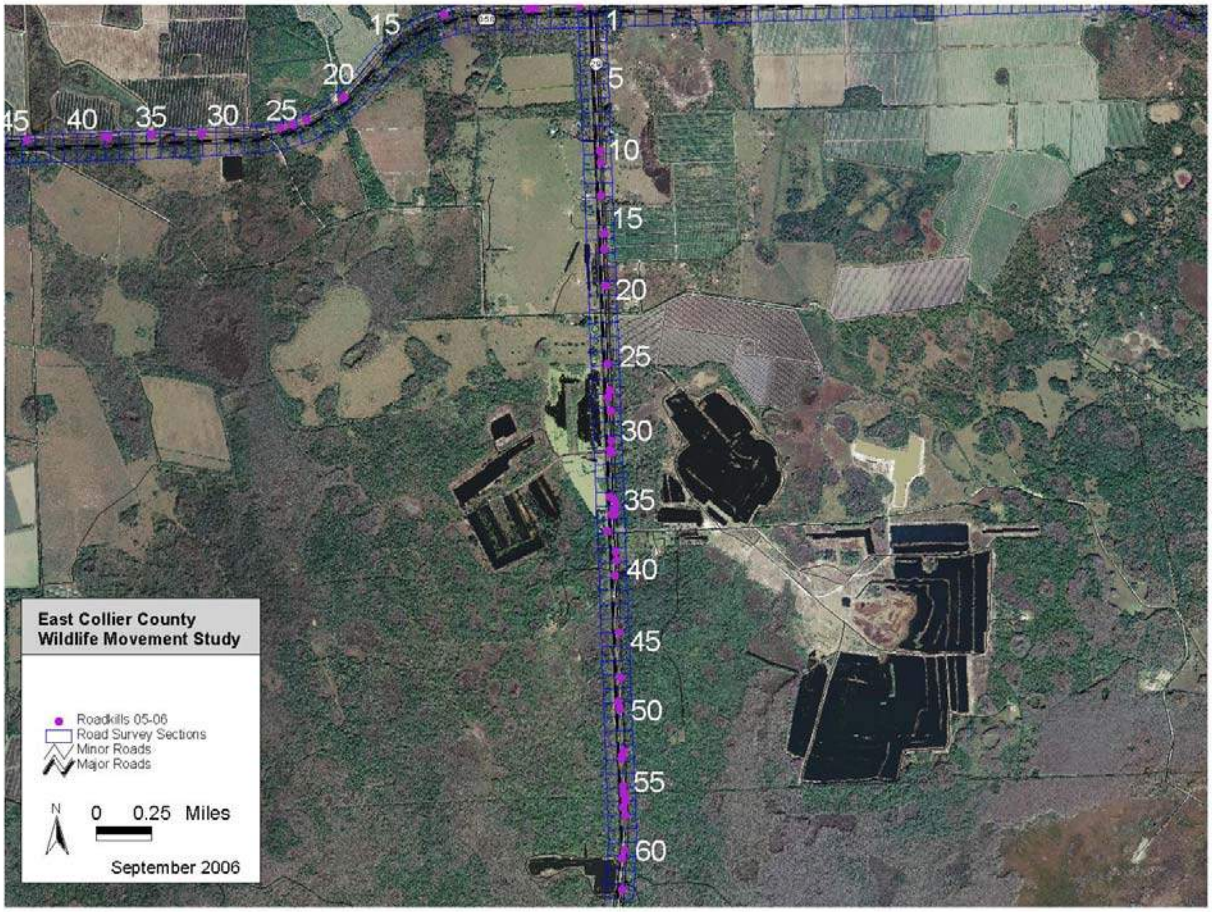

Figure A-2. All roadkills recorded on SR 29 south partitioned into 100-m road segments.

Table A-1. Road-kill data.

Date	Road	Section	Segment	Type	Species
20051204	29	S	10	Mesomammals	Virginia oppossum
20060423	29	S	11	Alligator	alligator
20060423	29	S	11	Mesomammals	raccoon
20060224	29	S	13	Mesomammals	Virginia oppossum
20051204	29	S	16	Mesomammals	Virginia oppossum
20060522	29	S	17	Birds	eastern meadowlark
20060719	29	S	20	Birds	red shoulder hawk
20060224	29	S	25	Mesomammals	Virginia oppossum
20051204	29	S	27	Alligator	alligator
20051204	29	S	28	Birds	black vulture
20060701	29	S	29	Alligator	alligator
20051212	29	S	31	Snakes	water snake
20051204	29	S	31	Frogs	pig frog
20060501	29	S	32	Birds	black vulture
20051204	29	S	32	Turtles	snapping turtle
20051212	29	S	32	Turtles	snapping turtle
20060426	29	S	35	Alligator	alligator
20060213	29	S	35	Birds	barred owl
20060501	29	S	36	Birds	black vulture
20060109	29	S	36	Mesomammals	Virginia oppossum
20060109	29	S	36	Mesomammals	Virginia oppossum
20060522	29	S	36	Mesomammals	Virginia oppossum
20060816	29	S	36	Turtles	Florida red-bellied turtle
20060320	29	S	37	Mesomammals	Virginia oppossum
20060719	29	S	39	Birds	great egret
20060726	29	S	39	Snakes	yellow rat snake
20060322	29	S	41	Birds	black vulture
20051209	29	S	45	Mesomammals	9 banded armadillo
20060523	29	S	48	Snakes	brown water snake
20060426	29	S	49	Mesomammals	raccoon
20060127	29	S	50	Birds	anhinga
20060322	29	S	53	Birds	black vulture
20060109	29	S	53	Birds	turkey vulture
20060109	29	S	53	Mesomammals	Virginia oppossum
20060104	29	S	55	Birds	black bird
20051209	29	S	56	Birds	black vulture
20060104	29	S	56	Snakes	black racer
20060125	29	S	56	Birds	black vulture
20060322	29	S	56	Birds	black vulture
20060125	29	S	56	Mesomammals	Virginia oppossum
20060322	29	S	57	Birds	black vulture
20051207	29	S	58	Birds	barred owl
20060701	29	S	60	Alligator	alligator
20060611	29	S	60	Birds	black vulture
20060701	29	S	60	Birds	black vulture
20060327	29	S	61	Small Mammals	rat
20060719	29	S	63	Mesomammals	9 banded armadillo

Appendix B

An Assessment of Vertebrate Roadkill on State Road 29, Florida, USA
Spicer 2017

An assessment of vertebrate roadkill on State Road 29, Florida, USA

Mark Spicer

BSc (Hons) Wildlife Conservation

Durrell Institute of Conservation & Ecology

University of Kent

April 2017

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My dissertation flourished through the assistance, encouragement, generosity and patience of others, including my supervisors Dr. Matt Struebig from the University of Kent and Wendy Collinson Jonker, Project Executant of The Endangered Wildlife Trust's Roads and Wildlife Project. I hope Wendy is as proud of this work as I am of hers which informed it.

Transport costs were unexpectedly yet generously supported by Dr. Sue Huson from the Manchester Centre for Genomic Medicine and Laurie Spicer. Initial planning was guided by the knowledge and experience of Assistant Professor J.D. Willson from the University of Arkansas and Dr. Dan Smith from the University of Central Florida. In the latter stages Dr. Susan Miller from the University of Cape Town, who taught me the value of high quality data recording, offered her thoughts on the manuscript.

Various staff from the Sheriff's Departments of Collier and Hendry counties, Collier County Traffic Operations (CCTO), the US Fish & Wildlife Service (USFWS), Florida Fish & Wildlife Conservation Commission (FWC) and the US National Parks Service were kind enough to offer information, encouragement and support. I am especially grateful to Sergeant Danny Curran of Collier County Sherriff's Department, Lieutenant Dodd Bulger, Angela Holden and Jennylynn Redner from the FWC, Mark Danaher from the USFWS and Terri Meyer from the CCTO. Dr. Steve Johnson from the University of Florida and Bryan Turner were invaluable in identifying flattened frogs and ruptured reptiles. Many thanks also go to the unknown but numerous residents of southwest Florida for (generally) exercising patience towards the mysterious Englishman who plagued their morning commute for six weeks.

The campground at Florida Fish & Wildlife Conservation Commission's Fisheating Creek Outpost provided a delightful woodland home for me and my tent during fieldwork, and I am extremely grateful to the staff and fellow campers for their company, conversation and donations of firewood & refreshments. I am forever indebted to Adrienne Grenier for keeping me smiling amongst the carcases.

Finally, I would like to dedicate this dissertation to the memory of Nick White, whose contribution would have been appreciated throughout.

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ABBREVIATIONS USED IN THE TEXT

BCNP	Big Cypress National Preserve
BMR	Birds, mammals & reptiles
CIA	Central Intelligence Agency
CCTO	Collier County Traffic Operations Section
ENP	Everglades National Park
FDOT	Florida Department of Transportation
FHWA	Federal Highways Authority
FPNWR	Florida Panther National Wildlife Refuge
FWC	Florida Fish & Wildlife Conservation Commission
FSPSP	Fakahatchee Strand Preserve State Park
Km	Kilometre
I-75	Interstate 75
NPS	United States National Park Service
SR 29	State Road 29
SR 82	State Road 82
USA	United States of America
US 41	Highway 41
USFWS	United States Fish & Wildlife Service
USNO	United States Naval Observatory
WVC	Wildlife Vehicle Collision

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ABSTRACT

Wildlife roadkill constitutes a major conservation concern and a conspicuous example of human-wildlife conflict, central to the discipline of road ecology. Inconsistency of research methods complicates comparisons of spatial and temporal aspects of roadkill. I applied a recently published, standardised roadkill assessment protocol to an area of conservation concern within southwest Florida. A 100-kilometre stretch of State Road 29 was driven at 50 km h^{-1} at dawn for 40 consecutive days, with vertebrate roadkill georeferenced and recorded to species. The protocol was complemented by a randomised 50-kilometre series of walked surveys providing an estimate of amphibian roadkill and traffic volume. A total of 549 vertebrate carcases representing 60 species were counted from the driven survey, producing a mean rate of 0.13 roadkill km^{-1} d^{-1}. Driven surveys revealed two hotspots with roadkill rates of >0.275 roadkill km^{-1} d^{-1}. Hotspots should be considered for mitigation measures such as warning signage, speed reductions or wildlife tunnels. Roadkill rates and traffic volume demonstrated a complex relationship. Traffic volume correlated strongly to amphibian roadkill in extra-urban areas with daytime traffic <300 vehicles hr^{-1}. Extra-urban areas with daytime traffic >300 vehicles hr^{-1} showed markedly fewer carcass numbers, suggestive of localised population reductions amongst terrestrial vertebrates. The walked survey of amphibians highlighted substantial under-recording using the driven survey protocol in a subtropical wetland, and the development of standardised, taxon-specific methods to accommodate very high abundance and roadkill rates should be considered a priority within road ecology. This represents the first robust and replicable summer baseline assessment of vertebrate roadkill on State Road 29, serving as a tool for informing future research in an area of conservation concern, for planned expansion of the road and for further developing the field of road ecology.

1. INTRODUCTION

Our world is at once connected and divided by a network of more than 30 million kilometres of paved roads (CIA 2016). In the United States of America (USA), with more vehicles *per capita* than any other country (Sousanis 2011), the road network extends to over 6.6 million kilometres, covering ~18,000 km^2 (FHWA 2014). The average driver in the USA drives 22,000 kilometres each year (FHWA 2016), and in doing so risks becoming one of the nation's 33,000 annual road fatalities (Luoma & Sivak 2014). Worldwide, approximately 1.25 million people are killed in road traffic accidents every year, which is equivalent to one every 25 seconds (WHO 2016). Negative effects of roads are not confined to our own species, as they form a major impediment to wildlife movement (Beebee 2013), fragmenting habitats and the populations within them (Coffin 2007). The ecological impacts of roadways extend to approximately 20% of the entire land surface of the USA (Forman & Alexander 1998), yet they are only conspicuous where wildlife and traffic collide, resulting in roadkill, vehicle damage or personal injury (González-Gallina *et al*. 2015; Kroll 2015).

Wildlife-vehicle collisions (WVC) cause approximately 200 human deaths each year in the USA (Huijser *et al*. 2007). Fatalities usually involve large ungulates such as moose (*Alces alces*), and swerving to avoiding WVC is itself a major cause of single-vehicle accidents (Sherman 1995). However, most WVC cause no human injury (95.4%, Huijser *et al*. 2007), in stark contrast to the wildlife involved. A lack of systematic recording makes gauging the extent of roadkill challenging (Seiler & Helldin 2006), but an analysis from 2014 (Loss, Will & Marra) suggests that up to 340 million birds become roadkill in the USA annually, and vehicles on these same roads are conservatively estimated to kill one million vertebrates daily (Lalo 1987). The threat to wildlife from motorised transport is global (Garriga *et al*. 2017), although certain taxonomic groups are more susceptible than others (Barthelmess & Brooks 2010). Whilst amphibians may be the vertebrate taxon most impacted overall by the effects of roads (Glista, DeVault & DeWoody 2008), thermoregulating reptiles using residual heat from road surfaces are also vulnerable to being struck by vehicles (D'Amico *et al*. 2015; Kioko *et al*. 2015), as are avian and mammalian scavengers feeding on road-surface carrion (Antworth, Pike & Stevens 2005).

The effects of roads on the biotic and abiotic components of the ecosystems through which they pass are indiscriminate (Coffin 2007), and their influence may be both subtle and profound. For example, road noise can drive changes in bird song (Slabbekoorn & Peet 2003) and, by altering detectability of pheromones, road surfaces may reduce reptile breeding success (Whitaker & Shine 2000). Ultimately, road networks may threaten populations (Trombulak & Frissell 2000) and even species (Ferraras *et al*. 1992; Havlick 2004; Kroll 2015).

In southwest Florida, road-related mortality has been the cause of the majority of recorded fatalities of four species of conservation concern (Harris & Scheck 1991): the American crocodile (*Crocodylus acutus*), Florida black bear (*Ursus americanus floridanus*), Key deer (*Odocoileus virginianus clavium*) and Florida panther (*Puma concolor coryi*). Florida panthers have been listed by Act of Congress as 'Endangered' since 1967, with fewer than 180 adults remaining in the wild (FWC 2016a). Construction of the Caloosahatchee River effectively isolated the population within southwest Florida (Dixon *et al*. 2007), where their habitat is fragmented by roads (Neal *et al*. 2003; Gross 2005; Meegan & Maehr 2012; Downs *et al*. 2014). Of 41 recorded panther deaths in 2016, 35 resulted from WVC (FWC 2016a). Roads, and the increasing numbers of vehicles which use them, represent a pervasive threat to biodiversity (Rhodes *et al*. 2014), and an important aspect of contemporary conservation planning.

Studying the complex relationships between roadways and the natural systems they bisect is the focus of road ecology. The term "road ecology" has been in use since 1998 (Forman), although it first appeared in German as "Straßen-Ökologie" some years before (Ellenberg, Müller & Stottele 1981). Of all aspects of road ecology, roadkill is the most familiar and has the longest history in the literature. Stoner (1925) provided one of the earliest records of roadkill in the USA, shortly before the impact of vehicles on the wildlife of Florida's Everglades was remarked upon by the naturalist C.T. Simpson (Grunewald 2006). Contemporary roadkill studies serve many purposes. They may engage the public with ecology (Vercayie & Herremans 2015), inform population estimates of either common (Colliono-Rabal & Peris 2016) or threatened species (McClintock, Onorato & Martin 2015), infer species absence (Caley Hosack & Barry 2016), identify roadkill aggregations (Gomes *et al*. 2009), or guide siting of mitigation measures (Bager & Rosa 2010; Garrah *et al*. 2015).

Despite the proliferation of roadkill studies in the past two decades, inconsistency of research methods has made comparisons between them challenging. In order to address this, Collinson *et al*. (2014) published the first standardised roadkill assessment protocol, based on research conducted in Limpopo Province, South Africa (Collinson 2013). This protocol provides the basis of this study, which to my knowledge represents the first time a standardised vertebrate roadkill assessment has taken place in North America. One study conducted between 1996 and 1998 took place in close proximity to my own and serves as the only record of local roadkill in the literature (Main & Allen 2002), but was neither standardised nor systematic. By using a standardised protocol to provide baseline data, my research will be of value for future comparisons and in development of plans for road expansion within the study area, while my recommendations regarding protocol design and implementation may benefit road ecology as a whole.

This study aims to identify spatial and temporal patterns of roadkill on a road in an area of conservation concern within southwest Florida, and to assess whether the protocol used is robust and flexible enough for widespread adoption. The objectives are:

1. To apply the protocol to obtain baseline roadkill data, and
2. To make specific recommendations for improvement of the protocol, and
3. To make specific recommendations for further research within the study area.

4. METHODS

2.1 Study area

The southern tip of the Florida peninsula, framed by the Atlantic Ocean and the Gulf of Mexico, is dominated by the Everglades, a wetland area of subtropical freshwater, brackish marsh and swamp (Figure 1). To the northwest, the mangrove and estuarine habitat persists, bordered by the conurbations of Miami on the Atlantic Coast and Naples to the west, overlooking the Gulf. Seldom more than 15m above sea level, these wetlands gradually give way to stands of trees such as cypress (*Taxodium distichum*) and sabal palm (*Sabal palmetto*). Much of this area is protected, with the contiguous Everglades National Park, Big Cypress National Preserve (BCNP), Fakahatchee Strand Preserve State Park (FSPSP) and the Florida Panther National Wildlife Refuge (FPNWR) together occupying almost 9,500 km^2 (5.5%) of the state.

State Road 29 (SR 29) connects the city of LaBelle in the north with Highway 41 (US 41) to the south. Approximately 40 kilometres south of LaBelle is Immokalee, a major agricultural centre, with much of the area between the two used for citrus and tomato production. With urban and agricultural centres concentrated along the northern half of SR 29, traffic volumes are higher than the south (CCTO 2016). The southern half passes through areas of swampland and cypress, with 38 kilometres running adjacent to and between two protected areas: BCNP and the Florida Panther National Wildlife Refuge (FPNWR). Wildlife-collision mitigation measures such as variable speed limits, underpasses and a three-metre high chain-link fence (Land & Lotz 1996) have been applied to the area around FPNWR. The Barron Canal, an artificial drainage channel, runs southward alongside the east of SR 29 from the southern limit of Immokalee to the US 41 junction.

Previously the principal east-west route between Tampa and Miami, US 41 has now been superseded by the faster Interstate 75 (I-75) which bisects SR 29 further north, the only major road to do so. Speed limits along SR 29 range from 56 to 97 km h^{-1}, with some areas having variable 97/72 km h^{-1} day/night limits. State Road 29 is a designated hurricane evacuation route, and is predicted to see a four-fold increase in traffic volume by 2035 (FDOT 2010), and there are plans to widen the road to a four-lane divided highway from Labelle to the I-75 (FDOT 2016).

2.2 Driven Survey

Following the protocol published by Collinson *et al*. (2014; hereafter "the protocol"), I drove a 100-kilometre stretch of SR 29 ("the transect") between the State Road 80 junction in the north (26.76163°N -81.43849°W) and US 41 to the south (25.91093°N -81.36445°W). Drives took place at 06h00 for 40 consecutive days (June 25th to August 3rd 2016) at 50 km h^{-1}. The entire carriageway and verges (up to the fence, barrier or treeline) were monitored by the driver for roadkill. Specimens were photographed and georeferenced using a Garmin eTrex 10 (Garmin Ltd., Schaffshausen, Switzerland) to <5m to avoid recounts (Guinard, Prodon & Barbraud *et al*. 2015). Domesticated, non-native and native species were recorded, although the domesticated were subsequently excluded from analyses. Where gravid vertebrates or those with attendant or exposed young were observed, I elected to record only the adult, as to do otherwise without introducing bias would necessitate examination of each adult female. Roadkill hotspots were defined as aggregations where roadkill rates exceeded the upper 95% confidence limit of the mean, based on roadkill km^{-1} d^{-1} (after Santos *et al*. 2015), calculated as total count $km^{-1}/40$. Surveys were undertaken using a Nissan Versa hatchback.

2.3 Walked survey

In anticipation of large numbers of amphibian roadkill (Smith, D., pers. comm), 50 one-kilometre sections of the transect were randomly selected in Excel (Microsoft 2010) for walked assessment. These sections were randomly assigned across fifteen weekdays (to avoid bias incurred by weekend variations in traffic volume) with surveys undertaken following the morning's driven counts, between 10h00 and 15h00. Both carriageways were surveyed, in a standardised manner: the southbound carriageway walked first, south to north, recording any carcass identifiable as amphibian. No data were recorded beyond the count for each kilometre surveyed. In keeping with the driven survey, the entire carriageway, shoulders and verges were observed. Means-between-points were used to produce an overall spatial profile of amphibian roadkill along SR 29.

Figure 1. Map of the study area and SR 29. LaBelle marked the northern end of the transect, with Immokalee towards the centre and the protected areas to the south. The 100 kilometre transect terminated at the US 41 junction, marked as Carnestown. Image © GoogleMaps 2016 & otels.com.

During each of the 50 walked surveys I recorded the number of vehicles using SR 29 during a 25-minute period. Means-between-points were used to produce traffic volume estimates of daytime vehicles hr^{-1}, which were corroborated against county traffic counts (portable counters; TimeMark Inc., Salem, USA) from the first quarter of 2016 (the most complete data set available; CCTO 2016) using Pearson's correlation coefficient (r).

2.4 Meteorological variables

All meteorological variables were taken from the Heller Immokalee personal weather station (KFLIMMOK4, accessed via wunderground.com) which, at 12 kilometres south of Immokalee, was the nearest weather station to the midpoint. In 2015, KFLIMMOK4 recorded precipitation of 1042.7mm, with temperatures from 0.3°C to 36.3°C (mean = 26.6°C; KFLIMMOK4 2015). Humidity figures were recorded at midday and midnight, with solar radiation and ultraviolet indices recorded at peak. Atmospheric pressure was recorded at minimum and maximum. As morning surveys record roadkill from the previous 24 hours, meteorological variables from both the day of the survey and from the day before were plotted against roadkill observations. Moon phase data was taken from the United States Naval Observatory (USNO 2016). As roadkill counts are not normally-distributed, Spearman's rank correlation coefficient (r_s) was used throughout in testing correlations, with results where $r_s \geq \pm 0.7$ and $p \leq 0.05$ signified correlation. *Post hoc* analysis of meteorological variables in R (R Core Team 2013) showed several variables correlating closely enough (i.e. $r_s \geq 0.7$, $p \leq 0.05$) to act as surrogates (Appendix 1).

2.5 Adjustments to the protocol

Aspects of the protocol were adjusted to local circumstances and the aims of this study. In the protocol, drives commence 1.5 hours after sunrise, which would have been both hazardous and impractical due to high traffic on SR 29. To avoid this, the transect was driven as early as light allowed detection of roadkill. A low, rising sun in front of or behind the observer may reduce detection of roadkill (Collinson 2013), but with this being a north-south transect (as opposed to west-east) this was less likely, and increased contrast from a low sun may actually increase detectability (Stander 1998). Starting surveys later than in the protocol would have introduced detection bias through increased susceptibility to scavenging, desiccation or other degradation of specimens (Santos *et al*. 2016). As inconveniencing other road users could have constituted a violation of Florida state statute (Collier County Sheriff's Office, pers. comm.), driven surveys were undertaken at the protocol's upper speed limit of 50 km h^{-1}. Finally, in testing the protocol's ability to capture rates and diversity of roadkill, the survey included carcases seen on the verges rather than solely those observed on the tarmacadam (Grilo, Bissonette & Santos-Reis 2009).

2.6 Data analysis

Analysis and mapping of georeferenced data was performed using ArcGIS 10.3 (ESRI 2014), based on land cover maps provided by the FWC (2016b), with a 500 metre buffer reflecting the area of greatest influence of roadways on herpetofauna (Rudolph *et al.* 1999). Species accumulation data was processed using EstimateS v9.3 (Colwell 2013) and Excel (Microsoft 2010). National Parks Service species lists for BCNP provided the local vertebrate inventory, which include introduced and established species (USNPS 2010, 2011a, 2011b; Pifer *et al*. 2011; Clark, R. pers. comm.).

5. RESULTS

3.1 Driven survey

A total of 4,000 kilometres were driven over a period of 121.75 hours (range 2.26 - 3.8 hours survey^{-1}, mean = 3.03 hours) with a total of 549 roadkill detected, representing 60 species, 32 families and 19 orders (Table 1). Herpetofauna accounted for 71% (n=390) of carcases. Reptiles (n=251, 45.7%) constituted the largest proportion of roadkill detected by vehicle, followed by amphibians (25.3%, n=139), mammals (19.5%, n=107) and birds (9.5%, n=52). A total of 53 roadkill were unidentifiable to species (amphibians = 44, birds = 4, reptiles = 2, mammals = 2). An inventory of species recorded in the driven survey is listed in Appendix 2.

Table 1: Vertebrate roadkill by class, family, genus and species.

Class	Families	Genera	Species	Individuals
Amphibia	4	3	5	139
Aves	10	23	23	52
Mammalia	8	9	10	107
Reptilia	10	18	22	251
TOTAL:	32	53	60	549

Half of the total count (50.6%, n=278) was accounted for by nine species (15%), namely the southern leopard frog (*Lithobates sphenocephalus*, n=60), Florida banded water snake (*Nerodia fasciata pictiventris*, n=57), Virginia opossum (*Didelphis virginiana,* n=41), Florida cottonmouth snake (*Agkistrodon piscivorus conanti* n=23), cornsnake (*Pantherophis guttatus* n=21), Florida softshell turtle (*Apalone ferox* n=20), American alligator (*Alligator mississippiensis* n=19), eastern mud snake (*Farancia abacura abacura* n=19), and raccoon (*Procyon lotor* n=18). Approximately one quarter (26.4%) of species listed by the US National Parks service as present within Big Cypress National Park were recorded as roadkill: 28.6% of mammals, 27.7% of amphibians, 23% of reptiles and 18.5% of birds.

Three species of domesticated animals were observed (chicken *Gallus gallus domesticus*, n=2; cat *Felis catus,* n=7; dog *Canis lupus familiaris*, n=4), all in the northern half of the transect. Four invasive species (cane toad *Rhinella marina*, n=4; Cuban tree frog *Osteopilus septentrionalis*, n=10; black rat *Rattus rattus*, n=3; veiled chameleon *Chamaeleo calyptratus*, n=2) were recorded.

A significant majority (85.1% of carcasses, 64.9% of species; z=9.831 p <0.0001) of roadkill were nocturnal or crepuscular, including all amphibian species and non-domesticated mammals (see Appendix 2). Most reptile species (59%) were nocturnal, whereas diurnal species produced the majority of avian roadkill records (68.2%).

Scavenging species (black rats, raccoons and opossums, n=62) formed 65% of non-domesticated mammal carcases (n=96). Black vultures (*Coragyps atratus*) were the most common bird in the survey, with 11 specimens recorded. Predatory and scavenging birds constituted eight of the 23 bird species, and 23 of the 52 specimens (44.2%).

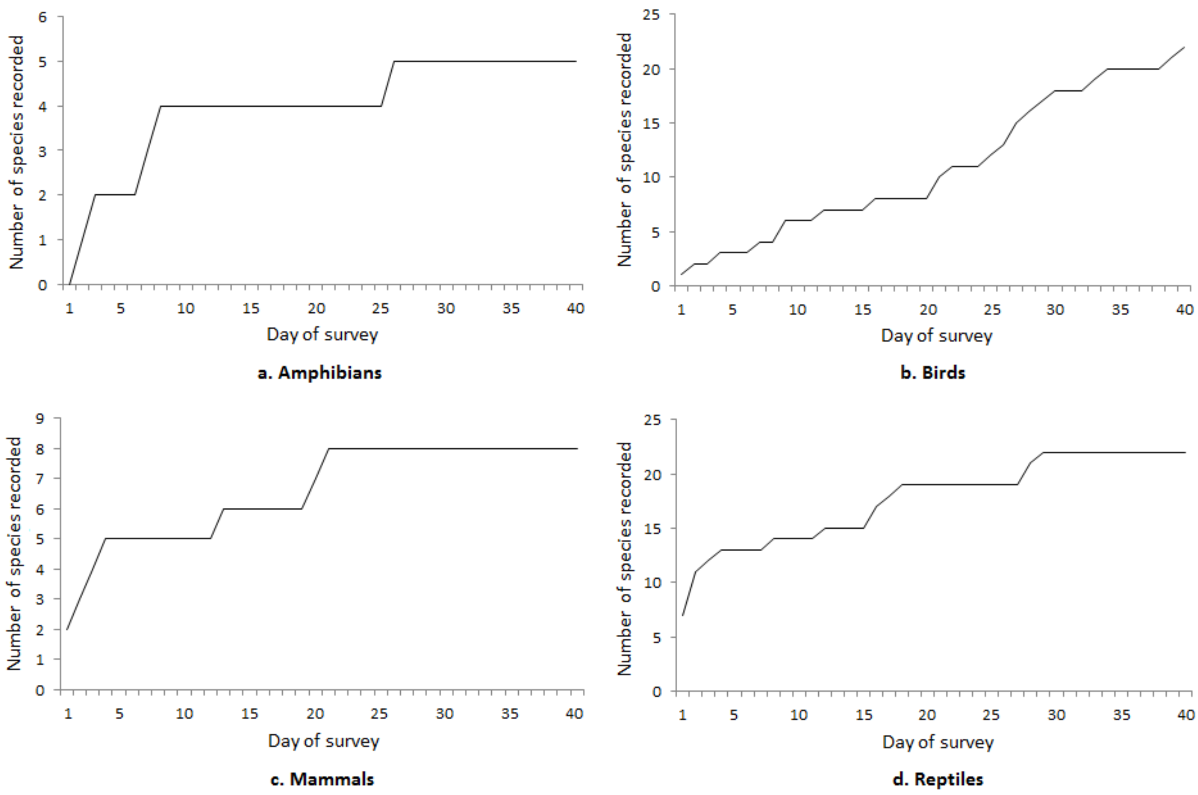

Figure 2. Species accumulation curves for the four classes of terrestrial vertebrates. Asymptote is reached for the three terrestrial vertebrate classes only (2a, 2c, 2d).

Species accumulation (collector's) curves (Figure 2) formed a plateau for mammals by day 22, followed by amphibians (day 27) and reptiles (day 29). Contrary to the plateau formed for the three terrestrial vertebrates, diversity amongst avian roadkill continued to increase throughout the sampling period (Figure 2b), with the survey period producing 51 avian roadkill samples (excluding domesticated species). Rarefying and extrapolating data for avian roadkill shows a curve reaching asymptote at 196 samples, equivalent to four times the effort expended (Figure 3).

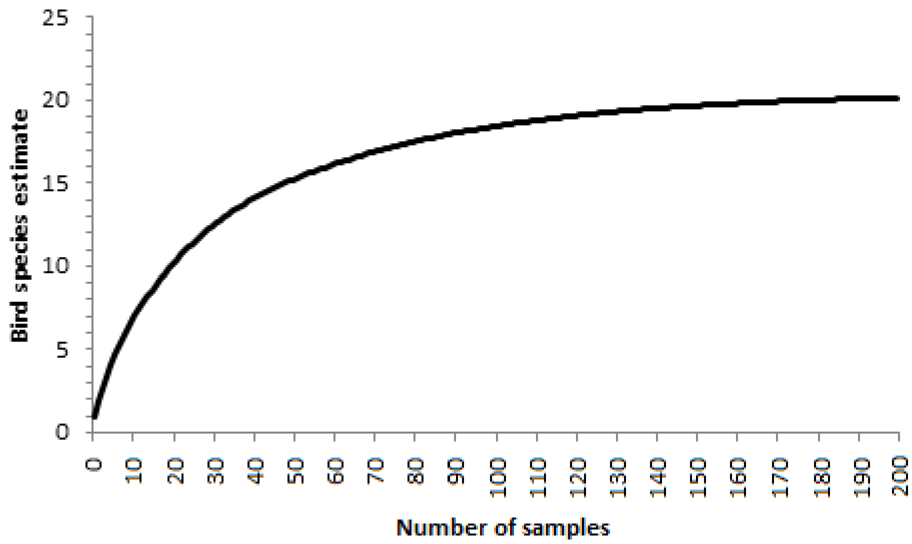

Figure 3. Rarefied and extrapolated avian accumulation curve. Curve used is species estimate (S_{est}) from EstimateS (Colwell 2013).

Several mammals and reptiles were seen to be have been gravid or with attendant young when killed. Four opossum carcases were observed with joeys nearby, and a total of 12 immature opossums were thus observed, of which 10 were dead (the remaining two were vocalising near the maternal carcass). Similarly, four Florida banded water snakes were recorded during four consecutive days with a total of 38 young nearby. Three specimens of another viviparous species, the green watersnake (*Nerodia floridana*), were also counted with dead young nearby (n=42). Evisceration of one eastern mud snake had exposed 12 eggs, within and outside the carcass.

3.2 Walked survey

The 50 one-kilometre walked surveys took 20.61 hours to complete, recording 1,212 amphibian carcasses. Counts ranged from 0-110.0 km^{-1} (mean = 23.29 km^{-1}, 95% CI 19.2-27.4, Figure 4a), and were significantly higher in the northern half of the transect (mean = 31.3 km^{-1}) versus the southern half (mean = 15.7 km^{-1}; t=17.338 d.f.=98 p=0.0001).

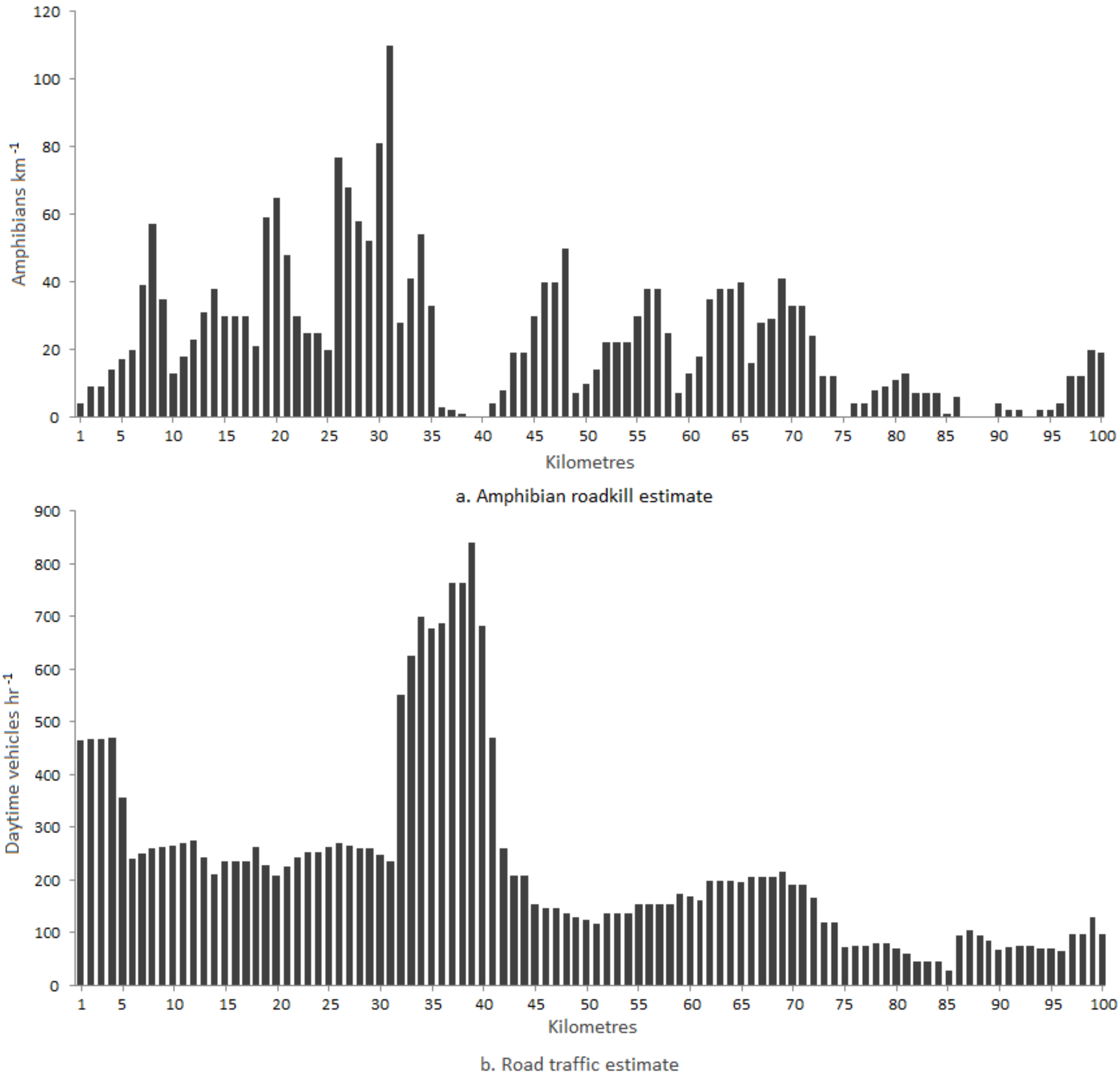

Figure 4. Amphibian roadkill (4a) and daytime traffic volume estimates (4b). Km1 marks the start of the transect in LaBelle, with km100 marking the final kilometre approaching the US 41 junction. SR 82 junction is at approximately km32, I-75 at km75.

Amphibian roadkill peaked at 110.0 km^{-1} at km31, with significantly reduced counts ($p<0.05$) evident in areas of highest traffic volume (such as urban centres), and from km87 to km95. Counts were below the lower bound of the 95% confidence interval in central Immokalee (km37 to km40) and adjacent to the BCNP and FSPNP protected areas (km87 to km95). No correlation was demonstrated between walked and driven amphibian counts ($r_s=0.3468$ $p=0.00041$).

Traffic counts recorded 4,922 vehicles in 20.83 hours (Figure 4b). Daytime traffic volume ranged from 28.9 hr^{-1} in the south to 840.4 hr^{-1} in central Immokalee (mean = 241.1 hr-1, 95% CI 194.3-265. Daytime traffic volumes were significantly higher in the northern half (mean = 336.3) than the southern half (mean=120.1; $t=7.759$ d.f.=98 $p<0.00001$). LaBelle (km1 to km4) and Immokalee (km37 to km40) appear as urban peaks with extra-urban traffic volumes highest immediately to the south of the SR 82 junction towards Immokalee (km32). Walked daytime traffic counts correlated significantly with quarterly county data from Collier County ($r=0.9454$ $p=0.001$; Figure 5).

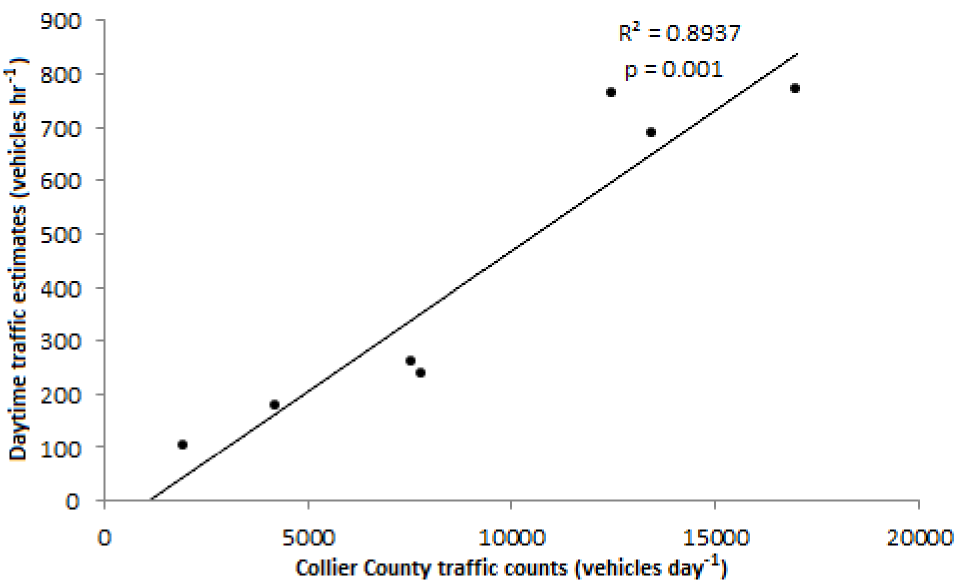

Figure 5. Correlation of walked traffic counts with Collier County data. Quarterly county traffic data and daytime walked counts were strongly, significantly and positively correlated.

3.3 Temporal and spatial patterns

Temperatures during the survey period ranged from 20.8°C to 36.7°C (mean 28.7°C). Mean overnight temperature was 22.8°C (range 20.8°C to 24.7°C), with daytime temperature averaging 34.6°C (range 30.5°C to 36.7°C). Rainfall totalled 287 millimetres, typically occurring in the late afternoon and evening. No temporal variable (atmospheric pressure, humidity, lunar illumination, rainfall, solar radiation, temperature or ultra-violet index) from either the day of the survey or from the previous 24 hours correlated significantly to rates of roadkill in any of the vertebrate taxa (not shown).

Significant variations (χ^2=16.796 d.f.=6 p=0.01) were demonstrated for roadkill rates during the driven survey, with weekend surveys counting higher numbers of roadkill than weekdays (Figure 6). As amphibians were undercounted in the driven survey, they were omitted from this analysis.

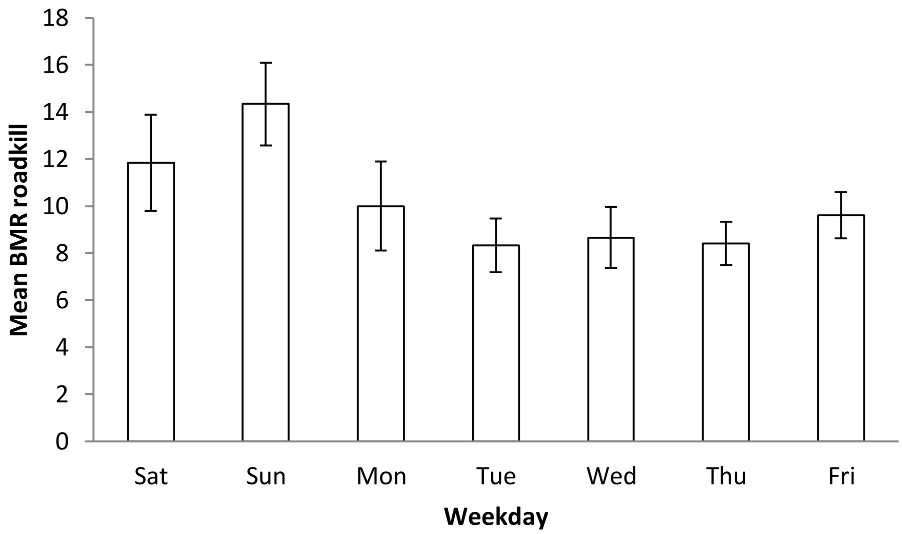

Figure 6. Variation in mean bird, mammal & reptile (BMR) roadkill by weekday. Saturday to Wednesday n=6; Thursday and Friday n=5.

The majority of carcasses in the driven survey were observed on the carriageway (97.63%, n=536). Of 549 specimens recorded in total, 51.73% (n=284) of carcases were on the driver's side (southbound carriageway) and 45.90% (n=252) were on northbound carriageway. The remaining 2.37% (n=13) were detected on the grass verges (1.82% southbound [n=10], 0.55% northbound side [n=3]). There was no significant difference between percentages detected on either carriageway (χ^2=3.371 d.f.=1 p=0.0534) or on either verge (χ^2=3.778 d.f.=1 p=0.0519).

Combined mean roadkill rate for all three non-amphibian classes (birds, mammals and reptiles, hereafter BMR) was 0.099 km^{-1} d^{-1} (upper bound CI 95% = 0.275 km^{-1} d^{-1}). The driven transect revealed two hotspots with roadkill rates >0.275 km^{-1} d^{-1}. Vertebrate roadkill rates recorded during the driven survey are shown in Figure 7, showing two clear peaks where BMR rates exceeded 0.275 km^{-1} d^{-1}.

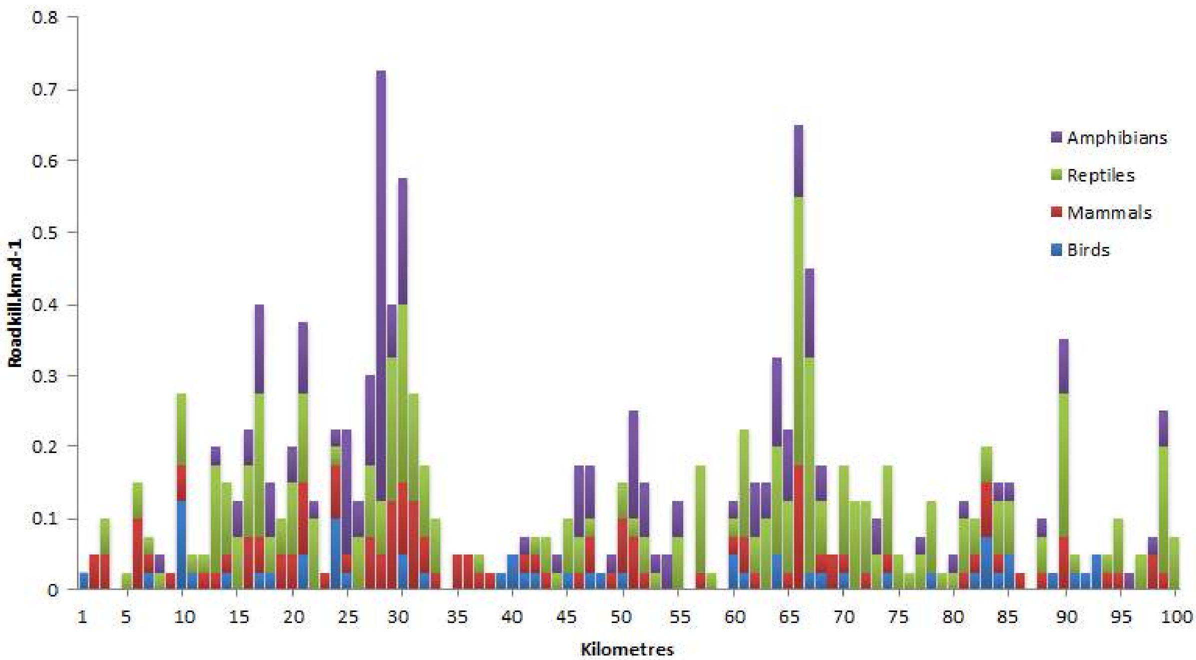

Figure 7. Spatial distribution of vertebrate roadkill on SR 29 by class and kilometre. Heterogeneity of distribution is apparent in all classes, with aggregations from km29-31 (northern hotspot) and km66-67 (southern hotspot).

Fewer roadkill were recorded in the urban settings of Labelle (km1-4) and Immokalee (km37-40) than in extra-urban areas. Five kilometres produced zero roadkill during driven surveys (km4, km34, km56, km59 and km87), of which only km87 is corroborated by the walked survey results (Figure 4).

The 38-kilometre section in protected areas produced 41% (n=175) of the BMR roadkill, representing 32 species, compared to 59% (n=235) representing 46 species from the unprotected sections. Mean daytime traffic volume was substantially lower in the protected areas (112 hr^{-1} versus 305 hr^{-1}).

Walked amphibian counts demonstrated a significant, strong positive correlation to traffic volume in the 85 kilometres where daytime traffic volume was <300 vehicles hr^{-1} (r_s=0.700, p<0.00001, n=85; Figure 8). Areas with traffic >300 vehicles hr^{-1} were confined to within Immokalee and LaBelle and the section of SR 29 between the SR 82 junction and Immokalee. This strongly positive relationship was not demonstrated across the entire transect (r_s=0.367, p=0.00018, n=100). No other correlates were detected between any spatial variable and any vertebrate class (not shown).

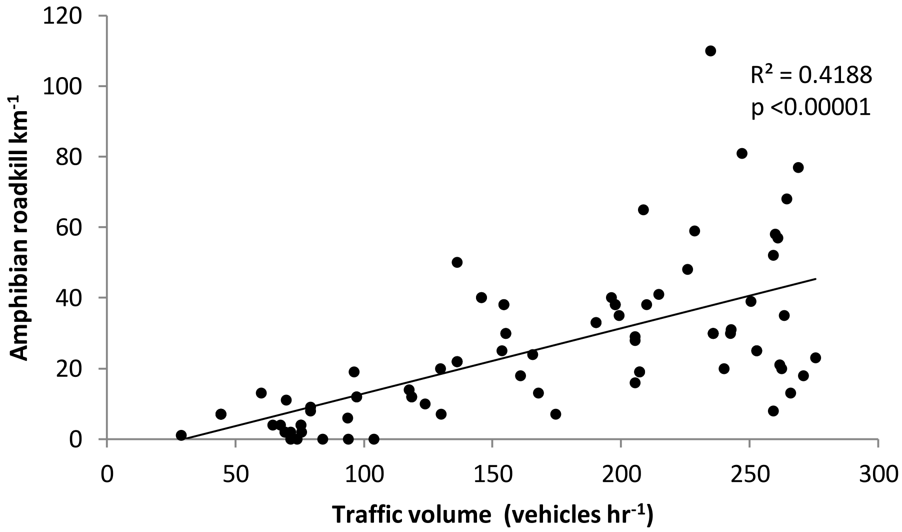

Figure 8. Correlation of amphibian roadkill with extra-urban traffic volume. Extra-urban is defined as areas outside LaBelle & Immokalee, corresponding to 85 kilometres with vehicle counts <300 hr^{-1}.

Mammalian and reptilian roadkill demonstrated a strong positive correlation (r_s=0.871, p=0.001, n=10; Figure 9) around the northern hotspot. This finding was not replicated in the second aggregation further south (where r_s=-0.25, p=0.479, n=10; not shown).

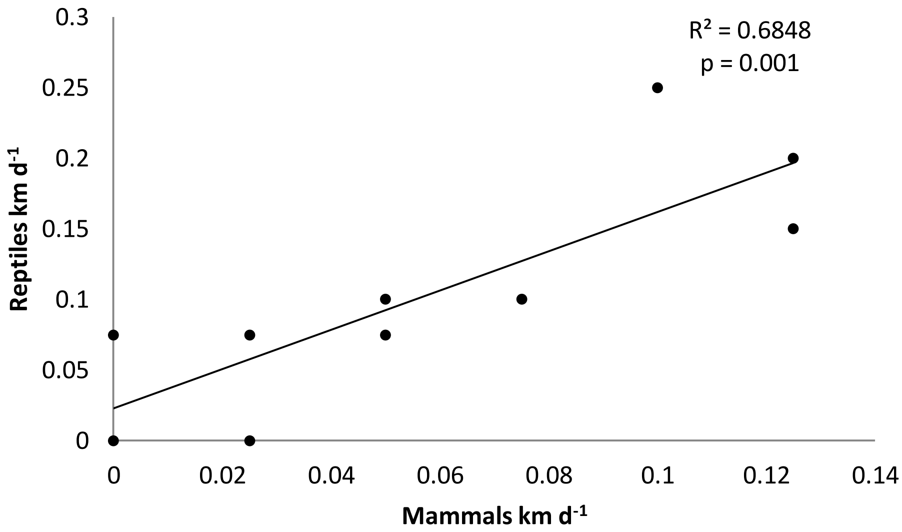

Figure 9. Correlation of mammalian roadkill to reptilian roadkill at the northern hotspot. Figure shows roadkill rates for 10 kilometres of SR 29, centred at km30.

The northern hotspot (Km29-31, 26.50805°N -81.43507°W to 26.48936°N -81.43471°W; Figure 10) occurred on a cattle-fenced stretch of SR 29 with a 96 km h^{-1} speed limit and daytime traffic volume of approximately 247 vehicles hr^{-1}. Amphibian, mammalian and reptilian roadkill all demonstrated a peak, with amphibian roadkill rate (walked survey) reaching its highest point, at 110.0 km^{-1} (mean = 23.29 km^{-1}). The pastureland to the west of the aggregation was being used for cattle grazing during the survey period, and was extensively flooded adjacent to the verge. Immediately east was a citrus plantation-marsh matrix, with elevated and drained cropland divided by areas of marsh.

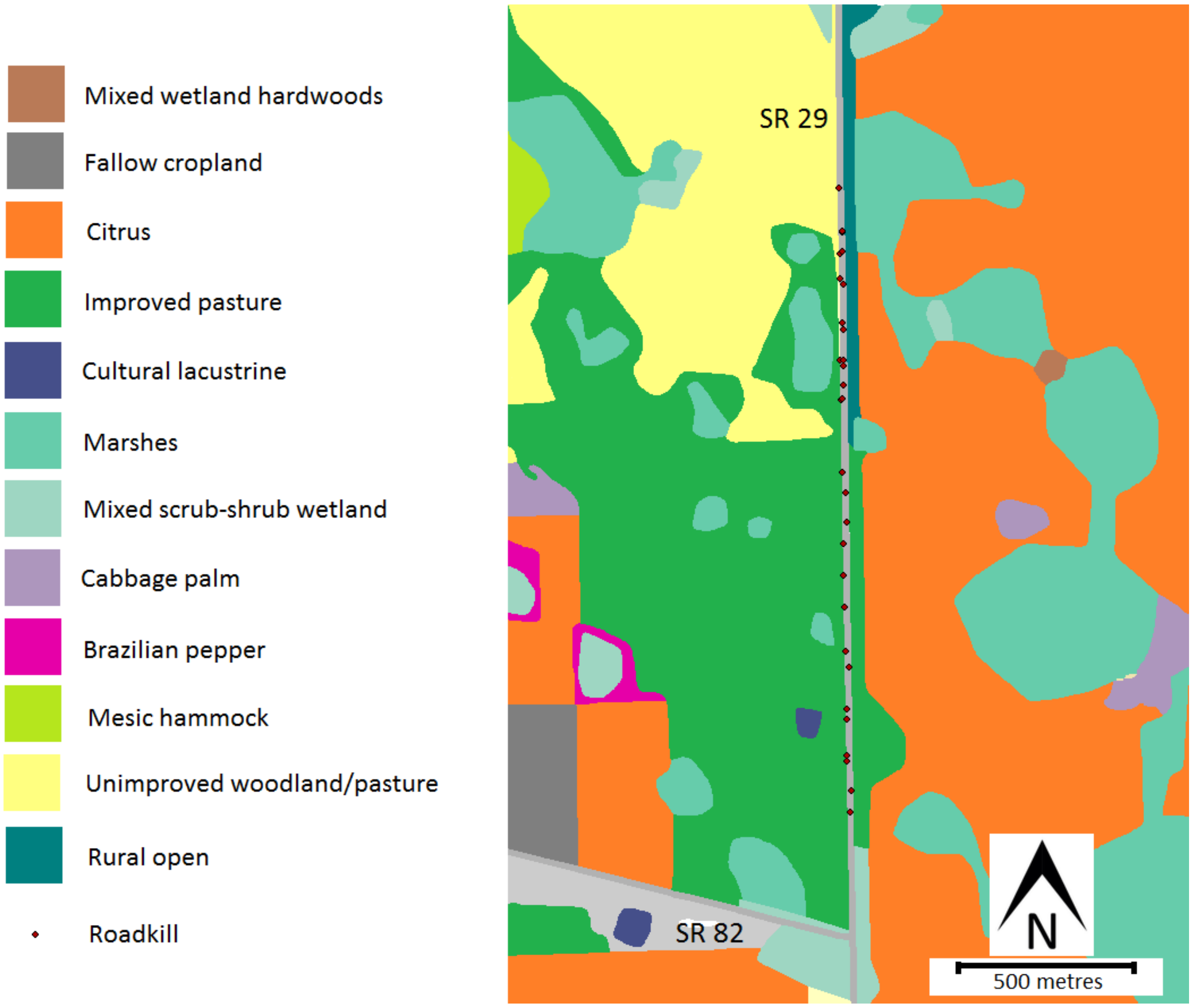

Figure 10. Land cover map of the northern roadkill hotspot km29 to 31. Rates were markedly higher north of the SR 82 junction than to the south. Points marked 'Roadkill' denote avian, mammalian and reptilian roadkill only. Land cover data: FWC (2016b).

The southern aggregation (km66-67, 26.22366°N -81.34449°W to 26.20651°N -81.34616°W, Figure 11) occurred within a protected area with daytime traffic volume of 205 vehicles hr^{-1}, and speed limit of 96 km h^{-1}. The BMR roadkill peak rate of 0.55 km^{-1} d^{-1} consisted of high numbers of reptilian and mammalian carcases. Amphibian roadkill (walked count) was slightly above the mean at 28.0 km^{-1}. This section of SR 29 had the Barron Canal alongside its eastern carriageway, and was elevated approximately two metres above the land to the west, with a bank leading down to the ditch and fence. The western boundary into the FPNWR was formed of marsh at the northern and southern ends, either side of mixed scrub-shrub wetland.

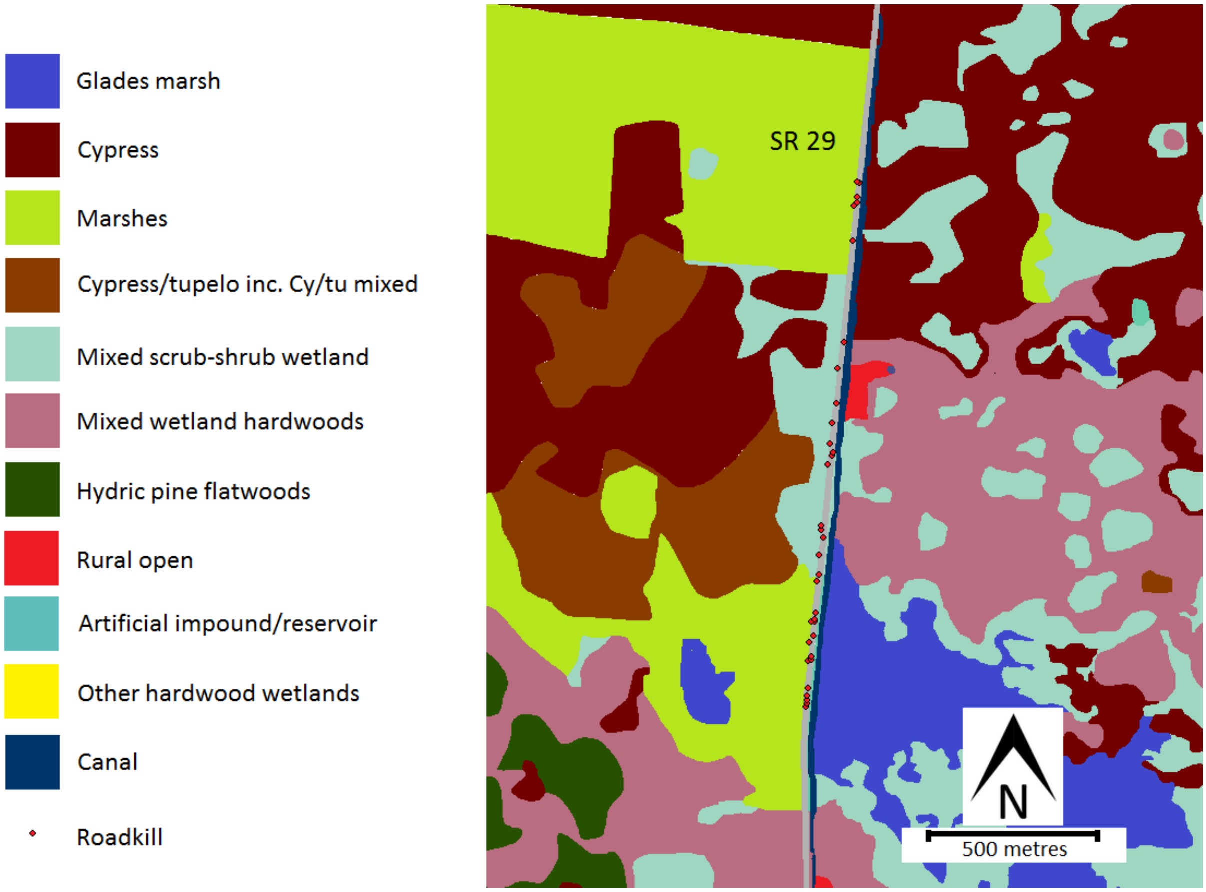

Figure 11. Land cover map of the southern roadkill hotspot km66 to km67. Points marked as roadkill denotes avian, mammalian & reptilian roadkill only. Land cover data: FWC (2016b).

6. DISCUSSION

Application of Collinson *et al.*'s 2014 protocol to a subtropical wetland demonstrated its utility as well as its major flaw. Despite the substantial differences in climate and vertebrate assemblage between Limpopo Province and southwest Florida, the protocol effectively captured a representative sample of the diversity of roadkill within the study area. Simultaneously, it highlighted that where individual taxa are particularly abundant, the protocol required modification to capture the extent of road mortality. Accurately assessing amphibian road mortality is of significant conservation value as amphibians are the most endangered vertebrate taxon (Toledo *et al*. 2014) and also the most prone to the effects of roads (Glista, DeVault & DeWoody 2008).

Although amphibians showed the lowest diversity during the driven transect, the walked survey revealed their high abundance and herpetofauna overall constituted the majority of roadkill in this survey. In the only published roadkill study conducted in close proximity my own, Main & Allen (2002) recorded (by vehicle) mammals most frequently (54%), with herpetofauna at 15% and birds at 11% ("unidentified" species, mostly mammals and herpetofauna, accounted for the remaining 20%). Their study recorded only one third (32.7%) of the daily roadkill counted during my research (4.48 roadkill day^{-1} versus 13.72 day^{-1}), although their work included both wet and dry seasons, the latter of which yielded significantly lower counts.

For the three terrestrial vertebrate classes (amphibians, mammals, reptiles), asymptote of collector's curves was achieved by day 30 of a 40 day survey, indicative of adequate survey effort. By contrast, the non-asymptotic avian curve indicated inadequate effort (Sosa & Schalk 2016), with extrapolation suggesting a period of 160 days to plateau. Birds were the most diverse group, with all 23 genera represented by singletons which is typical for the taxon in roadkill studies (e.g. Brockie, Sadleir & Linklater 2009), as is the weighting towards raptors (Lambertucci *et al*. 2009) and scavenging raptors in particular (Antworth, Pike & Stevens 2005). Low elevations (Clevenger, Chruszcz & Gunson 2003) and watercourses (Erritzøe, Mazgajski & Rejt 2003) both increase avian WVC, and were key features of the study area.

Having been developed in an area of low rainfall (Collinson *et al*. 2015), testing the protocol in a subtropical wetland proved a valuable test of if its ability to capture amphibian roadkill rates. Vehicle-based amphibian surveys have been described as “grossly inaccurate” (Elzanowski *et al*. 2009), and the lack of correlation between walked and driven amphibian counts highlighted the key shortcoming of the protocol in this habitat, recording just 139 carcases. Assuming the 50 randomised kilometres were reflective of the entire transect, the 1,212 amphibian roadkill recorded during walked counts equates to almost 97,000 carcases during the survey period. This figure includes all carcases, regardless of age, and may therefore be an overestimate, but as amphibians are generally rapidly removed or rendered undetectable on roads (Puky 2005) it is equally likely to represent an under-count. Elsewhere in Florida, anuran roadkill has been sufficient to render road surfaces dangerously slippery (Dodd, Barichivich & Smith 2004) yet, despite their abundance, amphibians are the most susceptible taxon to undercounting through small size, scavenging, vehicular attrition and solar desiccation (Hels & Buchwald 2001; Puky 2005). Several tree frogs (Hylidae) recorded were <2 centimetres in length, and some of the apparent amphibian peaks in the driven survey are explained by my seeing and therefore recording more specimens after the vehicle stopped, thereby producing false aggregations.

The vagility of individual amphibian species alters their susceptibility to road traffic relative to others, and may be highly seasonal (Carr & Fahrig 2001), as was the case with southern leopard frogs in this survey, which were more frequently counted than the less vagile, more aquatic (Glista, DeVault & DeWoody 2008) American bullfrog (*Lithobates catesbeianus*) from the same genus. A winter assessment, with reduced temperatures, lower rainfall, less standing water and altered amphibian activity patterns, could produce markedly different results.

Accurate assessment of amphibian roadkill is critical, as the taxon is acknowledged to be particularly sensitive to road effects, and WVC may be one of the factors reducing amphibian populations globally (Elzanowski *et al*. 2009). The protocol addresses differing diversity levels by recommending different sampling durations and distances, but is not equipped for areas of very high abundance such as here. The use of supplementary walked counts to complement driven surveys was suggested by Collinson *et al*. (2014) “… to target-specific locations where small-bodied species may occur”. The absence of a standardised method by which to undertake these counts is a challenge which requires addressing, and although Langen *et al*. (2007) propose survey methods which could be adapted this end, they have not been designed around a driven assessment. In assessing amphibian roadkill, Dodd, Barichivich & Smith (2004) restricted their counts to specific sections of their study area to form an overall impression of distribution. My approach counted a greater number of sections of the transect fewer times, and randomly selected sections for survey. The randomised, walked survey used here was capable of identifying spatial distribution patterns and, while the method used was crude, it offers promise if refined.

Roadkill counts only capture those specimens which both die and remain *in situ*, as an unknown number will leave the roadway and die elsewhere, be removed post mortem (principally by scavenging animals), or are rendered undetectable by repeated impact or weather (Antworth, Pike & Stevens 2005; Fahrig & Rytwinski 2009; Beckmann & Shine 2015; Kioko *et al*. 2015; Braz & Franca 2016; Santos *et al*. 2016). Scavenging effects have been considered in the protocol design and in part dictate the daily timing of research, although the scavengers involved and their impact will vary by location (Ratton, Secco & Da Rosa 2014). In the USA as elsewhere, roadkill may also be collected by road users regardless of legality for various reasons including consumption (Desmond 2013), and I witnessed alligator carcases being removed illegally during the course of my fieldwork. It is plausible that for smaller species, such as amphibians, my driven survey may have detected fewer roadkill at the southern end due to a longer exposure to daylight scavengers. Compensatory adjustment for the bias introduced by varying detection and persistence rates of carcases has been suggested by Guinard, Prodon & Barbraud (2015), and whilst it may be salient to incorporate such measures in obtaining overall estimates for specific purposes, they did not form part of the protocol, and have not been applied here.

Additional counting of specimens on the grass verges increased the total species count by only one species (bobcat *Lynx rufus*). Both bobcat carcases (and the bear removed by FWC) were detected off the carriageway, possibly due to body size predisposing towards greater movement from the carriageway (Main & Allen 2002). In addition, observing verges for roadkill was only possible due to the state's correctional facilities' rigorous program of grass cutting, and as verge conditions, width, vegetation access *etc*. are liable to vary widely, even within small spatial scales, it cannot be assumed to be possible and was understandably excluded from the original protocol.

Roadkill distribution patterns were more evident spatially than temporally, and two hotspots were revealed. The northern hotspot produced evidence of a trophic roadkill cascade. A high amphibian population in the adjacent flooded pasture explains the highest amphibian roadkill rate in the survey, as well as the corresponding aggregation of predatory reptiles. All mammals recorded as roadkill locally were of species known to scavenge (Whitaker 1996), likely drawn to the road by the abundant herpetofaunal carrion.

At the southern hotspot, SR 29 is elevated and effectively forms a causeway, features which have been linked to increased herpetofaunal roadkill rates (Langen, Ogden & Schwarting 2009). Elevation above ground level may represent a barrier to amphibians, explaining the modest local roadkill rate for the taxon, while still explaining the high reptilian roadkill. There was no evidence of trophic cascade at this location, as the mammalian and reptilian roadkill rates were not correlated, and of the eight mammals recorded five were marsh rabbits (the remaining three being Virginia opossums). This aggregation is more complex to explain than that in the north and warrants further investigation, particularly as it occurs within a protected area.

The cold spot seen in the extra-urban zone immediately south of the SR 82 junction provides evidence of the complex relationship between traffic volume and amphibian roadkill (Grilo, Bissonnete & Santos-Reis 2009; Sutherland, Dunning & Baker 2010), occurring within two kilometres of the hotspot north of the junction. It is possible that this was due to localised faunal depletion or population sink consequent to high traffic volumes (Fahrig *et al*. 1995; Langen *et al*. 2007; Teixeira *et al*. 2017), although amphibian populations may be highly resilient to such pressures (Mazerolle 2004). A reduction in amphibian population may reasonably be expected to reduce predators such as snakes, and the consequent reduction in roadkill would reduce the scavenging mammals strongly correlated to reptile numbers two kilometres north, although reduced detection due to greater degradation and obliteration of carcases consequent to higher traffic volume may also be a factor (Eberhardt, Mitchell & Fahrig 2013; Teixeira *et al*. 2017).

Temporal patterns were only evident in the analysis of kills-by-weekday. Tourism alters patterns of weekend road use (Angel *et al*. 2014), and is a major factor in Florida's economy, contributing over US$60 billion year^{-1} to the state's finances (Houston 2013). Although fewer vehicles use the roads at weekends compared to the weekdays, weekend drivers may travel at higher speeds and be more likely to experience road-traffic accidents (Yu & Abdel-Aty 2013). Nocturnal species constituted 79% of non-avian roadkill, and increased recreation-based road use during Friday and Saturday nights may explain the higher carcass volumes recorded on Saturday and Sunday mornings. In the absence of comparative day/night traffic counts, this hypothesis remains untested. Florida's winter influx of domestic tourists (Smith & House 2006) may have a measurable effect on roadkill patterns on the state's roads (Bernardino & Dalrymple 1992), further highlighting the value of a winter assessment.

Other temporal correlations were elusive, and it is likely that meteorological observations recorded at KFLIMMOK4, 50 kilometres from each end of the transect, inadequately captured the linear nature of SR 29. However, as relationships between variables such as temperature and anuran roadkill may be more likely to be observed over weeks or seasons rather than 24-hour periods (e.g. Glista, DeVault & DeWoody 2008, Coelho *et al*. 2012, D'Amico *et al*. 2015), it is possible that more local-to-carcass meteorological data may still not have demonstrated correlations. Nonetheless, distinct local seasonality and road use patterns warrant a winter comparator study. For example, decreased rainfall and temperature can be strongly associated with decreased anuran roadkill (Glista, DeVault & DeWoody 2008), which would be of particular relevance in my study area.

Temporal changes may be seen in patterns of breeding behaviour, and while there are few studies regarding the effects of roads on gravid vertebrates, it is suggested that roadkill of gravid herpetofauna may be detrimental at the population level (Jochimson 2005). The inclusion of traumatically ejected young would have added a further 109 roadkill to my driven survey count (19.3%). Sex-biases directly related to breeding behaviour have been reported in studies of roadkill mammals (e.g. Russell, Herbert & Kohen 2010), and such susceptibility is a consideration in seasonal roadkill mitigation efforts such as toad-crossings (e.g. Carrier & Beebee 2003), which protect specific taxa from vehicles at specific times.

The traffic volume data from the walked survey correlated closely to county figures, and although this was an estimate of daytime traffic when most WVC occurred overnight, it was indicative of overall traffic volume, strengthening the evidence that traffic volume and amphibian roadkill correlated in extra urban zones with up to 300 vehicles hr^{-1}. Traffic volume assessments must form an important part of planning for the expansion of SR 29. Globally, mitigation efforts have focused on species of conservation concern or those with which collisions represent a danger to human road-users, with a particular bias towards large mammals (Taylor & Goldingay 2010). Roadkill mitigation measures are already applied to SR 29's southernmost 38 kilometres in the form of chain-link fencing and underpasses (Foster & Humphrey 1995). While these measures may explain the absence of large mammals in this survey, such fencing is evidently permeable to all species recorded in this assessment by exploitation of gaps, climbing or passing through the links, which can have serious consequences for human as well as non-human road users. Judging from position, the largest specimen I recorded – an alligator of 2.4 metres total length – had passed under the fence. Vehicular collisions with alligators have resulted in human fatalities (Andrews, Gibbons & Jochimsen 2008), and its presence on the road constituted a serious hazard. Conversely, a sub-adult black bear killed on SR 29 (and removed by FWC prior to my morning survey) highlights an unintended consequence of fencing, in that large mammals that bypass barriers are subsequently trapped on the roadside (Dixon *et al*. 2007). Contingency plans for such events were recommended in an evaluation of the fencing and underpasses along I-75 (Foster & Humphrey 1995).

xpansion plans for SR 29 will require re-evaluation of existing mitigation strategies, including reconstruction of structures such as underpasses, and although no species of conservation concern were recorded by my survey, spatial elements of this assessment may inform such planning. As the majority of WVC recorded involved herpetofauna and meso-mammals of no current conservation concern, mitigation directed at the behaviour of animals as opposed to drivers (e.g. wildlife tunnels rather than signage) would likely be more effective (Beebee 2013) although also more costly (Taylor & Goldingay 2010).

7. RECOMMENDATIONS

While the protocol provides a relatively effective method of roadkill assessment, this study has illustrated clear opportunities for further development. In keeping with the objectives of increasing the utility and flexibility of the protocol, and to develop understanding of temporal and spatial roadkill patterns on SR 29, there are four key recommendations.

1. To develop a standardised walked protocol for assessment of amphibian roadkill.
2. To undertake a winter assessment of SR 29, repeating the hybrid driven-walked survey method applied here.
3. To further investigate and adequately explain the two hotspots identified.
4. To further investigation and explain the cold spot between the SR 82 junction and Immokalee and the area of roadkill absence corresponding to Km87.

8. CONCLUSION

The use of a standardised roadkill assessment protocol allows for meaningful temporal and spatial comparisons to be made between local, national and international studies. Testing the method published by Collinson *et al*. (2014) for the first time in North America has demonstrated that in areas with very high amphibian roadkill rates, the protocol may be better at gauging diversity of roadkill than quantity. Where roadkill rates are modest, as were recorded with three vertebrate taxa here and with all four vertebrate taxa in Collinson *et al*. (2015), the protocol is effective and valuable as an assessment tool, and is straightforward to apply.

By applying the protocol to SR 29, I have demonstrated spatial patterns in vertebrate assemblage and highlighted areas of aggregation. By adding a walked survey to the protocol I have also described the effects of traffic volume on rates of roadkill both spatially and temporally. Overall this assessment provides a robust baseline for future analysis of wildlife vehicle collisions on SR 29 as well as informing future expansion plans for the road. The study has also created avenues for further research within the study area and more widely in terms of developing methods of roadkill assessment.

There is significant conservation value in modifying the protocol by adding a taxon-specific assessment for amphibians. Amphibians are the taxon most impacted by roads, which are being used more frequently and by greater numbers of vehicles. Standardising a method for amphibian roadkill assessment would represent a significant development for both road ecology and the wider field of conservation.

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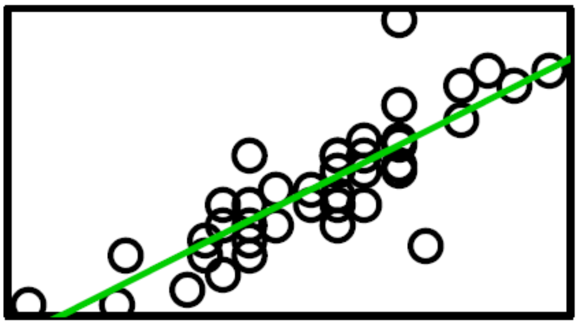
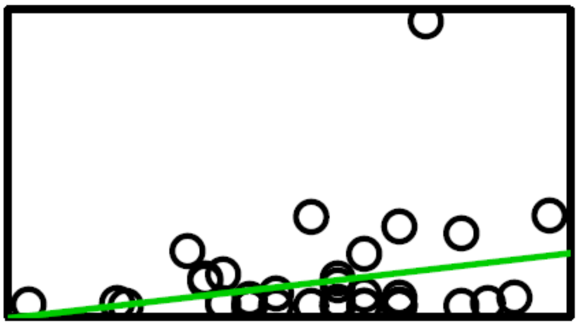
10. APPENDICES

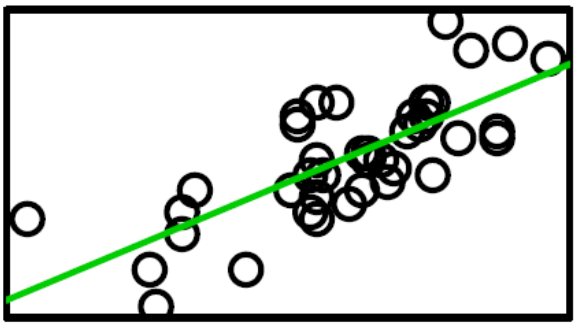
8.1 Appendix 1. Assessment of temporal variables for surrogacy. Variables demonstrating very strong ($r_s \geq 0.7$), significant correlations ($p \leq 0.05$), were deemed surrogates, with only one then tested against roadkill counts. Of all variables tested, only the four combinations illustrated matched these criteria. (a. r_s=0.8293 p=0.04; b. r_s=0.7737 p<0.0001; c. r_s=0.7268 p<0.0001; d. r_s=0.8572 p<0.0001).



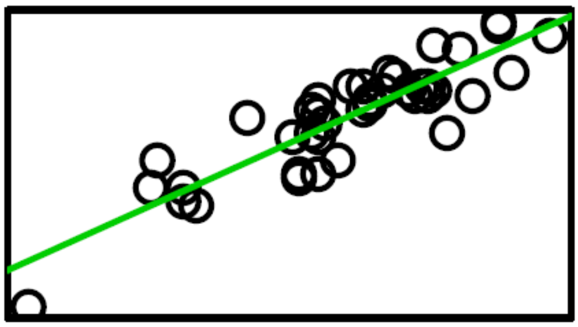
a. Pressure minimum vs Pressure maximum



b. Humidity (maximum) vs Precipitation



c. Temperature average vs Temperature minimum



d. Temperature average vs Temperature maximum

10.2 Appendix 2. Species inventory of roadkill recorded on SR 29. Behaviour (Beh.) refers to primary activity period: cathemeral = C diurnal = D, nocturnal =N.

Class	Order	Family	Species	Common name	Behaviour	n=
Amphibia	Anura	Bufonidae	*Rhinella marina*	Cane toad	N	4
Amphibia	Anura	Hylidae	*Osteopilus septentrionalis*	Cuban tree frog	N	10
Amphibia	Anura	Ranidae	*Lithobates catesbeianus*	American bullfrog	N	11
Amphibia	Anura	Ranidae	*Lithobates grylio*	Pig frog	N	10
Amphibia	Anura	Ranidae	*Lithobates sphenocephalus*	Southern leopard frog	N	60

Class	Order	Family	Species	Common name	Beh.	n=
Aves	Caprimulgif'mes	Caprimulgidae	*Antrostomus carolinensis*	Chuck will's widow	N	1
Aves	Caprimulgif'mes	Caprimulgidae	*Chordeiles minor*	Common nighthawk	N	1
Aves	Cathartiformes	Cathartidae	*Coragyps atratus*	Black vulture	D	11
Aves	Cathartiformes	Cathartidae	*Cathartes aura*	Turkey vulture	D	1
Aves	Columbiformes	Columbidae	*Columba livia domestica*	Feral Pigeon	D	1
Aves	Falconiformes	Falconidae	*Caracara cheriway*	Northern crested caracara	D	1
Aves	Falconiformes	Accipitridae	*Buteo lineatus*	Red shouldered hawk	D	5
Aves	Gruiformes	Rallidae	*Gallinula galeata*	Common gallinule	D	1
Aves	Gruiformes	Rallidae	*Rallus elegans*	King rail	D	1
Aves	Gruiformes	Aramidae	*Aramus guarauna*	Limpkin	D	4
Aves	Passeriformes	Cardinalidae	*Cardinalis cardinalis*	Cardinal	D	3
Aves	Passeriformes	Icteridae	*Quiscalus quiscula*	Common grackle	D	2
Aves	Pelecaniformes	Ardeidae	*Botaurus lentiginosus*	American bittern	D	1
Aves	Pelecaniformes	Ardeidae	*Nycticorax nycticorax*	Black crowned Night Heron	N	2
Aves	Pelecaniformes	Ardeidae	*Ardea alba*	Great egret	D	3
Aves	Pelecaniformes	Ardeidae	*Egretta thula*	Snowy egret	D	1
Aves	Phasianidae	Phasianidae	*Gallus gallus domesticus*	Domestic chicken	D	1
Aves	Piciformes	Picidae	*Dryocopus pileatus*	Pileated woodpecker	D	1
Aves	Piciformes	Picidae	*Melanerpes erythrocephalus*	Red headed woodpecker	D	1
Aves	Strigiformes	Strigidae	*Strix varia*	Barred owl	N	1
Aves	Strigiformes	Strigidae	*Megascops asio*	Eastern screech owl	N	2
Aves	Strigiformes	Strigidae	*Bubo virginianus*	Great horned owl	N	1
Aves	Strigiformes	Strigidae	*Asio flammeus*	Short eared owl	N	1

Class	Order	Family	Species	Common name	Beh.	n=
Mammalia	Carnivora	Felidae	*Lynx rufus*	Bobcat	N	2
Mammalia	Carnivora	Canidae	*Canis familiaris*	Domestic dog	-	4
Mammalia	Carnivora	Felidae	*Felis catus*	Domestic cat	-	7
Mammalia	Carnivora	Procyonidae	*Procyon lotor*	Raccoon	N	18
Mammalia	Cingulata	Dasypodidae	*Dasypus novemcinctus*	Nine-banded armadillo	N	13
Mammalia	Didelphimorpha	Didelphidae	*Didelphis virginiana*	Virginia opossum	N	41
Mammalia	Lagomorpha	Leporidae	*Sylvilagus floridanus*	Cottontail rabbit	N	4
Mammalia	Lagomorpha	Leporidae	*Syvilagus palustris*	Marsh rabbit	N	11
Mammalia	Rodentia	Cricetidae	*Oryzomys palustris*	Marsh rice rat	N	1
Mammalia	Rodentia	Muridae	*Rattus rattus*	Black rat	N	3

Class	Order	Family	Species	Common name	Beh.	n=
Reptilia	Crocodilia	Alligatoridae	*Alligator missisippiensis*	Alligator missisippiensis	C	19
Reptilia	Squamata	Anguidae	*Ophisaurus ventralis*	Eastern glass lizard	D	2
Reptilia	Squamata	Chamaeleonidae	*Chamaeleo calyptratus*	Veiled chameleon	N	2
Reptilia	Squamata	Colubridae	*Cemophora coccinea*	Scarlet snake	N	1
Reptilia	Squamata	Colubridae	*Coluber constrictor priapus*	Southern black racer	D	9
Reptilia	Squamata	Colubridae	*Diadophis punctatus punctatus*	Southern ringneck snake	N	3
Reptilia	Squamata	Colubridae	*Farancia abacura abacura*	Eastern mudsnake	N	19
Reptilia	Squamata	Colubridae	*Nerodia clarkii*	Gulf saltmarsh snake	N	1
Reptilia	Squamata	Colubridae	*N. fasciata pictiventris*	Florida banded watersnake	N	57
Reptilia	Squamata	Colubridae	*N. floridana*	Green watersnake	N	8
Reptilia	Squamata	Colubridae	*Opheodrys aestivus*	Rough Green Snake	N	2
Reptilia	Squamata	Colubridae	*Pantherophis alleghaniensis*	Eastern ratsnake	N	8
Reptilia	Squamata	Colubridae	*Pantherophis guttatus*	Corn snake	N	22
Reptilia	Squamata	Colubridae	*Regina alleni*	Striped crayfish snake	N	6
Reptilia	Squamata	Natricinae	*Thamnophis sauritus*	Peninsula ribbonsnake	N	17
Reptilia	Squamata	Viperidae	*Agkistrodon piscivorus conanti*	Cottonmouth snake	N	23
Reptilia	Testudines	Chelydridae	*Chelydra serpentina osceola*	Florida snapping turtle	N	6
Reptilia	Testudines	Emydidae	*Deirochelys reticularia chrysea*	Florida chicken turtle	D	4
Reptilia	Testudines	Emydidae	*Pseudemys nelsoni*	Florida red bellied cooter	D	1
Reptilia	Testudines	Emydidae	*Pseudemys peninsularis*	Peninsula cooter	D	1
Reptilia	Testudines	Kinosternidae	*Kinosternon baurii*	Striped mud turtle	D	14
Reptilia	Testudines	Trionychidae	*Apalone ferox*	Florida softshell turtle	D	20

8.3 Appendix 3. Research budget.

The high costs involved in carrying out roadkill surveys are frequently cited in the literature (e.g. Costa, Ascensão & Bager 2015). This study was conducted for approximately £2,950, unsalaried, based on the following: return flights (£500), car hire (£1050), accommodation (£ 450), fuel (£350), food (£400) and miscellaneous expenses (£200). Based on UK national minimum wage as of April 1st 2017 and one driver/observer over 25, the total hours involved in fieldwork (8.5hrs x 40 days = 340) would bring the total to £5,500. Consultancy-based rates would increase this significantly.

Appendix C

Small Animal Home Range/Dispersal Distance Data for Determining Approximate Culvert Crossing Spacing

Background and Notes:

Referred to as allometric scaling, home range diameter and dispersal distance has been applied as a metric for determining appropriate spacing of wildlife crossings (Bissonette and Adair 2008; wildlifeandroads.org). This is applicable under two conditions: 1) in the absence of telemetry or other wildlife movement field data to identify specific road crossing locations, and 2) when animal road crossings are condensed and continuous along a long stretch of road. For smaller species that occur along SR 29 we have little data on movement or known road crossing locations. Two brief road mortality studies were conducted that identified general patterns of road-kill hotspots (see Appendices A and B).

To support the two prior road mortality studies and refine our ability to select potential culvert crossing locations, we performed a literature search of small animals found on the Florida Panther National Wildlife Refuge and Big Cypress National Preserve vertebrate species lists. We selected species from these lists that would be most impacted by SR 29 and that would significantly benefit from and utilize culverts to cross under the road. The small animal species used in this analysis is provided below.

An exhaustive search revealed that small animal home range and dispersal distance data were only available for 22 of the 38 species on the list. We first sought data most closely representing the local area. When this was not available, we expanded the search to studies elsewhere in the state, SE United States and broader if that was the only information available. All values in the tables below are from published articles and reports and organized by taxonomic group, size, and terrestrial/aquatic habitat categories to generate overall averages for like classes. Included is an overall summary table and four separate taxonomic group tables.

It is important to note that overall summary totals are calculated values from the individual tables containing the original published figures from the literature. Standard deviations were quite high indicating high variability amongst the studies. Also, some studies provided breakdowns by sex while others presented combined results. In the overall summary, average and minimums for both home range diameter and dispersal distance were similar from 313 m (1,027 ft) to 351 m (1152 ft).

Species List

TX Group	Category	No.	Scientific Name	Common Name
Amphibian	Frogs	1	*Lithobates grylio*	Pig Frog
Amphibian	Frogs	2	*Acris gryllus*	Southern Cricket Frog
Amphibian	Frogs	3	*Lithobates sphenocephalus*	Southern Leopard Frog
Amphibian	Frogs	4	*Anaxyrus terrestris*	Southern Toad
Amphibian	Salamander	5	*Eurycea quadridigitata*	Dwarf Salamander
Amphibian	Salamander	6	*Notophthalmus viridescens piaropicola*	Peninsula Newt
Crocodilian	Alligator	7	*(J) Alligator mississippiensis*	(J) American Alligator
Mammal	Medium	8	*Procyon lotor*	Raccoon
Mammal	Medium	9	*Lontra canadensis*	River Otter
Mammal	Small	10	*Mustela vison evergladensis*	Everglades Mink
Mammal	Small	11	*Sylvilagus palustris*	Marsh Rabbit
Mammal	Small	12	*Oryzomys palustris*	Rice Rat
Mammal	Small	13	*Neofiber alleni*	Round-tailed Muskrat
Snakes	Large	14	*Lampropeltis getula floridana*	Florida Kingsnake
Snakes	Large	15	*Drymarchon couperi*	Eastern Indigo Snake
Snakes	Medium	16	*Pantherophis guttatus*	Corn Snake
Snakes	Medium	17	*Thamnophis sirtalis sirtalis*	Eastern Garter Snake
Snakes	Medium	18	*Pantherophis alleghaniensis*	Eastern Rat Snake
Snakes	Medium	19	*Coluber constrictor paludicola*	Everglades Racer
Snakes	Medium	20	*Coluber constrictor priapus*	Southern Black Racer
Snakes	Small	21	*Sistrurus miliarius barbouri*	Dusky Pygmy Rattlesnake
Snakes	Small	22	*Thamnophis saurita sackenii*	Peninsula Ribbon Snake
Snakes	Water	23	*Nerodia taxispilota*	Brown Water Snake
Snakes	Water	24	*Farancia abacura abacura*	Eastern Mud Snake
Snakes	Water	25	*Agkistrodon piscivorus conanti*	Florida Cottonmouth
Snakes	Water	26	*Nerodia floridana*	Florida Green Water Snake
Snakes	Water	27	*Nerodia fasciata pictiventris*	Florida Water Snake
Snakes	Water	28	*Liodytes pygaea cyclas*	S. Florida Black Swamp Snake
Snakes	Water	29	*Liodytes alleni*	Striped Crayfish Snake
Turtles	Aquatic	30	*Sternotherus odoratus*	Common Musk Turtle
Turtles	Aquatic	31	*Chelydra serpentina*	Common Snapping Turtle
Turtles	Aquatic	32	*Deirochelys reticularia chrysea*	Florida Chicken Turtle
Turtles	Aquatic	33	*Kinosternon subrubrum steindachneri*	Florida Mud Turtle
Turtles	Aquatic	34	*Pseudemys nelsoni*	Florida Red-Bellied Cooter
Turtles	Aquatic	35	*Apalone ferox*	Florida Softshell Turtle
Turtles	Aquatic	36	*Pseudemys peninsularis*	Peninsular Cooter
Turtles	Aquatic	37	*Kinosternon baurii*	Striped Mud Turtle
Turtles	Semi-aquatic	38	*Terrapene bauri*	Florida Box Turtle

Overall Summary – Species Home Range/Dispersal and Approx. Culvert Crossing Spacing

			Home Range Diameter (m)			Dispersal (m)			
Taxa	**Type/Size Class**	***n***	**avg**	**min**	**max**	**avg**	**min**	**max**	
Amphibians	frogs	2	3.58	0.88	2576		566	2912.5	
Amphibians	salamanders	2						800	
Crocodilians	alligator (juv)	1		1200	6000				
Snakes	small	1	106.41			19			
Snakes	medium-sized	3	354.95	257.32	510.90				
Snakes	large	2	1558.98	667.56	4425.20			8000	
Snakes	water	5	347.05	72.07	371.55	351.5		< 1000	
Turtles	semi-aquatic	1	101.56	60.76	139.12				
Turtles	aquatic	6	234.47	81.63	485.61	635.5	268	2312.82	
Mammals	small	4	100.88			247.45	200	1150	
		27	**350.98**	**334.32**	**2073.63**	**313.36**	**344.67**	**3035.06**	Avg
			504	444.41	2338.16	255.75	194.67	2904.14	Stdev

Amphibian Summary

			Home Range Diameter (m)			Dispersal (m)			
Taxa	**Common Name**	***n***	**avg**	**min**	**max**	**avg**	**min**	**max**	
Frogs	southern cricket frog								
Frogs	southern toad	1	3.58	0.88	2576		132	825	
Frogs	pig frog								
Frogs	southern leopard frog	1					1000	5000	
		2	3.58	0.88	2576		566.0	2912.5	Avg
							613.77	2952.17	Stdev
Salamanders	peninsula newt	1						1000	
	dwarf salamander	1						600	
		2						800	Avg
								282.84	Stdev

Snake Summary

				Home Range Diameter (m)			Dispersal (m)			
Taxa	**Type/Size Class**	**Common Name**	***n***	**avg**	**min**	**max**	**avg**	**min**	**max**	
Snakes	small	dusky pigmy rattlesnake	1				19			
Snakes	small	dusky pigmy rattlesnake (m)		133.04						
Snakes	small	dusky pigmy rattlesnake (f)		79.78						
Snakes	small	peninsula ribbon snake								
			1	106.41			19			Avg
				37.66						Stdev
Snakes	medium	southern black racer	1	390.88	257.32	510.9				
Snakes	medium	Everglades racer								
Snakes	medium	cornsnake	1	369.1						
Snakes	medium	eastern rat snake	1	304.88						
Snakes	medium	eastern garter snake								
			3	354.95	257.32	510.9				Avg
				44.71						Stdev
Snakes	large	Florida kingsnake	1	793.08						
Snakes	large	eastern indigo snake	1		667.56	4425.2			8000	
Snakes	large	e. indigo snake (m)		2617.26						
Snakes	large	e. indigo snake (f)		1266.6						
			2	1558.98	668	4425			8000	Avg
				946.58						Stdev
Snakes	water	FL cottonmouth (m)	1	722.52						
Snakes	water	FL cottonmouth (f)		298.54						
Snakes	water	eastern mud snake	1	91.66						
Snakes	water	Florida watersnake	1		137.96	300.44	433			
Snakes	water	striped crayfish snake								
Snakes	water	S. FL black swamp snake								
Snakes	water	brown watersnake	1				270		< 1000	
Snakes	water	FL green watersnake	1	275.48	6.18	442.66				
			5	347.05	72.07	371.55	351.5		< 1000	Avg
				446.09	93.18	100.56	115.26			Stdev

Turtle Summary

				Home Range Diameter (m)			Dispersal (m)			
Taxa	**Type**	**Common Name**	***n***	**avg**	**min**	**max**	**avg**	**min**	**max**	
Turtles	aquatic	common musk turtle	1		113.4	257.8		0	740	
Turtles	aquatic	Florida softshell								
Turtles	aquatic	Florida chicken turtle	1		79.78	356.82				
Turtles	aquatic	FL chicken turtle (m)		294.24						
Turtles	aquatic	FL chicken turtle (f)		188.82						
Turtles	aquatic	FL mud turtle	1	486.64				774	815	
Turtles	aquatic	FL red-bellied cooter	1	120	10	990	650		6500	
Turtles	aquatic	common snapping turtle	1	376.44	167.36	688.04	621	30	3226	
Turtles	aquatic	peninsula cooter								
Turtles	aquatic	striped mud turtle	1		37.62	135.38			283.1	
Turtles	aquatic	striped mud turtle (m)		99.36						
Turtles	aquatic	striped mud turtle (f)		75.76						
			6	234.47	81.63	485.61	635.5	268	2312.82	Avg
				155.96	65.85	333.27	20.51	438.47	2607.84	Stdev
Turtles	semi-aquatic	Florida box turtle	1	101.56	60.76	139.12				

Small Mammal Summary

			Home Range Diameter (m)			Dispersal (m)			
Taxonomic Group	**Common Name**	***n***	**avg**	**min**	**max**	**avg**	**min**	**max**	
small mammal	Everglades mink (f)	1	80						
small mammal	round-tailed muskrat	1	46.04			462			
small mammal	marsh rabbit	1	224.54				200	2000	
small mammal	rice rat	1	52.92			32.9		300	
		4	100.88			247.45	200	1150	Avg
			83.74			303.42		1202.08	Stdev

Meso-Mammal Summary

This category was left out because the representatives from this group that might use the culvert crossings had average home range sizes and dispersal distances exceeding all other species groups included in the analysis by at least an order of 10. Therefore, it was determined that the large crossing spacing was sufficient to meet their needs for habitat connectivity, though the smaller culvert crossings might still be used by species in this category. Members of this group included river otter and raccoon.

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