FINAL REPORT

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Project 55: Ocelot Movements along the Rio Grande Corridor and possible Impacts of Proposed International Bridges

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Project Title: Ocelot Movement along the Rio Grande Corridor and Possible Impacts of Proposed International Bridges

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Objective: To develop and information base to facilitate ocelot (Felis pardalis) management along the Rio Grande Corridor and help formulate conservation strategies that will assist endangered cat persistence and coexistence with international bridges.

PREFACE

The attached Final Report entitled "Spatial Patterns and Habitat Use by Free-Ranging Cats near International Bridges in Texas" by Clay V. Fischer and Michael E. Tewes resulted directly from this objective and is submitted in fulfillment of the report requirement.

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Date: November 6, 1996

Approved by: ____________________
Neil E. Carter
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Date: December 31, 1996

FINAL REPORT

SPATIAL PATTERNS AND HABITAT USE BY FREE-RANGING CATS NEAR INTERNATIONAL BRIDGES IN TEXAS

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ABSTRACT

Reaction to international bridges and habitat use versus availability of an ocelot (*Felis pardalis*)and 8 bobcats (*Felis rufus*) in the Lower Rio Grande Valley of Texas were studied from May 1995 through August 1996 using radiotelemetry. The ocelot never approached any international bridges. Bobcats were located several times within 1 km of international bridges but were not recorded passing under the bridges. Ocelot locations collected during this study (*n* = 119) were pooled with locations collected during a previous study in 1992 and 1993 (*n* = 86) and used to determine home range size. Radio locations (*n* = 761) of 4 female and 4 male bobcats were obtained and used to determine home range size. Habitat use for female bobcats (*n* = 174), male bobcats (*n* = 137), and the ocelot (*n* = 92) was determined using locations with a 1 ha error polygon completely within 1 habitat type. Habitat use versus availability was determined from infrared aerial photographs and ArcInfo software. Habitat use by the ocelot was different ($P < 0.05$) from availability of habitats within its home range; thorn forest habitat was preferred. Wetland, early successional, and developed land habitats were avoided. Habitat use by 4 pooled female bobcats and 4 pooled males was different ($P < 0.05$) from availability within the home range; early successional habitat was preferred by females and thorn forest was preferred by males. Both sexes avoided

developed land habitats. Ocelot avoidance of 60% of the habitat types suggests a problem coping with fragmentation of thorn forest habitats. Data suggests that habitat fragmentation would be less disruptive to bobcats compared to ocelots.

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INTRODUCTION

The Lower Rio Grande Valley (LRGV) of Texas is part of the Matamoran District of the Tamulipan Biotic Province of south Texas (Blair 1950). Conversion of this unique ecosystem (Jahrsdoerfer and Leslie 1988) to cropland has fragmented and reduced possible habitat of the ocelot and jaguarundi by 95% (Purdy 1983). Ocelots (*Felis pardalis*) and jaguarundis (*Felis yagouaroundi*) are listed as endangered in the United States by the Texas Parks and Wildlife Department (TPWD) and the U. S. Fish and Wildlife Service (USFWS) (Laack 1991). South Texas is the only area in the United States that supports a known resident population of ocelots. The recent signing of the North American Free Trade Agreement (NAFTA) has led to increased development of international bridges in the LRGV. The response of wild cats to the fragmentation of habitat associated with the bridges is poorly understood.

The tasks of this study were to: (1) visually examine potential survey sites, (2) conduct live box-trapping for ocelots, jaguarundis, and bobcats, (3) safely immobilize captured wild cats to collect biological information and samples and attach radio-collars, (4) radio-track captured wild cats to collect information on movements and habitat use, (5) assess the feasibility of a variety of bridge designs, operational features, and mitigation plans to determine their applicability to endangered cat conservation in south Texas, (6) conduct a literature survey and review other bridge-wildlife projects to provide information addressing the situation along the Rio Grande, and (7) provide four copies of a final report, complete with three copies of USGS 7.5' maps depicting locations of the study efforts to TPWD.

LITERATURE REVIEW

Ocelot

The ocelot is a spotted medium-sized cat found from Argentina to Texas (Navarro-Lopez 1985). Prior to 1900, the ocelot could be found as far north and east as Arkansas and Louisiana (Woodward 1980, Navarro-Lopez 1985). Presently, ocelots found in the United States are confined to southern Texas and possibly Arizona (Hall 1981).

Even though the ocelot is listed as a furbearer, little was known of its life history until the 1980's. Since then, studies in Belize (Konecny 1989), Mexico (Caso 1994), Peru (Emmons 1987; Emmons et al. 1989), Texas (Navarro-Lopez 1985, Tewes 1986; Laack 1991) and Venezuela (Ludlow and Sunquist 1987, Sunquist et al. 1989) have increased knowledge about ocelot ecology. However, little is known about ocelot ecology relative to the construction of international bridges or bridge effects of cat use of the Rio Grande Corridor.

Jaguarundi

The jaguarundi is a small, unspotted, slender-bodied, long-tailed, short-legged, weasel-like cat (Davis and Schmidly 1994). The jaguarundi is reported from Central and South America and as far north as southern Texas (Caso 1994). However, the jaguarundi is extremely rare in Texas (Tewes and Everett 1986). The last confirmed report of a jaguarundi in southern Texas was from 21 April 1986 when a road-killed individual was found in Cameron County. Prior to this, the last confirmed specimen was in 1969 (Harwell & Siminski 1990). This felid is listed as endangered in the United States and is thought to inhabit only the extreme southern 3 counties (i.e., Cameron, Hidalgo, and Willacy counties) of Texas (Tewes and Everett 1986). There are numerous unconfirmed reports of jaguarundis north of this area, but most of these seem to be misidentified feral cats or other species.

In 1969, a study was initiated by a Texas A&I graduate student to ascertain the status of the jaguarundi in south Texas. No wild jaguarundis were sighted or captured during this brief field study, but one hunter-killed specimen was sent to Texas A&I University (Goodwyn 1970).

Predators and Wildlife Crossing Structures

Few studies have examined wildlife crossing structures and predators. Waters (1988) stated that coyotes (*Canis latrans*), gray wolves (*Canis lupus*), black bears (*Ursus americanus*) and lynx (Felis lynx) used underpasses when convenient, but continued to cross a fenced interstate where crossing structures were not present. In a study concerning European badgers (Meles meles), (Ratcliffe 1974) stated that highway mortality ceased after installation of fences and underpasses. Foster and Humphrey (1992) found that bobcats (Felis rufus), black bears (Ursus americana), and Florida panthers (Felis concolor coreyi) used underpasses as travel corridors across an interstate highway in southern Florida. Extensive fencing of both sides of the road and placement of wildlife crossing structures at sites where animals were known to cross the road aided acceptance and use of crossing structures. Prior to construction of the fence and installation of the wildlife crossing structure on I-75 in southern Florida, highway mortality was a common cause of death for the endangered Florida panther.

Most studies concerning wildlife crossing structures have dealt with ungulates. Reed et al. (1975) recommended that bridge-type underpasses be used concurrently with fencing. Underpasses should be wide, high, and provide approaching animals a clear view of the habitat or horizon on the far side of the underpass. Skylights or artificial lighting are unnecessary.

STUDY AREA

Data were collected from May 1995 to August 1996 in Hidalgo County, Texas at Santa Ana National Wildlife Refuge (NWR), Lower Rio Grande Valley NWR, Texas Nature Conservancy property, and TPWD property (Figure 1). The climate of this area is subtropical with dry winters and hot humid summers. Mean annual temperature was 23 C (Jacobs 1981). Winters are mild with occasional frosts, highest temperatures occur in August and lowest in January. Average annual rainfall was 57 cm with a peak in September. Tropical storms and hurricanes significantly impact the area.

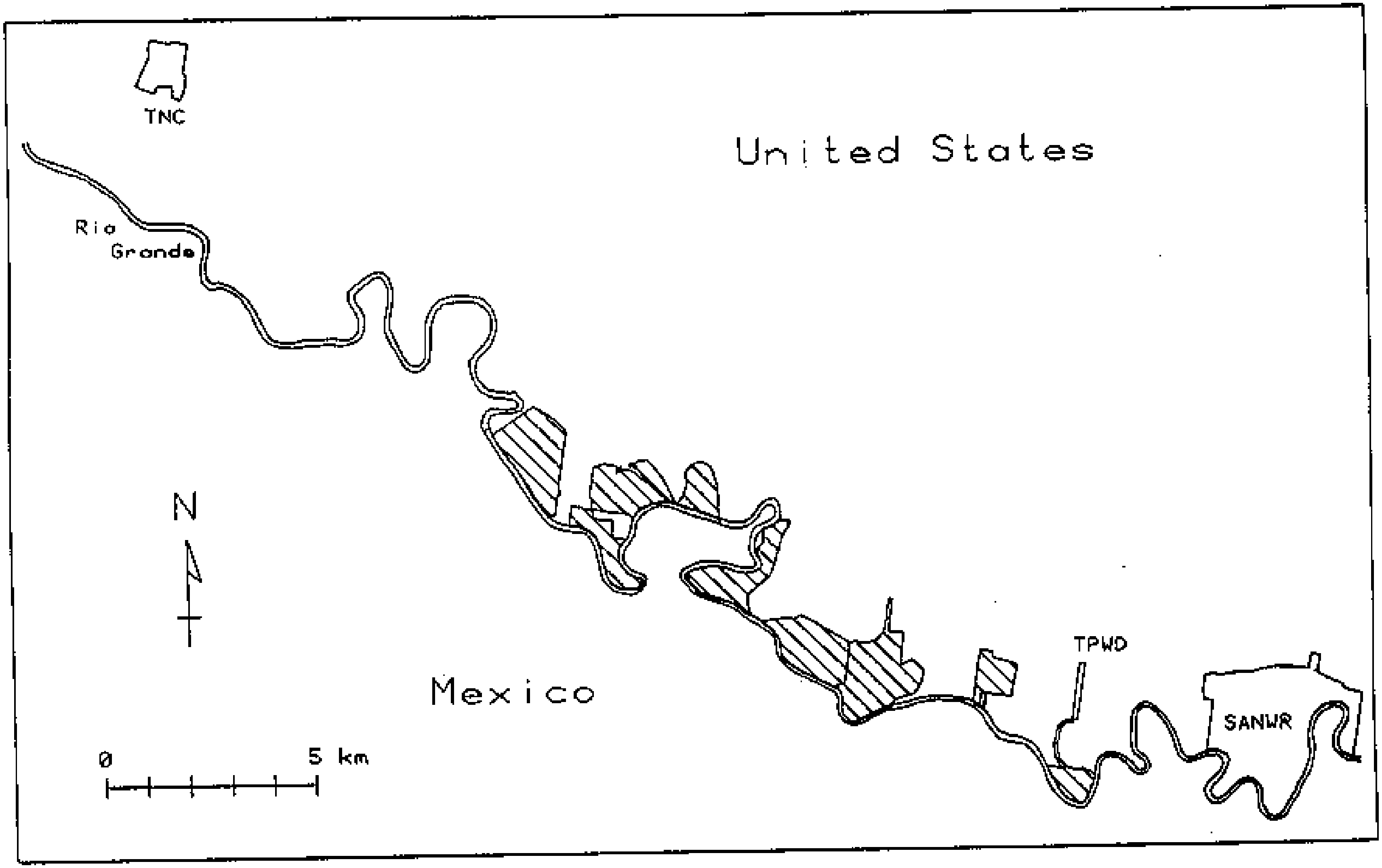
Hidalgo County is located in the Rio Grande Plain of south Texas (USFWS 1980). Soils in the area consist of mostly fluviatile deposits, ranging from dark, clayey soil in the uplands to gray, siltly loams adjacent to the river (USFWS 1980).

METHODS

Capture and Handling

Habitat potential, proximity to an international bridge, and accessibility were criteria used to determine trap sites. Cats were captured with Tomahawk wire box-traps (107 x 50 x 40 cm). A live chicken was placed in a compartment attached to the rear of each trap. Traps were set in brush near game trails, and in shade to reduce the risk of hyperthermia. During winter, fall,

Figure 1. Study area: Santa Ana National Wildlife Refuge (SANWR), Lower Rio Grande Valley NWR tracts (shaded), Kelly Brush (TPWD), and Chihuahuan Woods (TNC).



and spring, traps were open continually. However, during the summer, traps were closed at 10:00 a.m. and reopened at 4:00 p.m. to reduce exposure of captured animals to extreme heat.

Cats were immobilized with a mixture of ketamine hydrochloride (20 mg/kg body weight) and xylazine hydrochloride (5 mg) (Beltran and Tewes 1995) administered by pole syringe. A radio-collar (Advanced Telemetry Systems) was attached to the cat after sedation. Body weight, total body length, right hind-foot length, tail length, girth, ear length, canine length, and teat length or scrotum width were obtained. Body temperature was monitored throughout the procedure and alcohol rubbed on pads of feet and ice packs placed between legs when it rose above 40 C. Ectoparasites were collected and preserved in isopropyl alcohol. Five cubic centimeters (cc) of blood were withdrawn with half placed in 10 cc of Longmire's buffer solution and the other half in an anticoagulate and then refrigerated. Sedated cats were then returned to the box-trap for recovery. Cats were released when recovery from sedation occurred (approximately 4 hours).

Data Collection

A Telonic's portable tracking receiver and "H" antenna were used to monitor cats. Tracking occurred during both diurnal and nocturnal hours to obtain a more accurate estimate of home ranges. A minimum of 2 bearings were taken from different stations with a Suunto hand-held compass. Each bearing was corrected for "true north" variation by adding 8^0 to the bearing obtained. Date, time, and station number were noted. Wild cats were located $\geq$60 times and at least 8 hours passed between locations to facilitate independence of locations.

Home Range Estimation

MacDonald et al. (1980) defined home range as the smallest convex polygon that encloses the locational observations. The 95% minimum convex polygon (Mohr and Stumpf 1966) is the non-parametric model used to evaluate home range size. The 95% minimum convex polygon method was used because it excludes fixes representing unusual or exploratory trips by radio-collared cats (Kenward 1987).

Locations of stationary check stations were determined by use of the Global Positioning System. Coordinates of cat locations were analyzed using the Telem88 home range program. To improve accuracy and precision of animal locations, a maximum of 15 minutes was allowed between fixes and bearings that intersected at angles <30 or >150 degrees were discarded.

Habitat Use Versus Availability

Habitats were identified by infrared photographs and ground truthing. Habitat types were classified as developed land, wetland, early succession, riparian forest, or thorn forest (Table 1). Habitat types were digitized using ArcInfo. Cat location estimates with a 1 ha error polygon and individual home

Table 1. Habitat classification for the study area in the Lower Rio Grande Valley of Texas, 1995-1996.

Physiognomic division	Habitat
Developed Land	Oil & Gas Structures
	Cropland
	Grazing Pastures
	Homesites
Wetland	Wetland
Early Successional	River Cane
	Baccharris
	Baccharris/Willow
	Early Thorn forest
	USFWS Revegetation
Grassland	Grassland
Riparian Forest	Elm Forest
	Elm/Mesquite Forest
	Hackberry Forest
	Mixed Deciduous
	Mixed Forest
Thorn Forest	Ebony Forest
	Thorn Forest

range polygons were overlaid onto the digitized habitat map. Habitats containing error polygons of locations estimates that did not overlap >1 habitat type were considered habitats used. Location error polygons that overlapped >1 habitat type were not included in the analysis. Because removal of locations reduced sample sizes for individual bobcats, composite ranges formed by uniting home range polygons of individual bobcats were considered available habitat (Hellgren et al. 1991)

Telemetry data collected from 1992-1996 were used to determine habitat use of the ocelot. Data among years were pooled because of small sample size. Habitat use and availability was determined by the method described above. Preference or avoidance of individual habitat types was determined by using Chi-square analysis (Neu et al. 1974) and Bonferroni simultaneous confidence intervals (Byers et al. 1984). If habitats were used more or less ($\underline{P} < 0.05$) than available, they were considered preferred or avoided, respectively.

Totals of 174 radio locations from 4 females and 137 radio location from 4 males were used to compare habitat use to habitat availability for bobcats. A total of 92 radio locations were used from 1 adult female ocelot at Santa Ana NWR to compare habitat use to availability for ocelots.

RESULTS

Study sites were surveyed for a combined 8,304 trap nights (Table 2). We captured 326 specimens representing 16 species (Table 3). The most frequently captured species was the Common raccoon (*Procyon lotor*) which accounted for almost half of all specimens. Bobcats were captured 26 times, including 5 recaptures.

Home Range Estimation

Bobcat.--Twenty bobcats were trapped and radio-collared. However, due to collar failure or death of the cat, ≥50 locations were obtained for only 8 bobcats for which home range estimates were determined (Table 4). Mean home ranges were 2.93 km^2 (n = 3, SD = 1.32) for adult males and 3.76 km^2 (n = 3, SD = 2.22) for adult females. Mean home range was 3.35 km^2 (n = 6, SD = 1.69) for both sexes. Several cats were located in Mexico and home ranges of BF5, BF 10, BF19, BM6, and BM8 overlapped into Mexico (Figure 2).

Ocelot.--The ocelot tracked during this study was an adult female recaptured by Americorp personnel in April 1995 on Santa Ana NWR. During 1995 and 1996, the cat was radio-tracked by Americorp members and Clay Fischer. Home range estimates for 1992-1993 and 1995-1996 were 5.36 km^2 and 7.73 km2, respectively (Table 5). This cat had previously been collared and radio-tracked in 1992-1993. Locations collected during the 1992-1993

Table 2. Trap sites, number of trap nights, and size of the tracts in the Lower Rio Grande Valley of Texas, 1995-1996.

TRAP SITE	TRAP NIGHTS	SIZE (ha)
Santa Ana NWR	2,294	827
Milagro-Kelly Brush	1,263	95
Vela Woods	992	90
Pharr Settling Basin	854	501
Hidalgo Bend	726	215
Pate Bend	737	180
Cottam	259	394
Gabrielson	939	260
Chihuahuan Woods	240	115
Total	8,304	

Table 3. Animals captured with 8,304 trap nights in the Lower Rio Grande Valley of Texas, 1995-1996.

SPECIES	SCIENTIFIC NAME	NO. OF CAPTURES
Mammals		
Bobcat	(_Felis rufus_)	26
Coyote	(_Canis latrans_)	6
Feral dog	(_Canis familiaris_)	13
Common raccoon	(_Procyon lotor_)	157
Virginia opossum	(_Didelphis virginiana_)	54
Nine-banded armadillo	(_Dasypus novemcinctus_)	28
Striped skunk	(_Mephitis mephitis_)	20
Eastern cottontail	(_Sylvilagus floridanus_)	1
Southern plains woodrat	(_Neotoma micropus_)	5
Eastern fox squirrel	(_Sciurus niger_)	2
Birds		
Great-tailed grackle	(_Quiscalus mexicanus_)	1
Green jay	(_Cyanocorax yncas_)	4
Mourning dove	(_Zenaida macroura_)	1
White-tipped dove	(_Leptotila verreauxi_)	3
Cooper's hawk	(_Accipiter cooperii_)	1
Red-tailed hawk	(_Buteo jamaicensis_)	1
Harris hawk	(_Parabuteo uncinctus_)	3
Total captures		326

Table 4. Home range and number of locations for 8 radio-collared bobcats using 95% minimum convex polygon method in the Lower Rio Grande Valley of Texas, 1995-1996.

ID	Sex/Age	No. of Locations	Home Range (km^2)
BF4	F/A	107	1.20
BF5	F/A	103	5.03
BM6	M/A	83	3.19
BM8	M/A	111	4.11
BF10	F/A	99	5.05
BM13	M/A	90	1.50
BM15	M/SA	84	0.43
BF19	F/SA	84	0.99
Adult male (n = 3)			$\bar{x}$ = 2.93 SD = 1.32
Adult female (n = 3)			$\bar{x}$ = 3.76 SD = 2.22
Comb./Adult (n = 6)			$\bar{x}$ = 3.35 SD = 1.69

[a] M = Male; F = Female

A = Adult; SA = Subadult

Figure 2. Ocelot (dashed) and bobcat (solid) home ranges as determined by 95% convex polygon method in relation to international bridges.

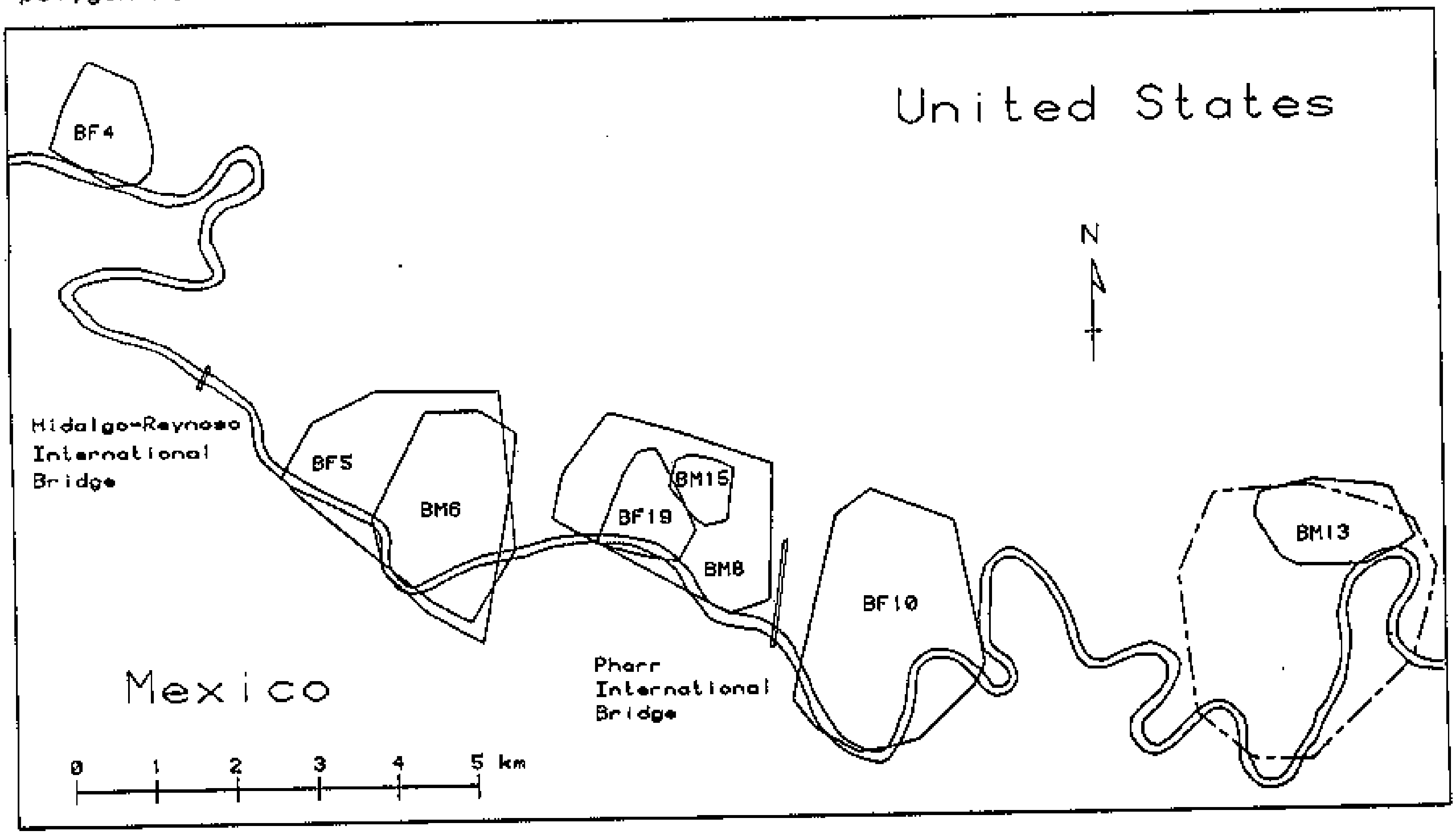


Table 5. Home range and number of locations for the ocelot on Santa Ana NWR using 95% minimum convex polygon method in the Lower Rio Grande Valley of Texas, 1992-1993 and 1995-1996.

ID	YR	Sex/Age[a]	No. of Locations	Home Range (km^2)
OCE88	1993	F/A	86	5.36
	1996		119	7.73
	Pooled		205	8.00

[a] F = Female

A = Adult

period (_n_ = 86) and 1995-1996 period (_n_ = 119) were combined and used to determine home range size. Estimated home range size, pooled across years was 8.00 km^2. No other ocelots were captured or radio-tracked.

Habitat Use Versus Availability

Bobcat.--Habitat availability and use were determined for female and male bobcats, respectively (Tables 6 and 7). Female bobcats preferred early successional habitats and avoided developed land (Table 8). Thorn forest, grassland, wetland, and riparian forest habitats were used in proportion to their availability (Table 8). Male bobcats preferred thorn forest habitats and avoided developed land (Table 9). Riparian forest, grassland, wetland, and early successional habitats were used in proportion to their availability (Table 9).

Ocelot.--Estimated home range from pooled data (Table 10) was used to compare habitat availability with use for the ocelot. The ocelot preferred thorn forest habitat (Table 11). Wetland, early successional, and developed land habitats were avoided (Table 11). Riparian forest was used in proportion to its availability (Table 11).

Table 6. Habitat use and availability for 4 female bobcats. Use is based on 174 locations in the Lower Rio Grande Valley of Texas, 1995-1996.

Habitat type	Total area (ha)	Proportion of home range	Expected usage	Observed usage
Thorn Forest	153	0.04	7.53	11
Riparian Forest	107	0.03	5.24	5
Wetland	338	0.09	16.61	9
Early Succession	802	0.20	35.55	64
Grassland	148	0.04	6.58	10
Developed	2,379	0.61	116.89	75
Total	3,927	1.00	174.00	174

Table 7. Habitat use and availability for 4 male bobcats. Use is based on 137 locations in the Lower Rio Grande Valley of Texas, 1995-1996.

Habitat type	Total area (ha)	Proportion of home range	Expected usage	Observed usage
Thorn Forest	277	0.10	13.63	39
Riparian Forest	291	0.10	14.32	16
Wetland	264	0.09	12.98	13
Early Succession	351	0.13	17.29	32
Grassland	65	0.02	3.21	1
Developed	1,534	0.55	75.57	36
Total	2,781	1.00	137.00	137

Table 8. Simultaneous confidence intervals using the Bonferroni approach for use of habitat types by 4 female bobcats in the Lower Rio Grande Valley of Texas, 1995-1996.

Habitat type	Expected usage	Actual usage	Bonferroni 95% C.I. for actual usage (p)[a]
Thorn Forest	0.04	0.06	$0.01 \leq p \leq 0.11$
Riparian Forest	0.03	0.03	$-0.01 \leq p \leq 0.06$
Wetland	0.09	0.05	$0.01 \leq p \leq 0.10$
Early Successional	0.20	0.37	$0.27 \leq p \leq 0.47$+
Grassland	0.04	0.06	$0.01 \leq p \leq 0.05$
Developed	0.61	0.43	$0.33 \leq p \leq 0.53$-

[a] (+) denotes habitat was used more ($P \leq 0.05$) than expected.

(-) denotes habitat was used less ($P \leq 0.05$) than expected.

Table 9. Simultaneous confidence intervals using the Bonferroni approach for use of habitat types by 4 male bobcats in the Lower Rio Grande Valley of Texas, 1995-1996.

Habitat type	Expected usage	Actual usage	Bonferroni 95% C.I. for actual usage (p)[a]
Thorn Forest	0.10	0.29	$0.18 \leq p \leq 0.39$+
Riparian Forest	0.11	0.12	$0.04 \leq p \leq 0.19$
Wetland	0.09	0.05	$0.01 \leq p \leq 0.10$
Early Successional	0.20	0.39	$0.27 \leq p \leq 0.47$
Grassland	0.04	0.06	$0.01 \leq p \leq 0.05$
Developed	0.61	0.43	$0.33 \leq p \leq 0.53$-

[a] (+) denotes habitat was used more ($P \leq 0.05$) than expected.
(-) denotes habitat was used less ($P \leq 0.05$) than expected.

Table 10. Habitat use versus availability for pooled home range of the ocelot on Santa Ana NWR. Use is based on 92 locations in the Lower Rio Grande Valley of Texas, 1992-1996.

Habitat type	Total area (ha)	Relative area	Expected usage	Observed usage
Thorn Forest	279	0.35	32.18	55
Riparian Forest	299	0.38	34.57	36
Wetland	62	0.08	7.14	1
Early Succession	54	0.07	6.23	0
Developed	103	0.13	11.88	1
Total	798	1.00	92.00	92

Table 11. Simultaneous confidence intervals using the Bonferroni approach for use of habitat types by the ocelot on Santa Ana NWR, Lower Rio Grande Valley of Texas, 1992-1996.

Habitat type	Expected usage	Actual usage	Bonferroni 95% C.I. for actual usage (p)[a]
Thorn Forest	0.35	0.60	$0.47 \le p \le 0.73$+
Riparian Forest	0.38	0.39	$0.26 \le p \le 0.52$
Wetland	0.08	0.01	$-0.02 \le p \le 0.04$-
Early Successional	0.07	0.00	$0.00 \le p \le 0.00$-
Developed	0.13	0.01	$-0.02 \le p \le 0.04$-

[a] (+) denotes habitat was used more ($P \le 0.05$) than expected.
(-) denotes habitat was used less ($P \le 0.05$) than expected.

Figure 3. Locations of BF16 in relation to international bridges.

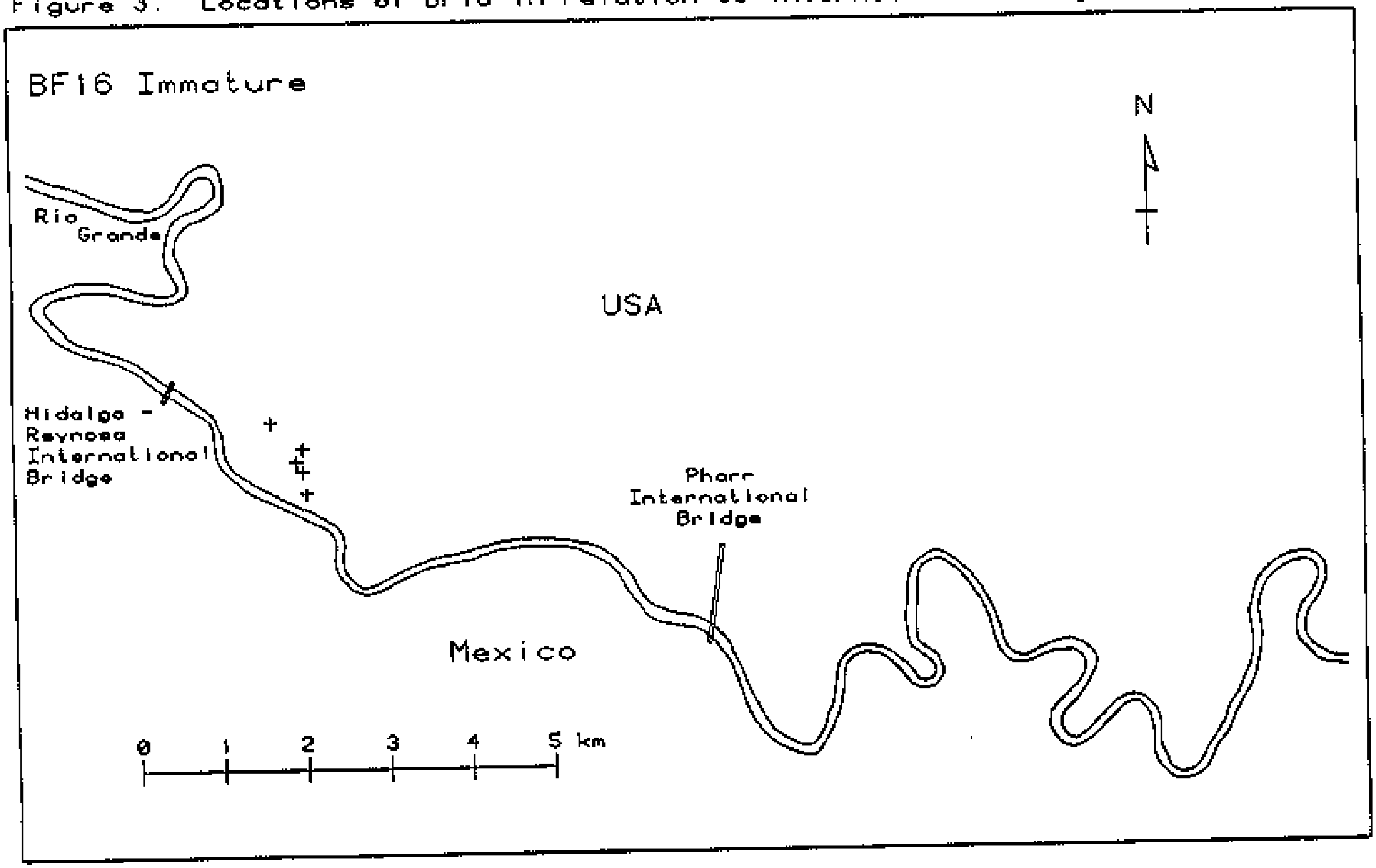
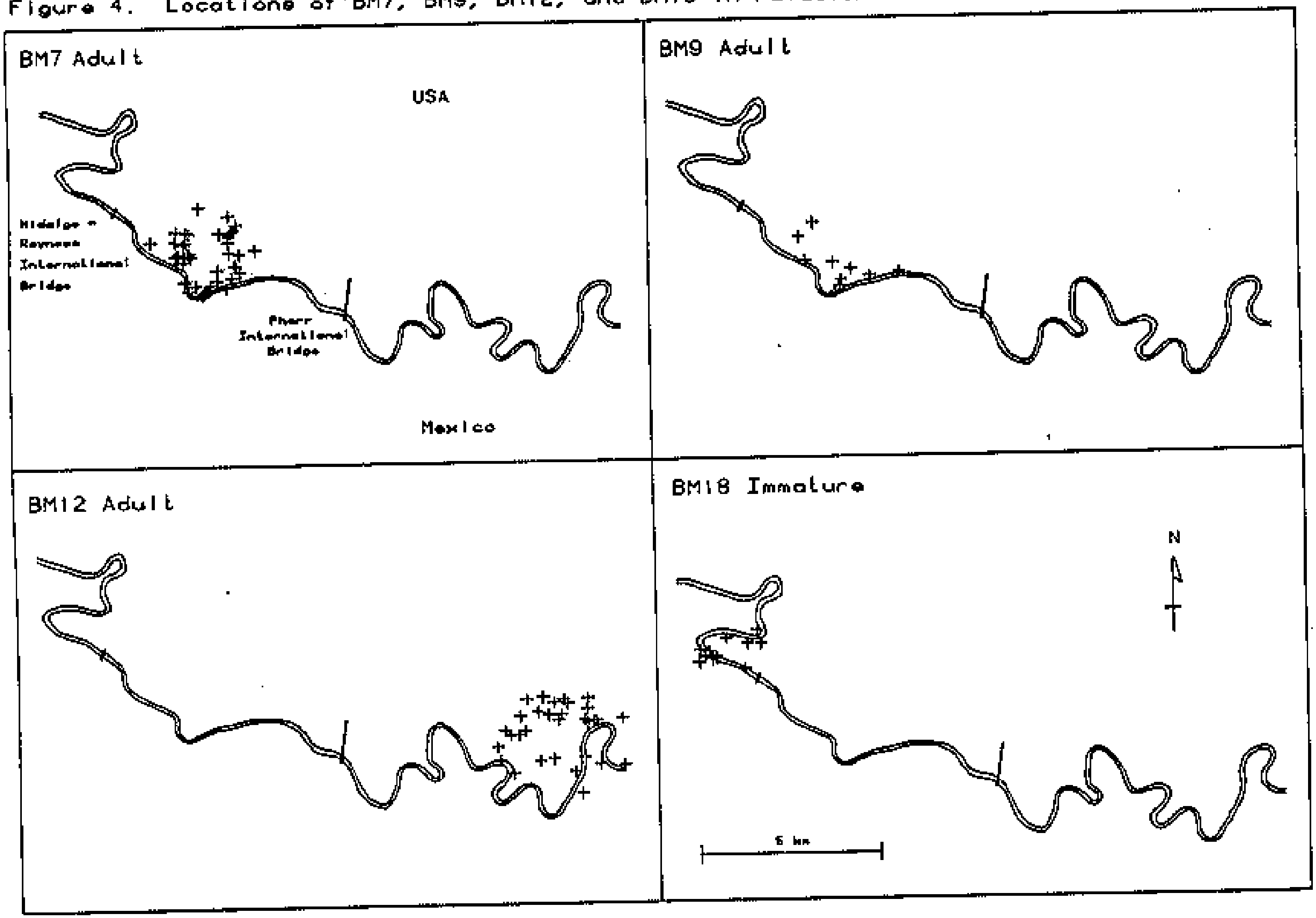


Figure 4. Locations of BM7, BM9, BM12, and BM18 in relation to international bridges.



occurred in the area. Although none of the study cats were found to pass under bridges, it is possible that bobcats are moving along the river corridor and under this bridge. Natural revegetation has occurred at the bridge site and there is minimal human disturbance in the area other than farming.

Ocelot.--The Pharr International Bridge is approximately 6 km west of Santa Ana NWR. When the ocelot traveled outside of the Santa Ana NWR, it always moved east and away from the bridge. A corridor of riparian forest along the river was sometimes used to move 1 km east of the refuge. Riparian forest or thorn forest do not exist immediately west of Santa Ana to serve as a travel corridor. This ocelot was not observed passing under or around any international bridges.

DISCUSSION

Bobcat

Home range estimates for bobcats in this study were much smaller than those reported by Fuller et al. (1985) and Litvaitis et al. (1986). This might be due to a larger bobcat population in the study area or better available habitats. Also, small home ranges could reflect a greater diversity of prey sources in the LRGV and thus the ability of a viable bobcat population to survive in a smaller area. This would be very important in a fragmented ecosystem like the LRGV.

This study provides the first empirical evidence of habitat use by bobcats in the agro-ecosystem of the Lower Rio Grande Valley of Texas. As expected for a habitat generalist, bobcats used all habitat types to varying degrees. Even though bobcats avoided developed land (i.e., cropland), several individuals were observed using cropland for hunting or traveling during the night and on one occasion during mid-day. This is important since all habitat within 20 m of the bridge is destroyed during construction. Habitat at the Los Indios Bridge which was completed in 1992 is a monoculture of 1-m tall guinea grass (Panicum maximum). The ability of bobcats to use various habitats facilitates their possible movement past this structure now.

Observing scat and locating bobcats near international bridges suggests possible movement past international bridges if sufficient vegetational cover is present and human disturbance is low at the bridge site. Bridges which span only from riverbank to riverbank are less amenable to passage than elevated causeways, but may be used when human disturbance is minimal and adequate habitat exists on either side. Since bobcats exhibit usage of more habitat types than ocelots, bobcats may be more likely to use crossing structures not surrounded by thorn or riparian forest.

Ocelot

The ocelot on Santa Ana NWR exhibited a smaller home range than that reported for female ocelots by Tewes (1986) and Caso (1994), but larger than estimates given by Navarro-Lopez (1985) and Laack (1991). This cat was possibly the only ocelot on Santa Ana NWR and competition for space with other ocelots was minimal. Therefore its home range may be a result of the distribution of thorn forest and riparian forest on Santa Ana NWR. The ocelot home range was larger than any of the bobcat home ranges

This study also supports the importance of thorn forest to ocelots in south Texas. Because ocelots have a strong preference for dense thorn forest and use of riparian forest, fragmentation of these habitats without adequate travel corridors could have a significant effect on the persistence of the ocelot population in the LRGV.

Ocelot habitat use data would seem to indicate that bridges or crossing structures would be used infrequently unless some type of cover occurs on either side of the bridge. Ocelot avoidance of early successional, wetland, and developed land habitats, common habitat types in the LRGV, will reduce the utility of crossing structures until surrounding habitat has had adequate time to regenerate. Revegetation of bridge sites with riparian or thorn forest should facilitate ocelot and bobcat use of crossing structures.

CONCLUSION

Of the two bridges in the study area, the Pharr International Bridge seems most properly suited for wild cat movement. It is an elevated causeway which extends on the U.S. side from the river to the flood levee 3.7 km away. A similar structure exists on the Mexican side as well. If revegetation of the riverbank is allowed to occur, it may facilitate passage of free-ranging cats under the bridge.

The Hidalgo-Reynosa International Bridge will probably prevent passage of free-ranging cats along the river. This bridge spans from bank to bank, thus leaving little space for a wildlife corridor. Also, the area under the bridge is well lighted and used by U.S Border Patrol agents as a surveillance site. Illegal human crossings also occurs in the area when Border Patrol agents are not around. Cats radio-collared on either side of the bridge seemed to avoid the area. Survival of wild cats in this area is particularly difficult. An example would be BM18, a subadult male that was killed by poachers on refuge property <1 km from the bridge. Human disturbance in the area will also be a problem for dispersing animals since Reynosa, Mexico, a city of 500,000 people is located on the south bank of the Rio Grande. While trying to capture cats on refuge property, it was not uncommon to see illegal aliens walking across the refuge tract.

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APPENDIX A. BRIDGE DESIGN AND FEASIBILITY IN SOUTH TEXAS

Prior to 1990, there were 6 international bridges in the LRGV. All bridges consisted of a simple span (100-200 m) from riverbank to riverbank without wildlife crossing structures. This design is the least expensive, but can reduce or prevent wildlife movement along the river. Since the signing of NAFTA, numerous bridges have been proposed for construction. However, now that certain conservation groups and federal agencies are interested in creating a wildlife corridor along the Rio Grande, more attention has been directed to the construction of bridges which minimize interference with wildlife movement along the river. The following section discusses designs and costs of current or proposed bridges in the LRGV and mitigation associated with these designs.

SIMPLE SPAN

The Hidalgo-Reynosa International Bridge completed in the 1960's, is a representative of the bridges in the LRGV. At this bridge, the levees on both sides are built on the riverbank. The bridge stretches from levee to levee. This leaves approximately 30 m of river corridor on either bank. However, this is a heavily populated and developed area. The International Boundary and Water Commission (IBWC) has built a non-public use road under the bridge and vegetation does not grow under the bridge. This area is well lighted because of the high human population levels in the area. Since this bridge has no wildlife crossing structures and corridor area under the bridge is small and heavily used by humans, this bridge may effectively separate free-ranging cat populations on either side.

The Los Indios Bridge is a recently completed structure (i.e., November 1992). This design consists of a fenced-at-grade road leading to a four-lane bridge from the levee. The bridge spans and extends about 50 m on either side of the river. The bridge site is being allowed to revegetate naturally and is currently covered in guinea grass. Movement along the river is only possible under the bridge on either riverbank, because fencing extends from the levee to the bridge and no wildlife crossing structures are provided. As mitigation, 12.15 ha of wetland between the bridge and the levee on the U.S., side has been set aside by officials from Cameron County as an area where development will not occur. At $7286.50/ha ($2,950/acre), this land is valued at $88,500.

Fencing on both sides of the roadway to the bridge is 2.4 m of chain-link fence with 3 strands of barbed wire above. The fence has been constructed so that during flooding, it will lay horizontal and not hamper water flow or be destroyed by moving debris. Cost of the 3 km fence is approximately $105,600. Cost for the bridge and roadway was approximately $7,000,000.

The proposed Anzalduas International Bridge would also be a simple span design. It would consist of a four-lane fenced at-grade-road leading from the IBWC floodway to a simple span bridge at the river. Three wildlife underpasses (7 x 2.4 m) will be installed between the levee and river. A 20-m wide strip along the west side of the roadway will be established as a conservation easement. Also, 64.78 ha.(160 acres) on the east side of the roadway will be transferred to the USFWS once the bridge is operational. The sponsors of the bridge will pay USFWS $50,000 to revegetate the acreage. Sponsors also agree to minimally disturb the vegetation and designate a conservation easement tract in the Banker floodway.

ELEVATED CAUSEWAY

Completed in 1994, the Pharr-Rio Bravo International Bridge is four-lanes wide and extends from the U.S. levee to the Mexican levee, a distance of 7.4 km. The bridge is elevated approximately 7 m above the surrounding farmland. The cost of this bridge was $20,000,000. A single span of the river with an at-grade-road connection would have been $5,000,000 (Hidalgo County Eng., pers. commun.). This bridge design was decided upon because USFWS was interested in retaining a corridor between the Vela Woods and Milagro refuge tracts, also the IBWC was concerned about flow rates in the area during floods. Lighting on the bridge has been designed to focus only on the road and not the land or habitat below.

The Los Tomates Bridge is currently under construction and will stretch from levee to levee as well. It will be a four-lane bridge elevated at least 2 m above a designed flood elevation that provides a flow rate of 20,000 cubic feet per second. Cost for this bridge will be approximately $9,000,000. A simple span with an at-grade-road would have cost $1,500,000 (J. Hudson, Traffic Eng. Inc., pers. commun.). In addition, 68.83 ha (170 acres), of adjacent farmland will be purchased at $12350/ha ($5,000/acre) and donated to the USFWS as part of the wildlife corridor. Also, a 6.88 ha (17 acre) area which is now part of Lincoln Park will be donated to the USFWS. Since this area will be separated from the river corridor by the levee, a cat tunnel will be built to allow wild cat movement to the river. This tunnel will be a 1-m square x 25 m long tube. Some lighting will be provided by a grated sky-light, 6 m into the tunnel from the south side. Cost of the cat tunnel is $9,700. Light shields will be employed to concentrate lighting on the bridge and away from the wildlife corridor.

Another aspect of wildlife crossing structures that should be addressed in the LRGV is the need to connect the river corridor with habitat tracts distant from the river, such as Laguna Atascosa NWR. This may require constructing underpasses or culverts under roads that separate areas of habitat. A recently completed crossing structure is found on FM 509, 5.5 km north of the Los Indios Bridge. It is situated where the two-lane road crosses an intermittent creek. This structure is approximately 10 m wide x 13 m long x 1.3 m high and has flat areas termed "cat walks" with a 1-m clearance to walk under the road. There is no fencing (only guardrails) and vegetation is being allowed to naturally regenerate. Cost of the structure was $80,300 (R. Garcia, Cameron County Eng. pers. commun.)

APPENDIX B. Bridge-wildlife Interaction Literature Survey

Ford, S.G. 1980. Evaluation of highway deer kill mitigation on SIE/LAS-395. Final rep. no. FHWA/CA/TP-80-01, Calif. Dept. of Transp., Sacramento. 45pp.

A 3-mile section of U.S. Highway 395 divides the summer and winter ranges of a mule deer (Odocoileus heminous) herd. From 1962 through 1966, and 1971 through 1973, 85 and 33 deer were killed respectively. In the 1960's, the road was converted from 2 to 4 lanes. Three bridge-type underpasses, 36 one-way deer gates, and 7-foot fencing were installed. After renovation 2.6 deer per year were killed, compared to 10.8 deer per year before renovation. Problems with the project included private landowners leaving gates open, debris obstructing crossings and gates, erosion or animals creating crawl holes under the fence, eventual sagging of the fence, and damage to the fence caused by automobile accidents or vandalism. Deer adjusted their movements to the fence after 3 years. Ability to regularly repair fencing, human activities in the area, pattern of deer movement in relation to the fencing, and budgetary constraints are characteristics which need to be determined before resorting to a solution such as this.

Foster, M.L. and S.R. Humphrey. 1992. Effectiveness of wildlife crossings in reducing animal/auto collisions on Interstate 75, Big Cypress Swamp, Florida. Florida Game and Fresh Water Fish Comm. 124pp.

Five Florida panthers were involved in fatal collisions with vehicles on State Road 84. While being upgraded to an interstate, 24 underpasses designed for cougars and 64 km. of 3 meter fencing were installed. The underpasses were spaced an average of 1.42 km apart and placed points where cougars were known to cross the road. Four underpasses were monitored during the study. Ten cougar, 133 bobcat, 361 white-tailed deer, 167 raccoon, 9 alligator, and 2 bear passages were observed. Panther tracks were also found around unmonitored underpasses. Level and frequency of use varied according to location and configuration of cougar home ranges. Cougar used the underpasses at night. Deer and bobcats used the underpasses more liberally as crossing points and occasionally as forage areas. The authors reported that no deer, bear, bobcats or panthers have been killed by collisions in the 64 km stretch of the interstate since construction of the fence and underpasses. Statistical analysis of roadkill rates prior to, during, and after construction of fences and underpasses was done. Foster and Humphrey advocated devising a plan to extricate any cougars trapped on the road. The authors stated that fence maintenance and reducing human trespassing were important. Several figures and tables are provided and the report contains a bibliography of 89 wildlife-highway references.

Foster, M.L. and S.R. Humphrey. 1995. Use of highway underpasses by Florida panthers and other wildlife. Wildl. Soc. Bull. 23:95-100

Publication discussing Foster and Humphrey's 1992 study.

Fusari, M. 1982. Feasibility of a highway crossing system for desert tortoises. Contract rep. FHWA/CA/TP-81/1, Calif. Dept. Transp., Sacramento. 41pp.

An experimental crossing system was constructed to determine if desert tortoises, which are highly affected by the construction of roads, would use them. Most tortoises would use the crossings, but some would not. The system is comprised of an 18 inch barrier fence, culverts, and regular maintenance to remove debris from the culverts. This could help tortoises reclaim areas which have been penetrated by roads.

Gates, J.E. 1990. Highways: the search for solutions. in S.S. Lieberman (ed.), Deer management in an urbanizing region: problems and alternatives to traditional management. Humane Soc. U.S., Washington, D.C.

White-tailed (Odocoileus virginianus) deer-vehicle collisions cause the death of 200,000-350,000 deer, $400-700 million in damages to vehicles and property, and 8,000 human injuries and 120 deaths annually. Effective countermeasures are well-maintained ≥ 2.44 meter fencing with one-way gates or underpasses/overpasses. However these are very costly. Proper highway design and site, driver education, and slower driving speeds in problem area would also reduce collisions.

Goldsmith, R. 1995. Highway crossings to aid ocelot survival. Envision (Summer 1995). pp.4-5.

Article discusses how Texas Dept. of Transportation (TxDOT) is installing underpasses on several south Texas roads. This is being done to reduce ocelot-vehicle collisions and to alleviate habitat fragmentation problems caused by the roads. Lowered roadside mortality of ocelots has been noticed in areas where underpasses already exist.

Hanna, P. 1982. The impact of Interstate Highway 84 on the Sublette-Black Pine migratory deer population. A 12-year summary, with recommendations for mitigation of identifiable adverse impacts. Idaho Dept. Fish and Game, Project W-160, final report. 97pp.

Construction of I-84 across a mule deer migration route without suitable wildlife crossing structures has resulted in 392 reported deer-vehicle collision and yearly spending of $8,000-25,000 to feed deer that cannot get to their normal winter range. Eight bridge-type underpasses not designed for wildlife experience very little use by deer. Retrofitting with reflectors, wriggle gates, dirt ramps, and fencing modification have had very little effect.

Jensen, D.R. 1977. The Fish Creek Highway deer passage project. Unpubl. rep., Idaho Transp. Dept. 13pp.

A survey of tracks indicated that mule deer crossed in 3 main places in the area of U.S. Highway 30's proposed new alignment. Prior to construction, monitoring 75-100 deer crossings in winter. Three underpasses for movement of livestock and deer were constructed. Deer proof-fencing was also built. Underpasses were 12-15 feet wide, 12-15 high, and spanned 70 feet. Deer-proof fences were 8 feet high and totaled 5.5 miles in length. One-way deer gates and wing fences were installed at three connections with frontage roads. Tracks of 66 deer were found in the crossings after construction. Because of incorrect placement, deer did not use the one-way gates. Problems included automobile damage to the fence, sagging of the fence, and cutting of the fence by grazing lease-holders. Author recommends the use of net or woven wire.

Karthaus, G. 1985. Schutzmassen fur wanderde Amphibien vor einer Gefahrdung durch den Strassenverkehr-boebachtungen und Erfahrugen. Natur Landschaft 60:242-247.

Tunnels were used to reduce high numbers of road-killed amphibians in a swamp in the Netherlands.

Kuennen, T. (ed.). 1989. New Jersey's I-78 preserves mountain habitat. Roads & Bridges (February 1989), pp.69-73.

A six-lane highway was built skirting around a county park. Two 100-foot-wide overpasses, bordered with earthen berms and landscaped with native plants were readily used by white-tailed deer for foraging, antler rubbing, and travel across the highway.

Leedy, D.L. 1975a. Highway-wildlife relationships. Vol 1. A state-of-the-art report. U.S. Dept. Transp., Fed. Highway Adm. Rep. No. FHWA-RD76-4. 183pp.

Highway underpasses have potential to provide man a way to reduce wildlife-vehicle collisions. They are most effective when used with fencing.

Leedy, D.L. 1975b. Highway-wildlife relationships. Vol 2. An annotated bibliography. U.S. Dept. Transp., Fed. Highway Adm. Rep. No. FHWA-RD-76-5. 417pp.

This report lists 34 references concerning bridge-wildlife interactions and gives abstracts or summaries of them.

Leedy, D.L. and Lowell W. Adams. 1982. Wildlife Considerations in Planning and Managing Highway Corridors. U.S. Dept. Transp., Fed. Highway Adm., Off. of Res. and Dev.; U.S. Dept. of the Interior, Fish and Wildl. Serv., Off. of Biol. Serv.; Rep. No. FHWA-TS-82-212. 103pp.

Report recommends installing culverts, bridges, underpasses

or overpasses when constructing a highway across animal migration routes. Cites Reed (1981) for recommending large (4 m high x 4 m wide x 4 m long) open-bridge underpasses for mule deer. Report advocates using big-game fencing in conjunction with crossing structures to facilitate animal crossing and reduce animal-vehicle collisions and discusses terracing as another possible means to funnel deer to underpasses.

Leighton, D. 1988. Helping the animals cross the road. Can. Geogr. 108:22-28.

This popular article describes how elk responded to fencing and wildlife crossings installed on Trans-Canada Highway in Banff National Park. Twenty-six km of 2.4 m fencing and 11 animal crossings were installed. Crossings were either metal culverts or underpasses placed at traditional crossing points. After construction the elk-vehicle collision rate dropped 90 percent, however, elk appeared to cross the road much less often after construction than before.

Mansergh, I.M. and D.J. Scotts. 1989. Habitat continuity and social organization of the mountain pygmy-possum restored by tunnel. J. Wildl. Manage. 53:701-707.

Two isolated populations of the mountain pygmy-possum (Burramys parvus) were reconnected by construction of a funnel-shaped 60 meter long corridor of rocks and two 0.9 x 1.2 meter tunnels filled with rocks under the road that was separating the populations. Within 2 weeks, the corridor was being used by dispersing animals of the species. Mortality rates in the area of the road decreased to a level similar to that of the undisturbed areas and population structure reverted to the undisturbed condition.

McDonald, M.G. 1988. Glenn Highway moose monitoring study progress report. 24pp; 1989. Glenn Highway monitoring study. Second ann. prog. rep. 25pp. Alas. Dept. of Fish and Game.

Thirty-eight moose (Alces alces), on average were reported killed each year on an 8-mile stretch of highway near Anchorage. When the highway was widened to 6 lanes, lighting was installed along a 7 mile stretch and 9-foot fencing was built along both sides of a 1.5 mile stretch with a high accident rate. Sixteen one-way gates modified for moose were included in the fence. An underpass was constructed by raising and lengthening a creek bridge. Use of the underpass by moose was substantially greater in the second year than in the first, when it was blocked by ice. At least 25-30 crossings occurred from October to November 1988. A minimum of 50-60 crossings were confirmed from January to March, when the crossing was baited with alfalfa hay. A 70% reduction of moose-vehicle accidents has been documented. Fencing and lighting have been effective in altering the winter movements of moose.

Olbrich, P. 1984. A study examining the effectiveness of game warning reflectors and suitability of game passages. Research Centre for Hunting and Game Damage Prevention, Nordrhein-Westfalen (Bonn), West Germany. 16pp.

Pojar, T.M., D.F. Reed, and T.C. Reseigh. 1972. Highway construction-motorist and deer safety. Proc. West. Assoc. State Game and Fish Comm. 52:268-271.

This report describes how migrating mule deer used and responded to an underpass and an adjoining 8-foot fence. 1325 deer were found to have used the underpass during 3 spring and 2 fall migrations. Each spring or fall migration also had a 23% increase in usage over the previous spring or fall. Fences, reflectors, and lighted animated signs were also studied and discussed.

Ratcliffe, E.J. 1974. Wildlife consideration for the highway designer. J. Instn. Municipal Eng. 101:289-294.

This popular article discusses mortality of mammals on British roads and advocates the use of over- or underpasses and fencing as a way to reduce the rate of animal-vehicle collisions. It includes photos and a diagram of a concrete underpass with fencing designed for badgers. Use of underpass was not monitored, but no badger deaths were reported after construction. Finding the traditional paths that badgers use to monitor their territories was the first step in identifying the locations for the underpasses.

Ratcliffe, E.J. 1974. Through the badger gate. Bell Publ. Co., London. 118pp.

This book chronicles the use of tunnels under roads to reduce the number of road-killed badgers in the United Kingdom.

Reed, D.F., T.N. Woodard, and T.M. Pojar. 1975. Behavioral response of mule deer to a highway underpass. J. Wildl. Manage. 39:361-367.

A concrete box underpass 10 feet x 10 feet and 100 feet long under Interstate 70 was monitored for deer use during 4 years following completion in 1970. About 345 mule deer passed through the structure when migrating through the area. The underpass was successful in permitting 61% of the local deer herd to migrate safely under the highway. The rest of herd either curtailed migration, jumped the fence or went around the fenced area on either side of the structure. Larger and more open underpasses were recommended, with dirt floors and no skylights or artificial lighting.

Reed, D.F. 1981. Mule deer behavior at a highway underpass exit. J. Wildl. Manage. 45:542-543.

An additional 6 years of monitoring at the underpass in Reed et al. (1975) showed that mule deer were reluctant, wary, or frightened when exiting the underpass and would probably benefit from a larger structure.

Reed, D.F., T.N. Woodard, and T.D.I. Beck. 1979. Regional deer-vehicle accident research. U.S. Dept. Transp., Fed. Highway Adm. Rep. No. FHWA-RD-79-11. 61pp.

Report discusses several studies in Colorado to control and ease mule deer movement across highways and overs various ways to reduce deer-vehicle collisions such as overpasses, underpasses, deer guards, deer fences, one-way gates, highway lighting, and animated deer crossing signs. One quarter of underpasses studied were constructed specifically for deer. Deer were reluctant to use box-type underpasses but bridge-type underpasses were used freely. Underpasses with openness index > 0.6 ({height x width}/length, in meters) are recommended for areas of deer migration. Overpasses were used more reluctantly when width <2.48 meters or when netting is placed overhead to prevent animals from jumping or falling onto roadway. Report recommendes extending fences 0.8 kilometers beyond deer concentration areas and including underpasses or overpasses at least every 1.6 kilometer along the fence. One-way gates, when strategically located are effective in allowing deer to escape from highway rights-of-way. Techniques designed to modify deer behavior were more successful than techniques used to modify the behavior of motorists.

Reed, D.F., T.D.I. Beck, and T.N. Woodard. 1982. Methods of reducing deer-vehicle accidents; benefit-cost analysis. Wildl. Soc. Bull. 10:349-354.

Based on data of costs of constructing fences and underpasses and on the number of mule deer killed before and after construction, authors described the economics of reducing animal-vehicle conflicts. Benefits were savings in vehicle repairs and value of deer not killed; human injuries and deaths were excluded. A 6% discount rate was given as a future benefit. Costs of construction and maintenance were included. High kill areas are best suited for fencing. When fencing only one side of the highway, the cost-benefit ratio is not positive unless there are 6 dead deer/1.6 km of highway/year in the area before fence installation. A positive ratio is reached when there are 12 dead deer/1.6 km/year for fencing both sides of highway. A positive ratio for fencing both sides with an underpass is achieved when there are 18 dead deer/1.6 km/year.

Shoemark, G. 1989. The mountain pygmy possum--our unique alpine marsupial. Common Ground 2:27-29.

This article is ann account of the ecology of pygmy possum and two tunnels used to reconnect populations separated by a road and other development. The article also reports on some management issues including erosion of construction sites in upslope habitats and the need for captive-rearing and reintroduction.

Singer, F.J. 1978. Behavior of mountain goats in relation to U.S. Highway 2, Glacier National Park, Montana. J. Wildl. Manage. 42:591-597.

A 5.2 mile section of highway crossing a mountain goat (*Oreamnos americanus*) path was proposed for reconstruction. Prior to reconstruction, steep grades, curves and a narrow bridge slowed driving speeds, vehicle-mountain goat accidents were rare. However, the proposed highway will allow motorists to move at a faster pace. Recommendations were made to include a goat underpass in the main crossing area, with lead-in fences, and protective conifer cover. Fencing would also be placed to prevent goats from using other trails.

Singer, F.J., W.L. Langlitz, and E.C. Samuelson. 1985. Design and construction of highway underpasses used by mountain goats. Transp. Res. Record 1016:6-10.

An underpass (12-28 feet high x 90 feet wide x 44 feet across) under U.S. 2 in Glacier National Park was built to allow mountain goats access to a salt lick. Conifer saplings were planted as cover and metal screening was placed on the rail of the bridge to give the goats a greater sense of security. A second bridge located 200 feet east was improved to allow mountain goat passage under it. Existing goat trails were obliterated and new trails were dug leading to the entrance of both underpasses. After construction, goats were disturbed less and spent more time at the salt lick than before installation of the underpasses.

Singer, F.J., and J.L. Doherty. 1985. Managing mountain goats at a highway crossing. Wildl. Soc. Bull. 13:469-477.

After construction of U.S. Highway 2 in Glacier National Park, >99% of mountain goat crossings of the road were under one of the two underpasses built for them. Restrictive walls and fencing prevented goat access to the intervening roadway. Mountain goats moved through the area more easily than before installation of the underpasses. Construction hours and location, traffic speed, and visitor disturbance were managed during installation. This allowed goats to continue to use the salt licks during construction. Placing underpasses at traditional crossings and their large size were reasons attributed to goat usage of the underpasses. Other reasons were screening of the bridges, fencing and walls between the bridges, conifer planting at underpass approaches, obliteration of other crossing paths, controlling of visitor disturbance, and sequential construction that permitted adaptation by the goats. Goats made equal use of smaller and less protected underpasses. However, the larger underpass was more often selected as an alternate crossing route after an unsuccessful attempt.

Summarizations from prior literature were: (1) Underpasses must be located at traditional crossings. (2) Size is important, structure should not be confining. (3) High rates of highway mortality will not deter animals from using a traditional lick. (4) Fencing needs to be restrictive and constructed in general direction of ungulate movements. (6) Human harassment may cause animals to avoid an area temporarily.

Tyning, T. 1989. Amherst's tunneling amphibians. Defenders (September/October 1989), pp.20-23.

Two tunnels were installed under Henry Street in Amherst, Massachusetts, to allow for passage of the spotted salamander during migration. Tunnels were placed 200 feet apart and constructed so that interior would remain wet but not flooded. Low fences were funneled out 100 feet on either side of each tunnel. Preliminary indications show the tunnels to be effective.

Ueckermann, E. 1984. Untersuchung der Eignung von Wilddurchlassen und der Wirksamkeit von Wildwarnreflektoren. Forschung Strassenbau und Strassenverkehrstechnik 426:1-58.

Articel discusses 824 wildlife crossing structures on highways in West Germany that were studied for use by ungulates. Underpasses are preferred to overpasses. Roe and fallow deer accept crossing structures satisfactorily. However, red deer and wild boar require special dimensions and location. Headlight reflectors reduce game-vehicle accidents by 20-40%, but maintenance is expensive. Reflectors are not a satisfactory alternative to crossing structures with fences.

van Lierop, A.M.M. 1988. Means of preventing wild animals from drowning and being involved in road accidents. Centre Naturopa Documentation Seris No. 22:1-65. Council of Europe.

Article discusses game fences, jumps, overpasses, underpasses, tunnels, game mirrors, and canal-bank structures designed to prevent highway deaths of wildlife. Target species include red deer, roe deer, wild boar, badgers, otters, rabbits, and red fox.

Ward, A.L.,J.J. Cupal, G.A. Goodwin, and H.D. Morris. 1976. Effects of highway construction and use on big game populations. U.S. Dept. Transp., Fed. Highway Adm. Rep. No. FHWA-RD-76-174. 92pp.

At least 153 antelope (Antilocapra americana), 561 mule deer, and 10 elk (Cervus canadensis) were killed by vehicle collisions along a 55-mile section of I-80 west of Laramie, Wyoming, during a 5.5-year period. Antelope are reluctant to jump fences or use underpasses. Thus, I-80 is a barrier and the herd is managed accordingly. Maintaining good fences and preventing snow drifts over right-of-way fencing keeps antelope off the highway. Mule deer will jump fences but can be coerced into using underpasses with deer-proof fencing. Mule deer will usually jump a short fence before going through a crossing structure.

Ward, A.L., N.E. Fornwalt, S.E. Henry, and R.A. Hodorff. 1980. Effects of highway operation practices and facilities on elk, mule deer, and pronghorn antelope. W.S. Dept. Transp., Fed. Highway Adm. Rep. No. FHWA-RD-79-143. 48pp.

A wildlife fence, snow fences, and animal underpasses were constructed along I-80. Mule deer required two years to become accustomed to using the underpasses. Problems included deer walking around game fence and onto the road, holes in fence causes by hunters and poachers, and snowmelt, and snow drifts bridging the fence. Constant monitoring of fences is required during migration. Only one pronghorn antelope was known to use the underpass.

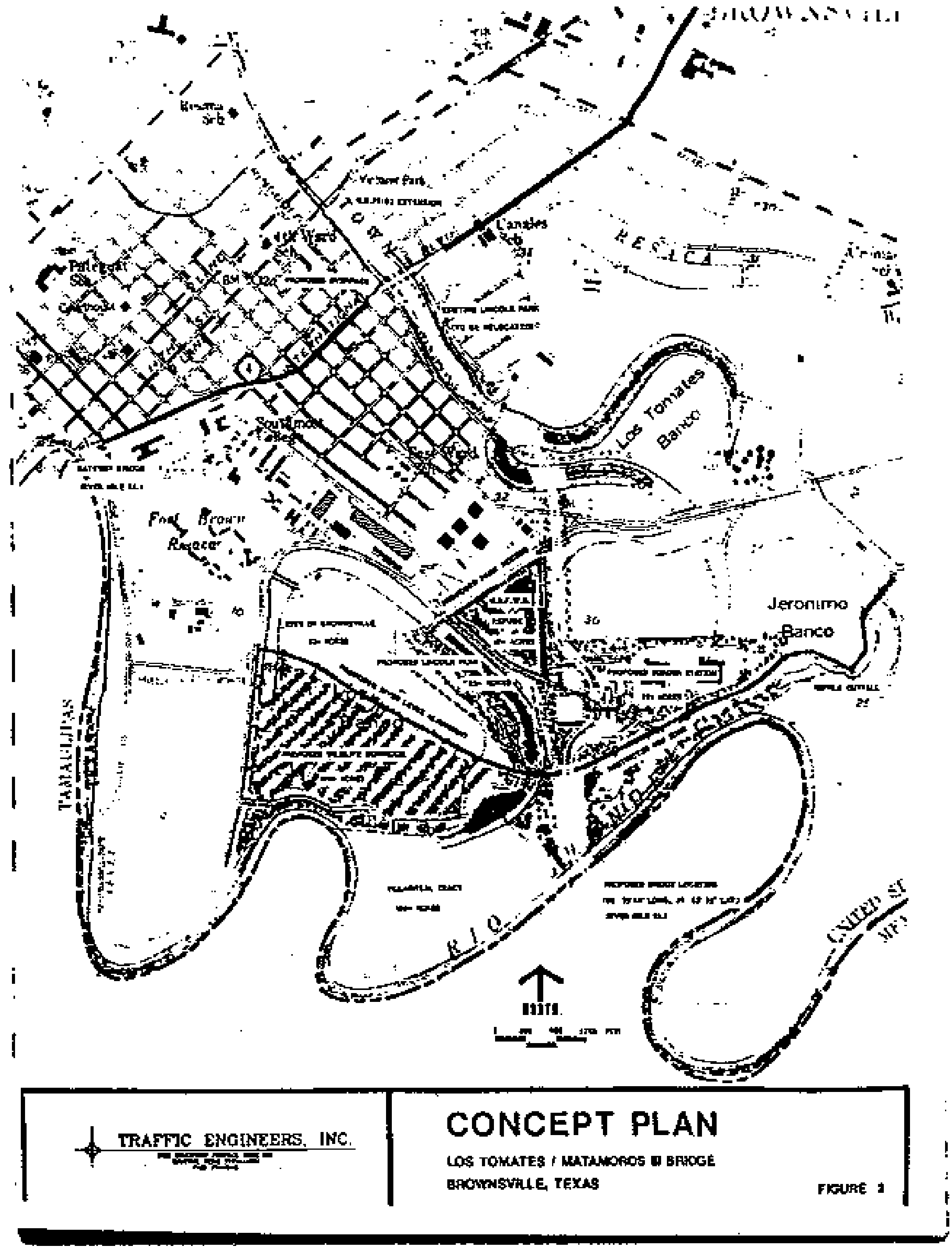
Ward, A.L. 1982. Mule deer behavior in relation to fencing and underpasses on Interstate 80 in Wyoming. Transp. Res. Record 859:8-13.

This article is a review of earlier works (1976, 1980), explaining how a stretch of highway to be fenced was determined and how fence had to later be extended because of continued deer-vehicle collisions, after which accidents ceased. Data on deer-vehicle accidents, deer use of underpasses and end runs around game fencing, and duration of seasonal ranges by telemetered deer are presented through spring 1981.

Waters, D. 1988. Monitoring program, mitigative measures, Trans Canada Highway twinning, km 0-11.4. Final rep. Environ. Can.-Parks. 57 pp.

A game fence and four underpasses were constructed in Banff National Park, to reduce the impact of a highway on wildlife. The highway was monitored for 3.5 years by checking tracks in sand traps. Underpasses were successful in allowing mule deer, white-tailed deer, and elk to cross. Elk distribution range-use patterns did not change significantly from those prior to installation. One exception was an area where crossing had previously taken place, but because of highway grade constraints, an underpass could not be located there. The game fence did not prevent carnivores from crossing the highway, although they did sometimes use the underpasses. Wolves and coyotes employed the fence in their hunting strategies, indicating that fences should not cut off escape areas from foraging and bedding areas. Fencing requires constant maintenance since wildlife exploit any breaks. Heavy snowfall, snowplow buildup, and high water were major reasons for maintenance.

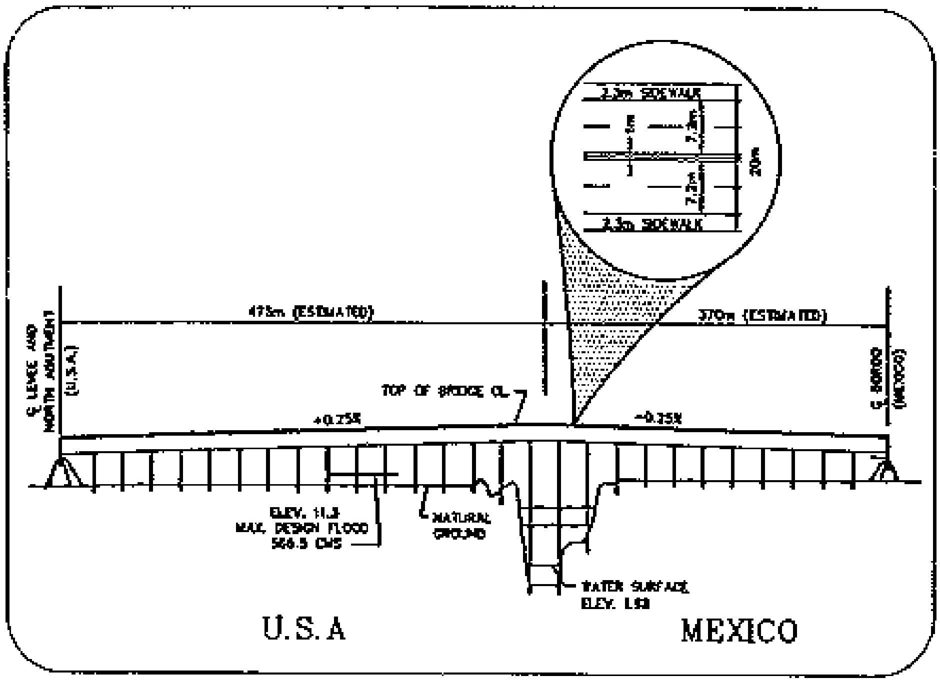
APPENDIX C. Proposed Los Tomates International Bridge



Appendix C. Continued.

Bridge

The proposed bridge structure will span from the relocated levees in the US. and Mexico. The structure will consist of four (4) travel lanes, plus protected pedestrian walkways (a total width of 65 feet) on both sides. Trucks will have special access lanes to and from the bridge structure that will allow easy access. S&B Infrastructure Ltd. is the design engineer for the bridge and levee.



Permits/Funding

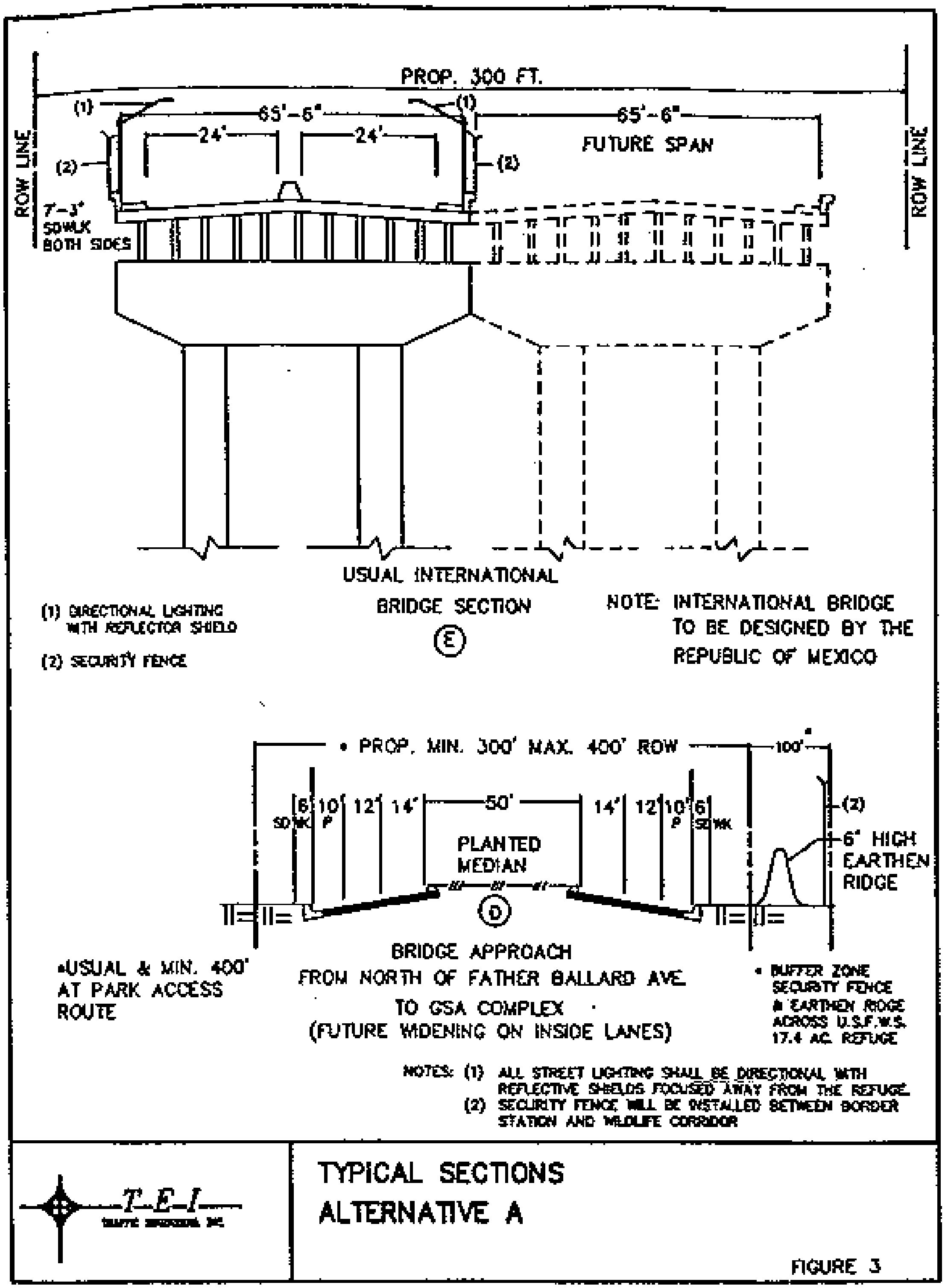
The Los Tomates/Matamoros Bridge project received an approval of its environmental assessment by the US Department of State on October 4, 1993, followed by a Presidential Permit issued October 9, 1993. The US Coast Guard permit was approved on June 16, 1994. The US portion of the project is funded by the following sources:

- US 77/83 Expressway - Texas Department of Transportation
- Lincoln Park replacement - Texas Department of Transportation
- Levee relocation - Cameron County in partnership with City of Brownsville
- Bridge construction - Cameron County in partnership with City of Brownsville
- Administration building/tolls - Cameron County in partnership with City of Brownsville
- GSA facilities - US government
- Wildlife protection - Cameron County in partnership with City of Brownsville

Levee Relocation

A portion of the International Boundary and Water Commission's levee will be relocated in order to construct the border station outside the floodway of the Rio Grande. The proposed new 7,400 foot river levee and 2,700 foot impala channels' west levee will be the first phase of the overall project. The new levee will be of the same design configuration as the existing levee.

Appendix C. Continued.



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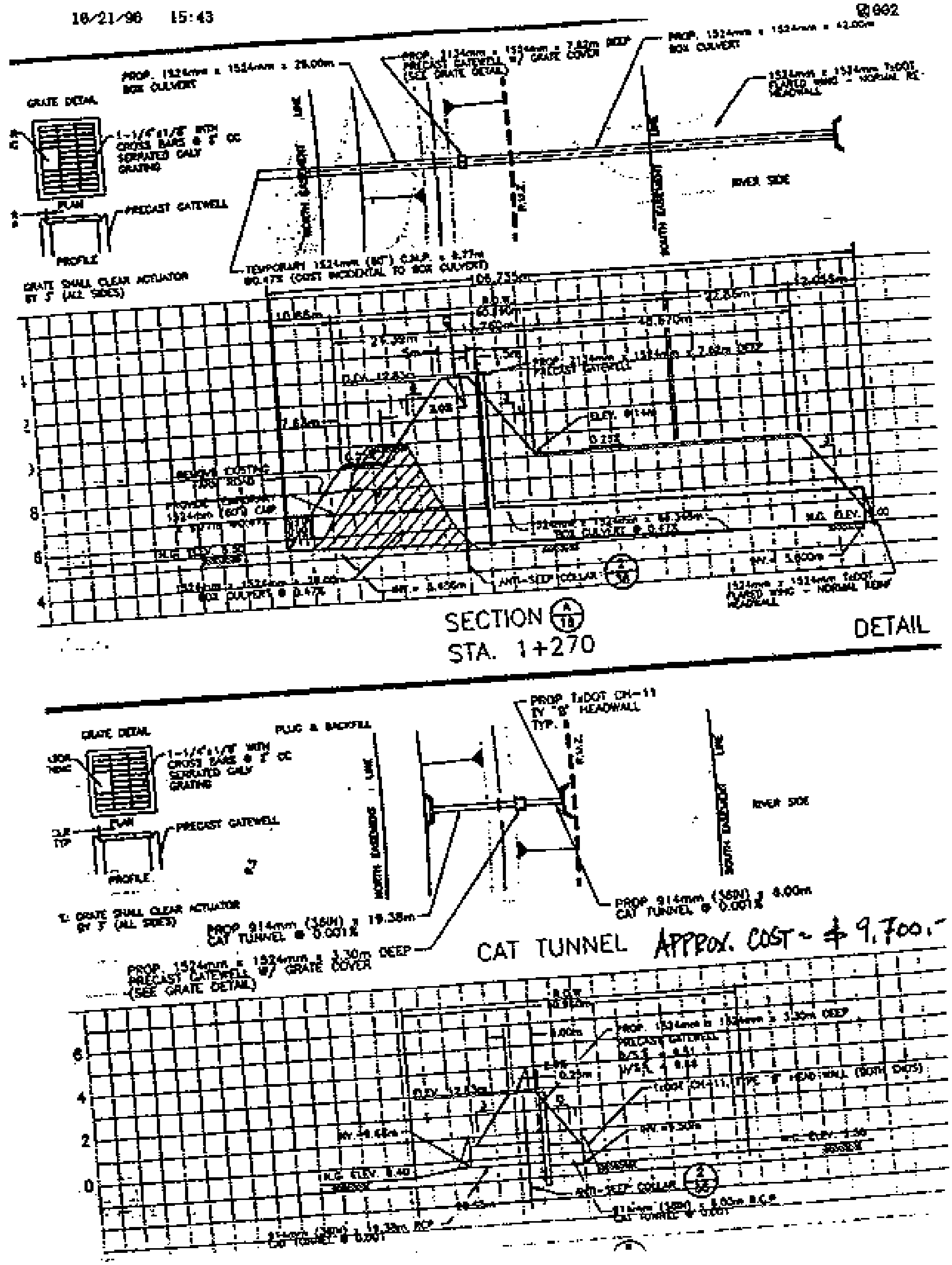
Appendix C. Continued.



Appendix C. Continued.

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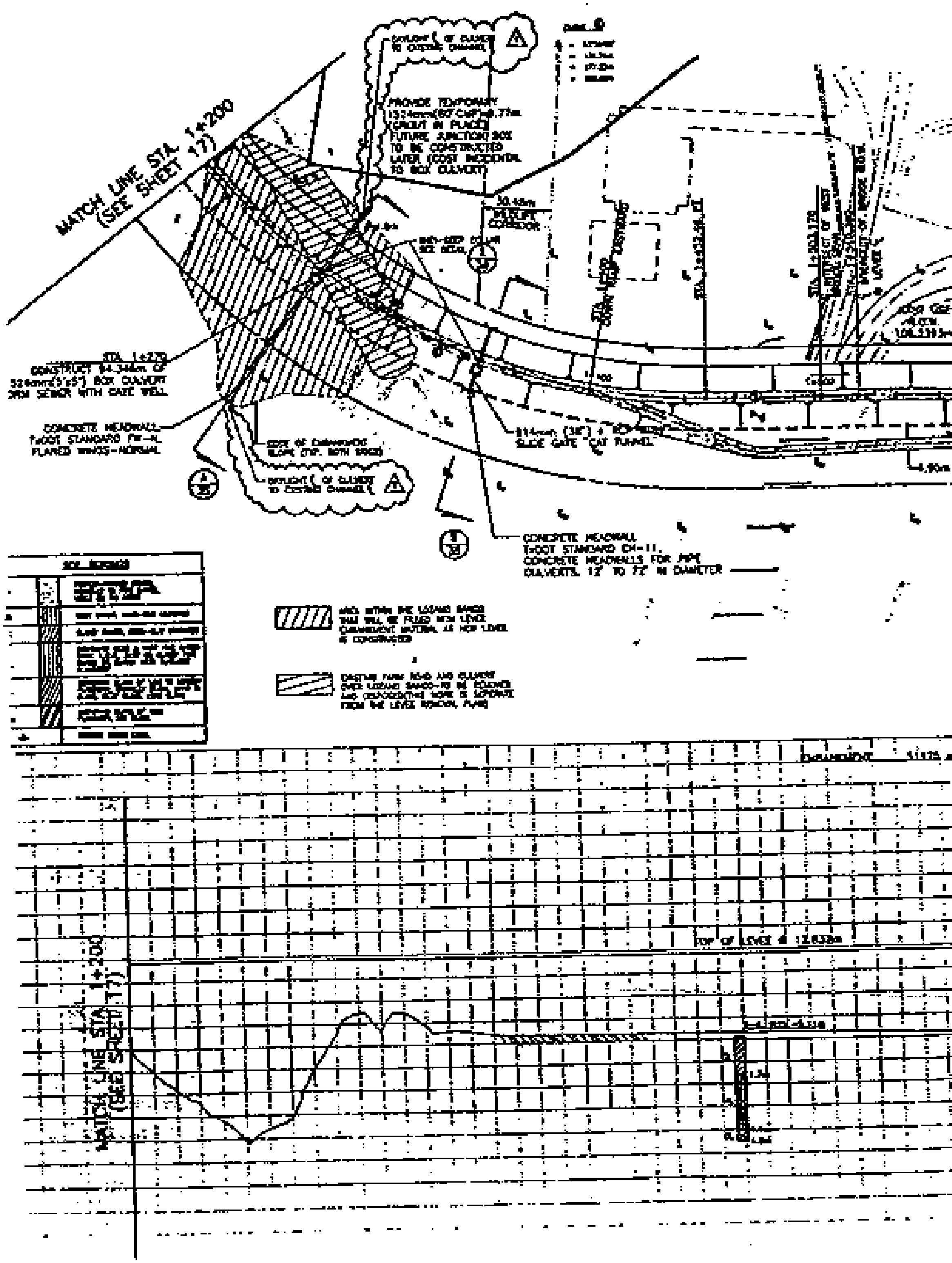
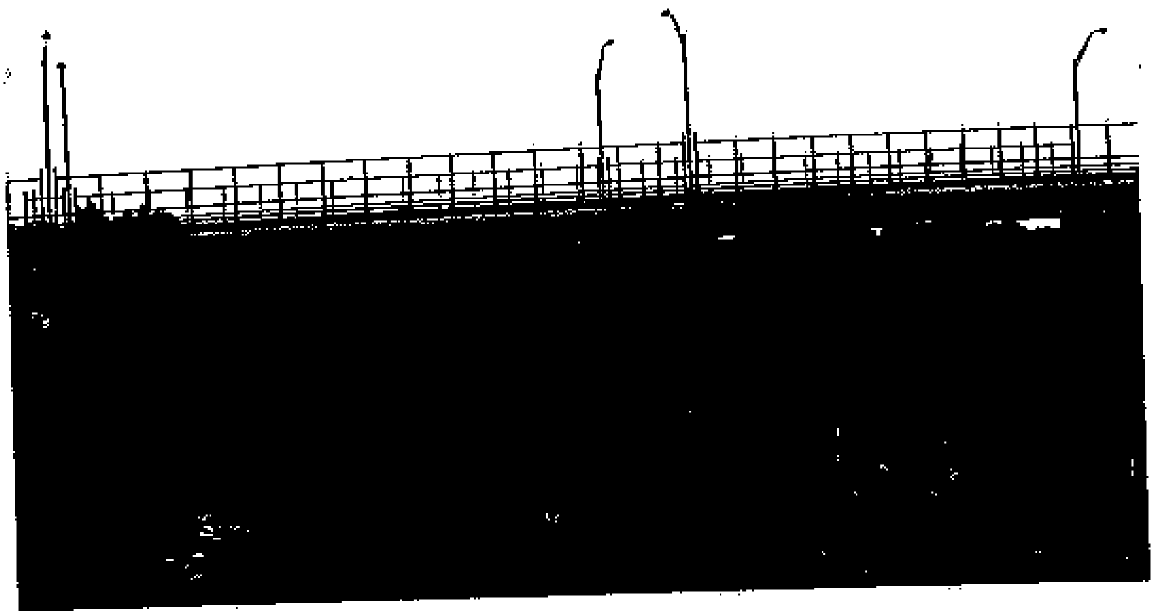
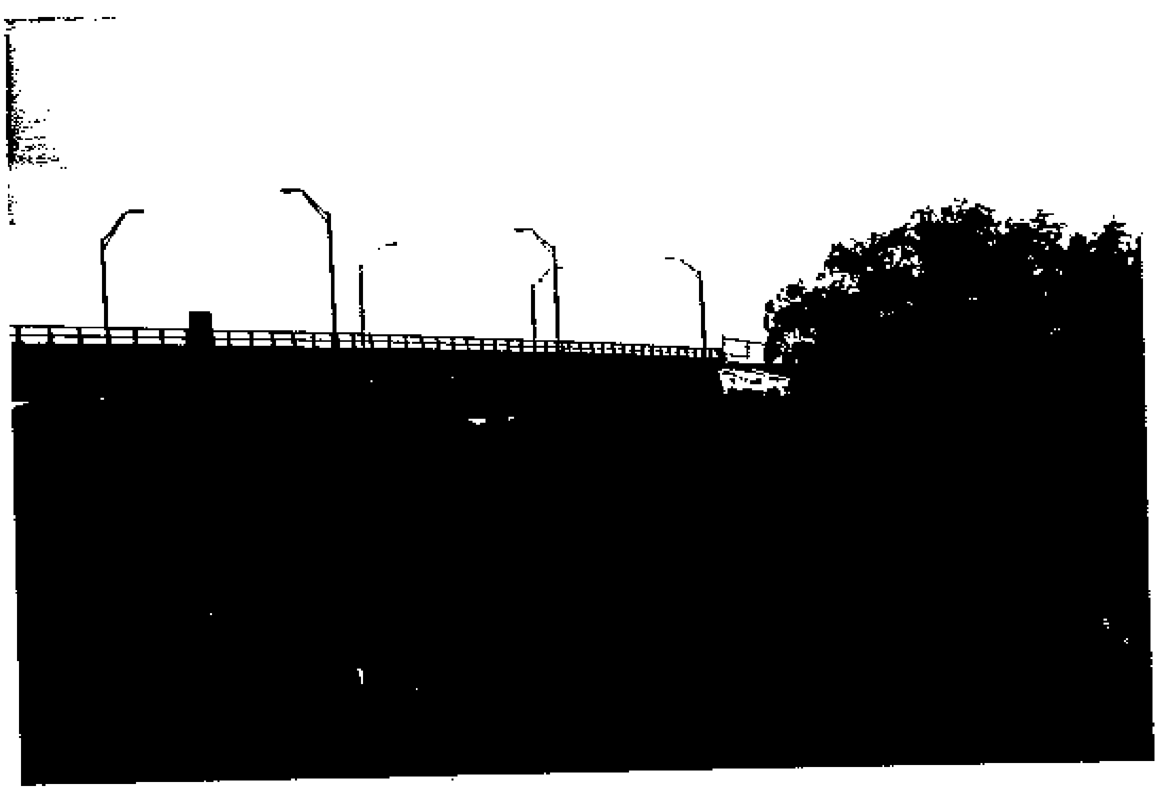


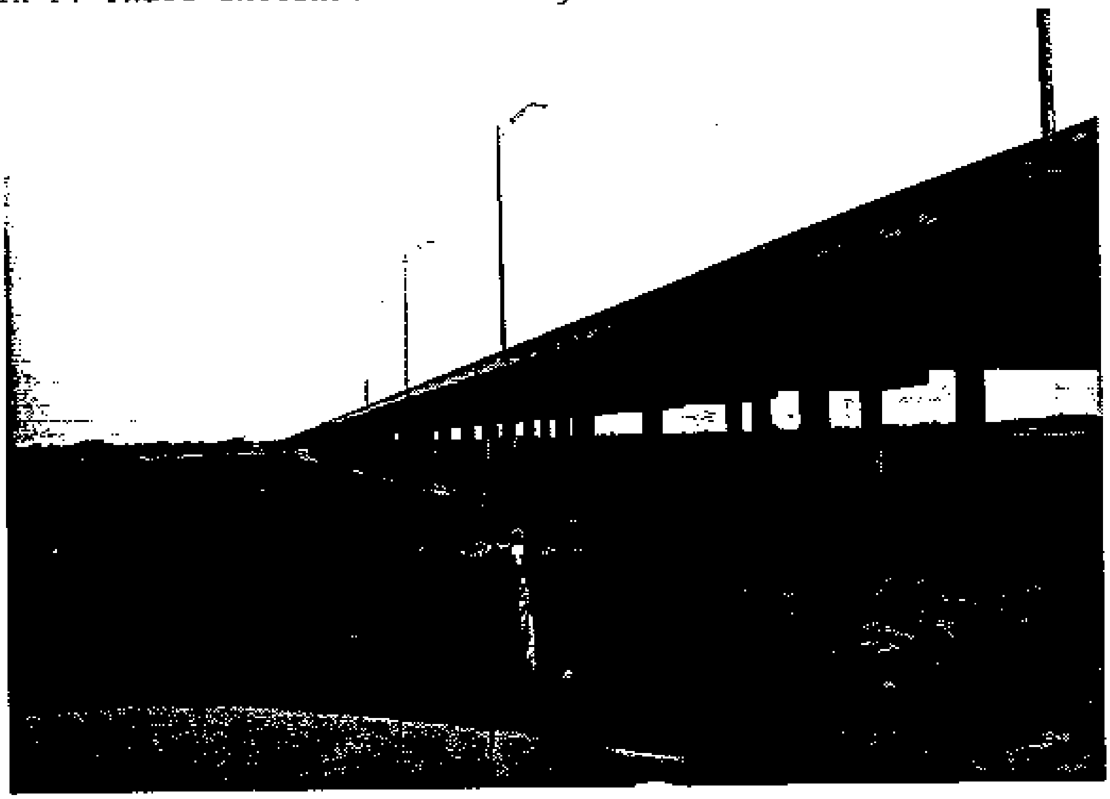
APPENDIX D. Los Indios International Bridge





APPENDIX E. Progresso International Bridge

APPENDIX F. Pharr International Bridge



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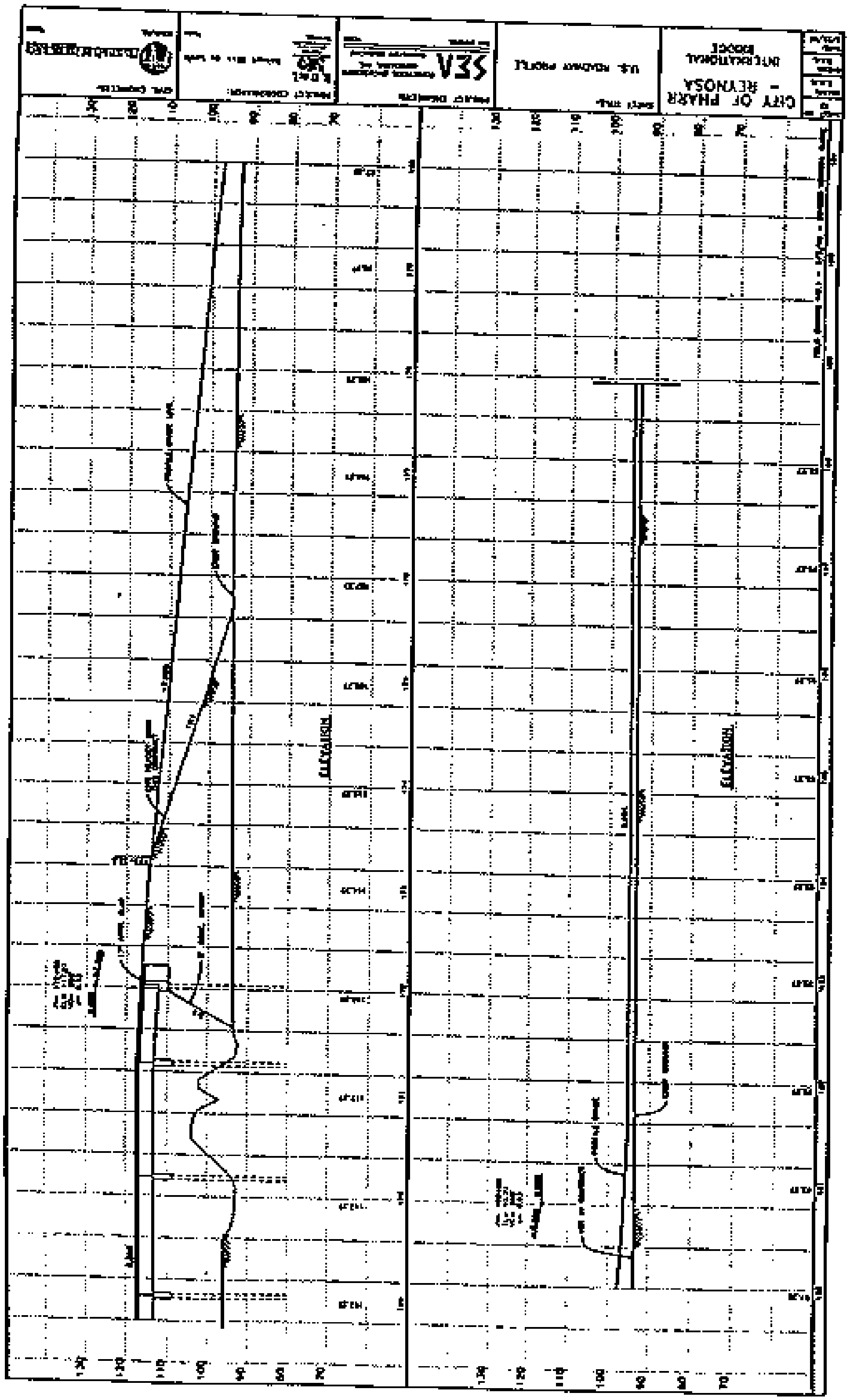
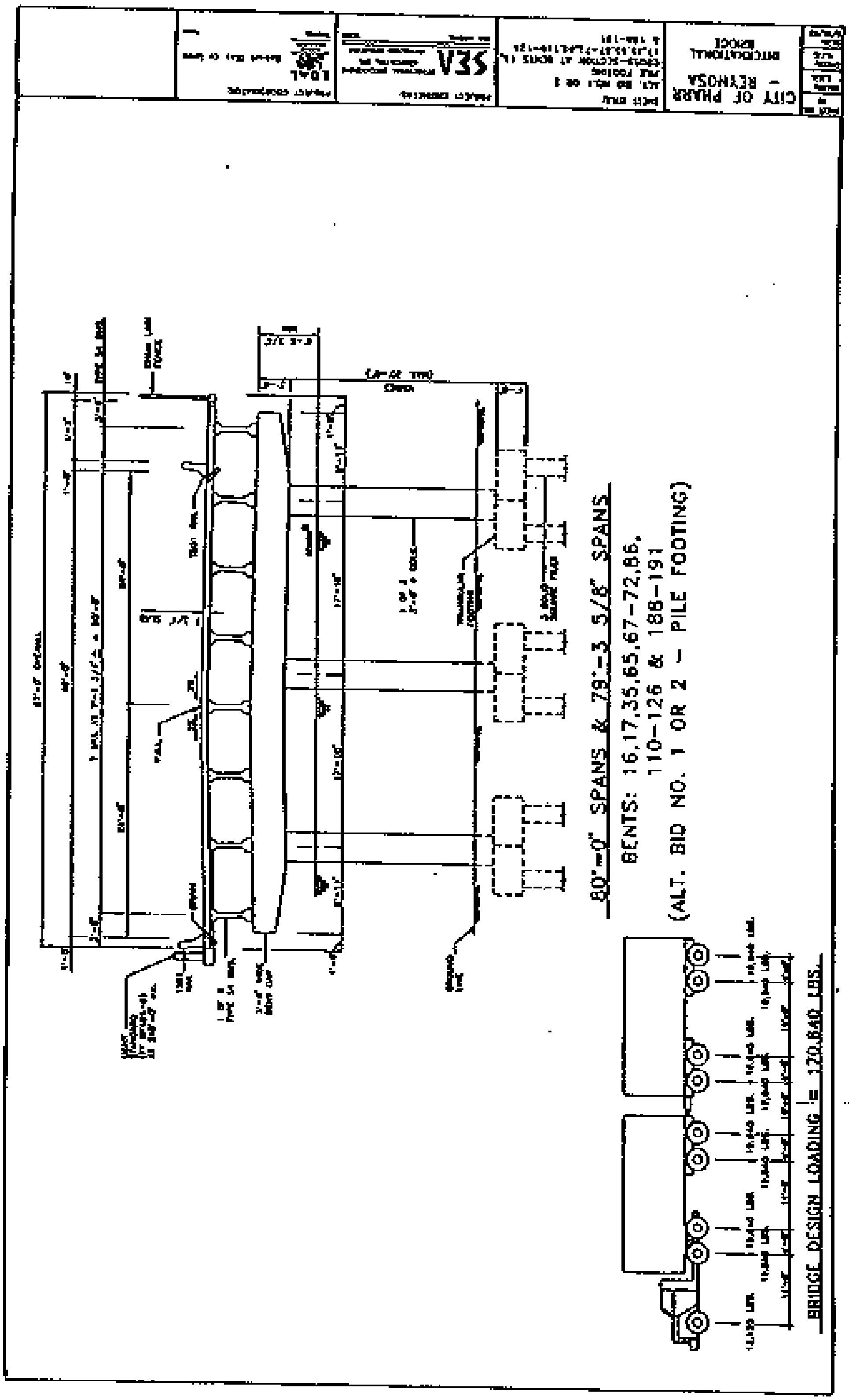


Appendix F. Continued.



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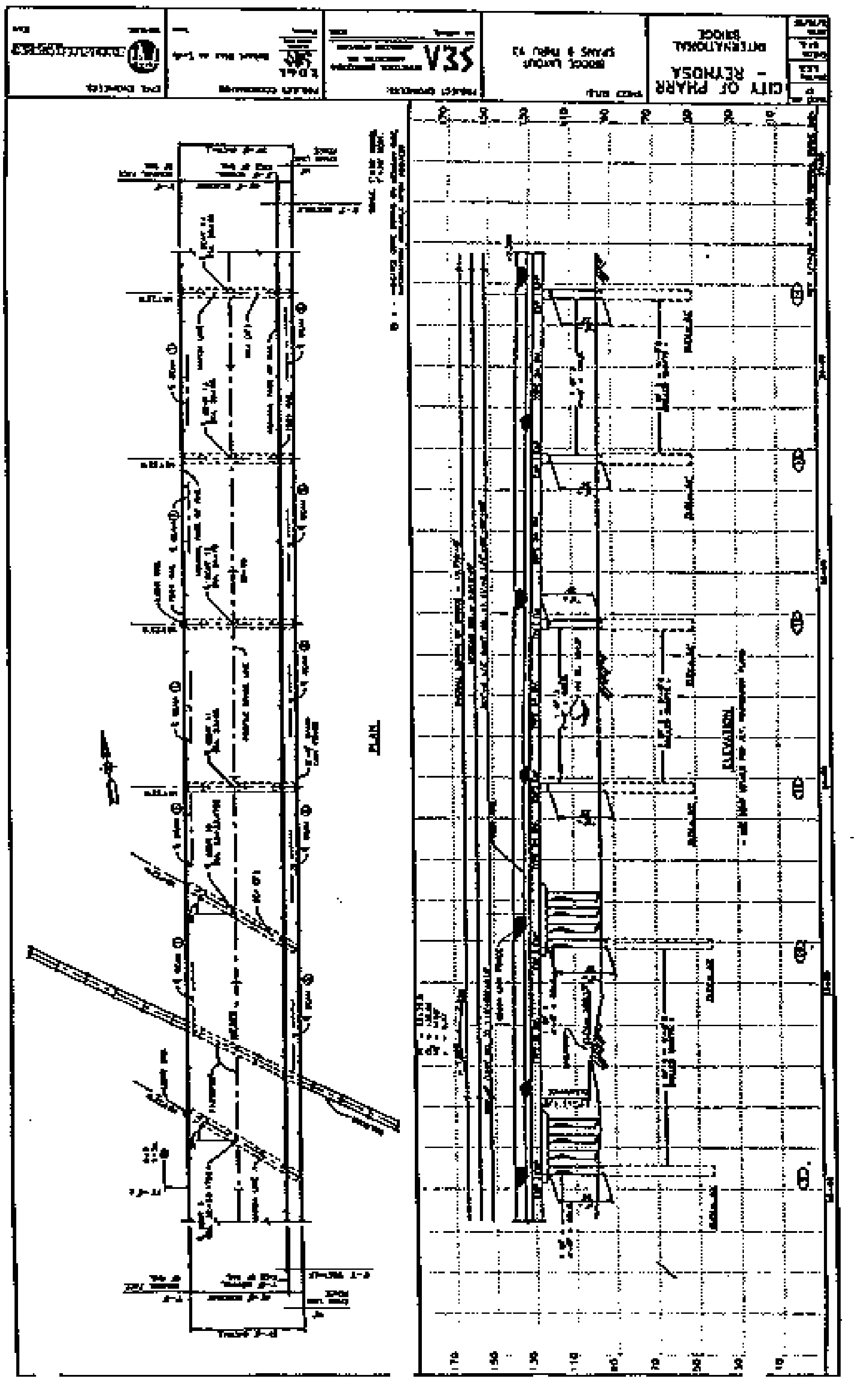
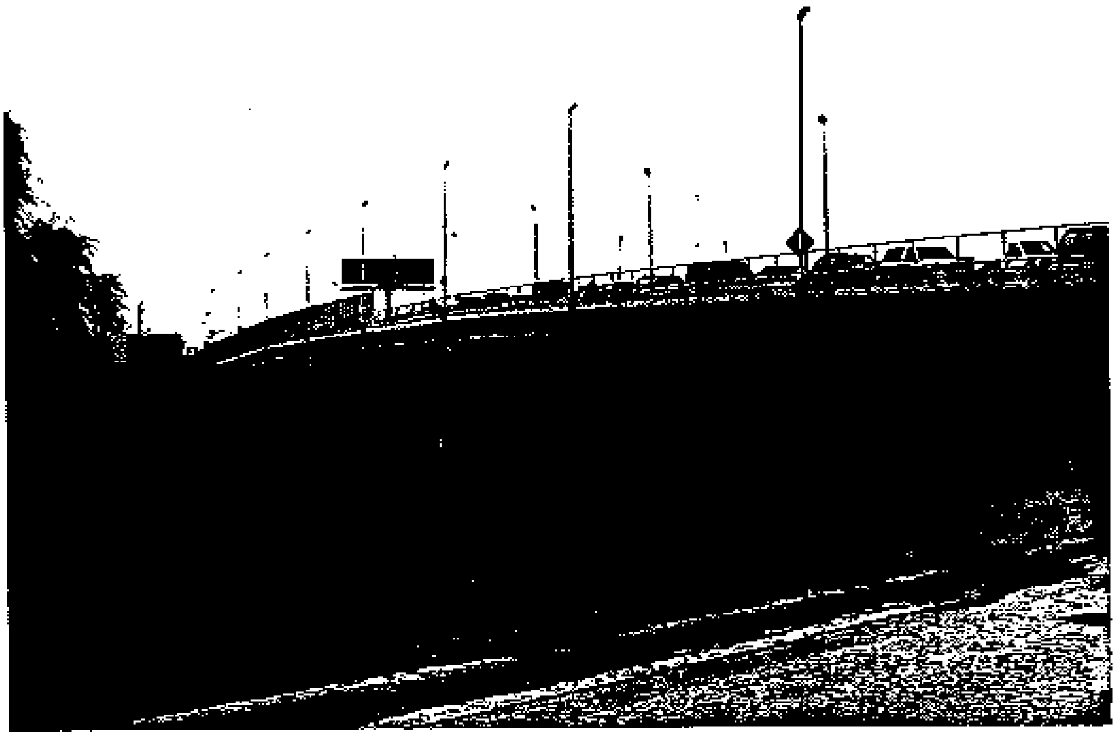
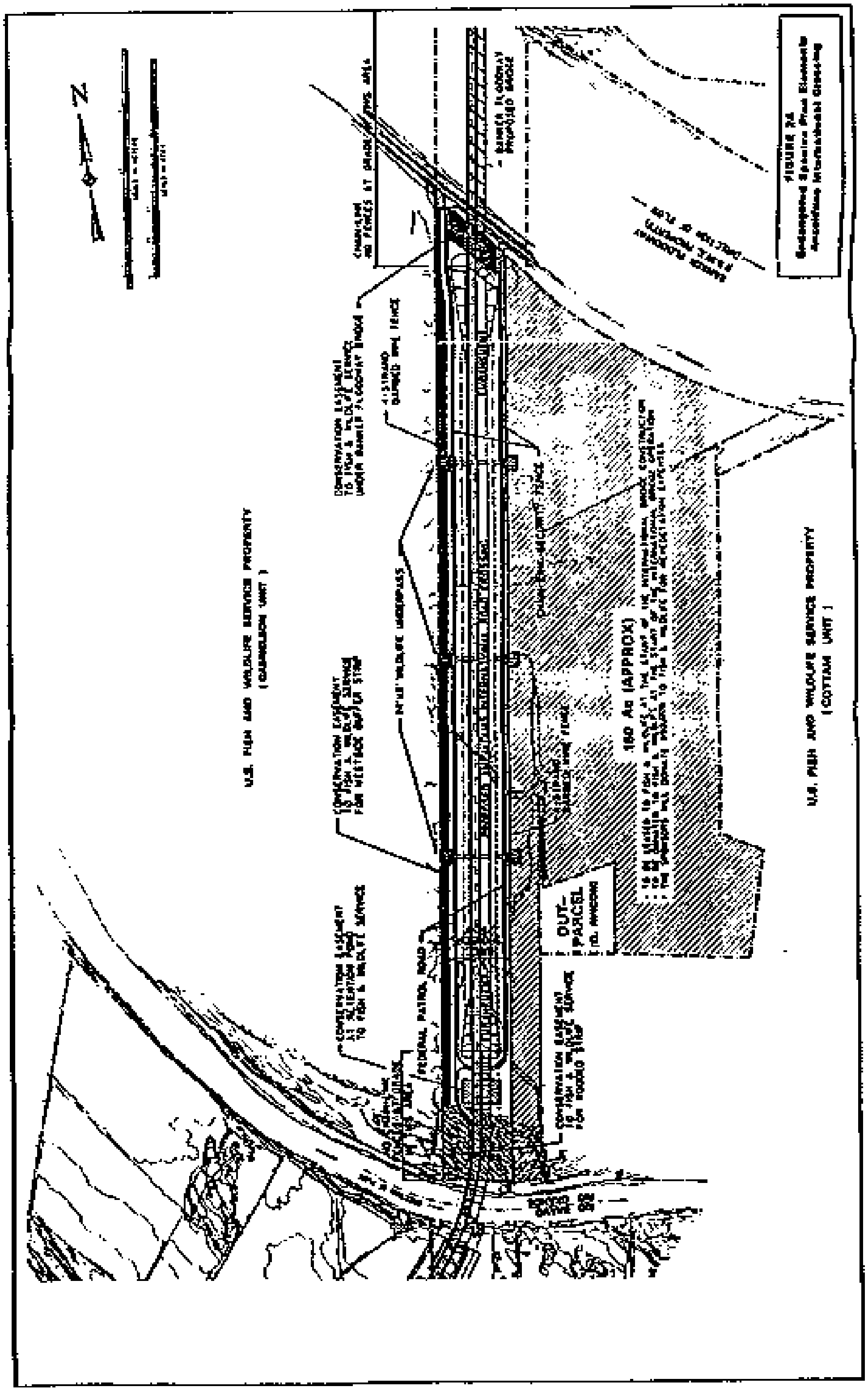


APPENDIX G. Hidalgo-Reynosa International Bridge



APPENDIX H. Proposed Anzalduas International Bridge



Appendix H. Continued.

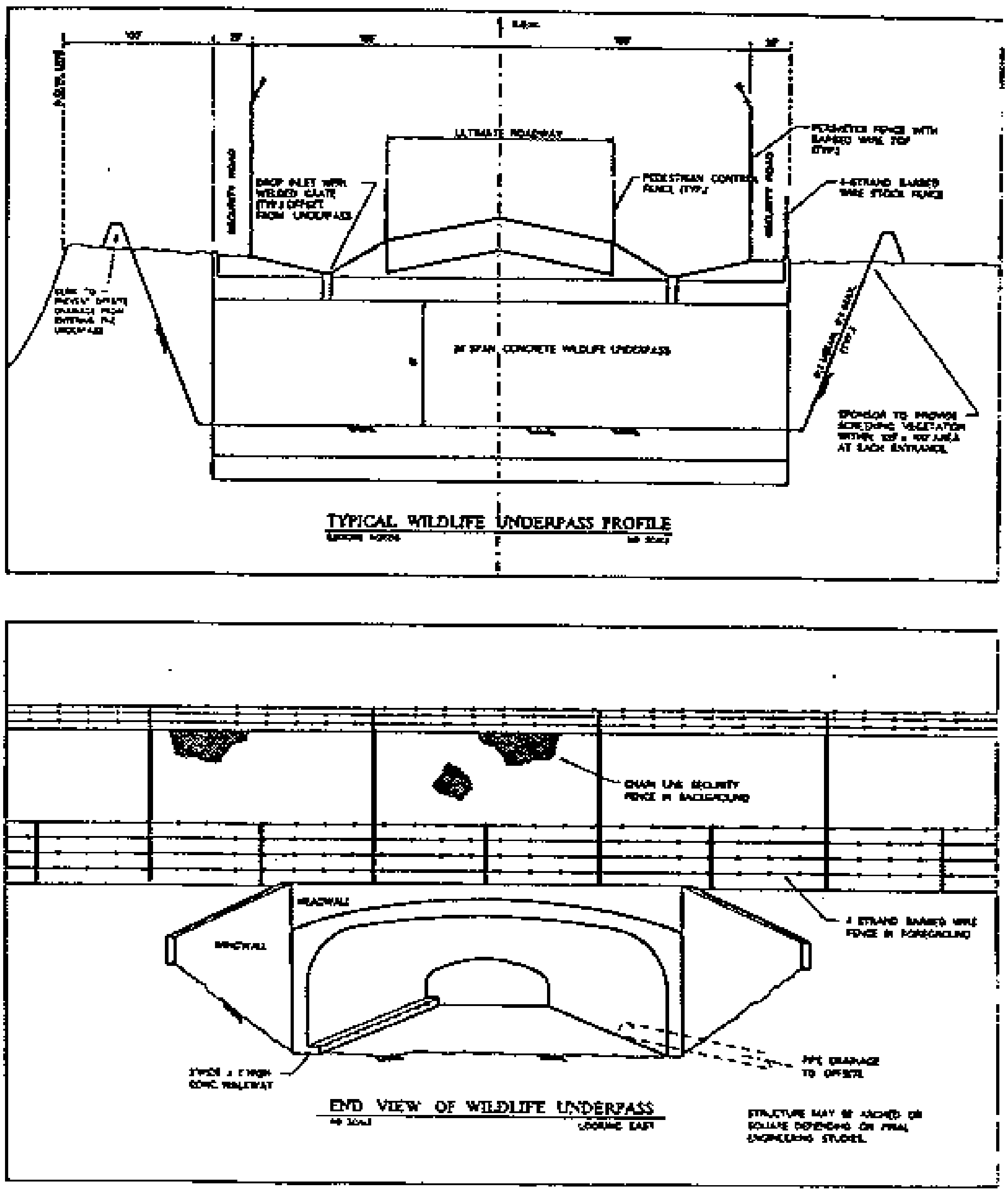
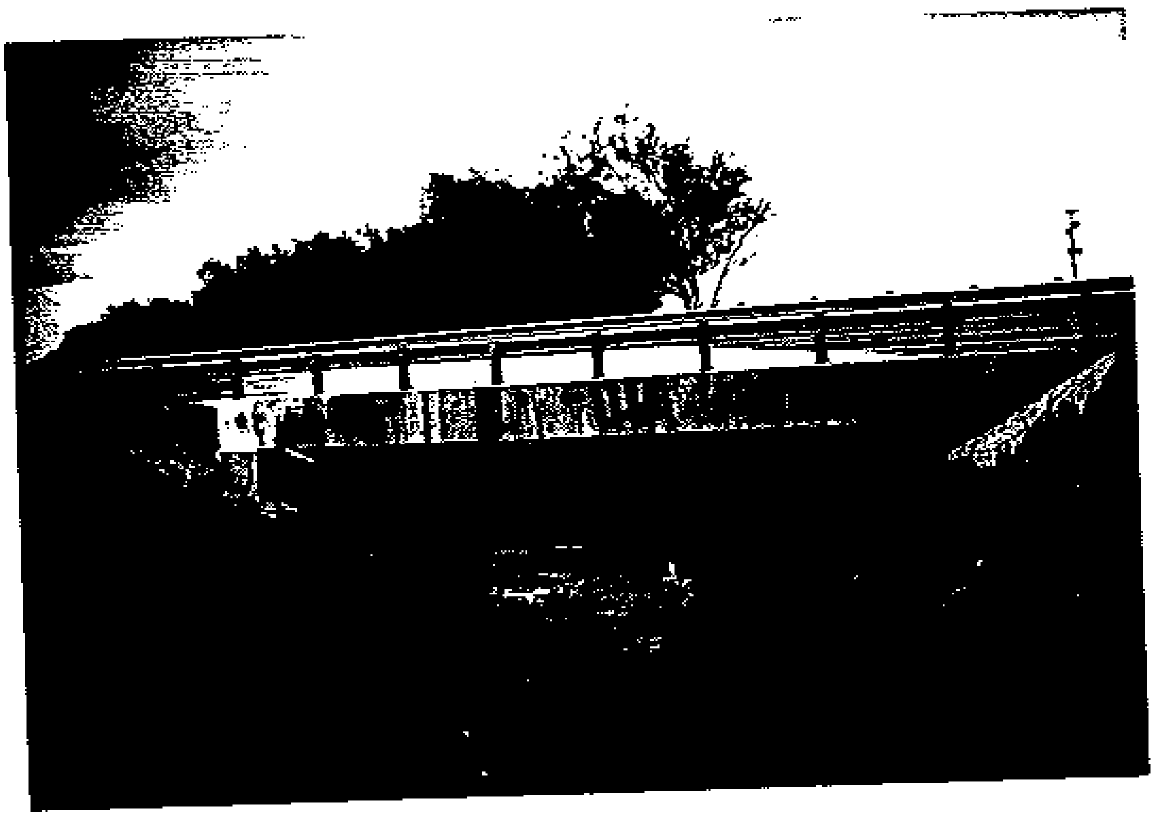


FIGURE 25
Typical Sections and Details
Wildlife Tunnel Structures

APPENDIX I. FM 509 Wildlife Crossing Structure



Appendix I. Continued.