Fish Passage Status of Selected Road-Stream Crossings on the Apalachicola National Forest, Florida, 2006

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Background

The ability to move freely through stream networks is an important aspect of a fish species' long-term viability (Fausch et al. 2002). Fish movement in streams prevents population fragmentation (Winston et al. 1991), allows for population recovery following disturbance (Detenbeck et al. 1992; Adams and Warren 2005; Roghair and Dolloff 2005), and provides access to critical habitats (Fausch and Young 1995). Early work examining effects of road-stream crossings on fish movement occurred primarily in the western U.S. and focused on anadromous Pacific salmon stocks. Effects of road-stream crossings on stream-resident fishes in the eastern U.S. received less attention, in part because such fishes were regarded as sedentary (Gerking 1959). Recent re-examination of historic movement studies (Gowan et al. 1994) and new research on a wide range of stream-resident fish species (Warren and Pardew 1998; Albanese et al. 2003; Schmetterling and Adams 2004) has shown a frequency and magnitude of movement that must be considered when making stream management decisions.

There are estimated to be over 50,000 road-stream crossings on National Forest managed lands in the eastern U.S. (M. Hudy, Forest Service U.S. Department of Agriculture, unpublished data). Each of these crossings represents a potential impediment or barrier to fish movement among stream reaches and watersheds. The Forest Service recognizes the importance of modifying or removing those crossings identified as barriers to meet its objective of restoring and maintaining native species diversity (Forest Service, U.S. Department of Agriculture 2004). In alignment with the Forest Service National Strategic Plan, the Southern Region has also listed the removal of barriers to fish and other aquatic organisms as a key strategy for meeting its critical objective of improving watershed condition (Southern Region Forest Service, U.S. Department of Agriculture *Draft*).

In 2003 and 2004 the U.S. Forest Service Southern and Eastern Regions and the San Dimas Technology and Development Center (SDTDC) hosted several fish passage assessment and remediation workshops. The National Inventory and Assessment Procedure (NIAP) (Clarkin et al. 2003) presented at these workshops provided a framework for collecting field data, but the assessment models, designed for western U.S. fish species, were not directly applicable to most species in the eastern U.S. The southeastern U.S. has over 660 freshwater fish species in 27 families encompassing a wide range of swimming and leaping abilities (Warren et al. 2000). Development of species-specific passage models was considered impractical and lack of data on leaping and swimming ability for most eastern fish species limited the usefulness of previously developed passage assessment software such as FishXing (Love et al. 1999).

In 2003, graduate students and biologists of the U.S. Forest Service Aquatic Ecology Unit – East at James Madison University began to develop models that would allow managers to quickly assess the passage status of a crossing. Three 'coarse screening filters' were developed based on leaping and

swimming abilities: Filter A strong abilities; Filter B moderate abilities; and Filter C weak abilities. Model validation showed that when using data collected with the NAIP the coarse filters were reliable tools for predicting fish passage (Coffman 2005).

In 2005 the USFS Southern Region, pursuing its critical priority of improving watershed condition, elected to allocate 10% of its Roads and Trails (TRTR) funds annually for four years to inventory road-stream crossings and identify fish passage barriers in the Southern Region. To insure a quality product with consistent data collection and analysis the Region partnered with the Southern Research Station, Center for Aquatic Technology Transfer (CATT) to design and execute an inventory and assessment program for road-stream crossings. The CATT developed an inventory protocol based on the NIAP, deployed field crews to collect data, and then classified each crossing as passable, impassable or indeterminate for each of the three coarse filters described above. The CATT completed inventories on several Forests in summer 2005 (Coffman et al. 2005) and summer 2006 (Coffman et al. 2007). Because Floridian streams present unique circumstances for assessment surveys due to their extremely low gradients and fine substrates, questions existed as to the extent of passage problems on National Forests lands in Florida. In January 2006, the CATT conducted reconnaissance surveys on selected crossings in the Apalachicola National Forest (ANF), to determine a preliminary understanding of fish passage status on National Forests in Florida.

Sites

The Apalachicola NF requested surveys on 14 non–randomly selected road-stream crossings. The streams included in the surveys were: Fisher Creek on Forest Road 376 (FR376), unnamed tributary to Fisher Creek (FR373), unnamed stream (FR325), Harvey Creek (FR326), unnamed tributary to Harvey Creek (FR360), two unnamed tributaries to Harvey Creek (FR326), unnamed tributary to Black Creek (FR107), Black Creek (FR107), West Prong New River (FR114), Black Creek (FR181C), unnamed tributary to New River (FR114), Big Cypress Swamp (FR115), and Fields Branch (FR123) (Figure 1).

Methods

Data Collection

Dimensions, characteristics, shape (Figure 2), and condition of road-stream crossing structures and data pertaining to the adjacent stream channel were recorded for each site following the National Inventory and Assessment Procedure (NIAP) for road-stream crossings (Clarkin et al. 2003). A CST/berger SAL series automatic level with 32x magnification mounted on a tripod and a 25-foot stadia rod graduated in tenths of feet were used to measure the elevation of the crossing structure inlet and outlet, tailwater control, and the water surface (Figure 3). A measuring tape marked in hundredths of a

foot was used to measure the distance between the crossings inlet and outlet. Photographs of the inlet and outlet were taken and each site was sketched on paper. Condition of the crossing structure was recorded and any natural barriers (e.g. waterfalls) immediately upstream or downstream were documented. Natural stream substrate covering the bottom of the crossing structure was recorded as continuous throughout the structure, discontinuous, or not present. Substrate had to cover 100% of the structure bottom for a crossing to receive a continuous throughout the structure designation. Crossing location was documented and photographs of the inlet and outlet were taken, but the structure was not surveyed if the crossing structure was a bridge, natural ford, open bottom arch, or clearly backwatered. Bridges and natural fords were assumed to always provide adequate upstream fish passage. By definition, open bottom arches receive a natural substrate continuous throughout structure designation, thus these structures receive a passable classifications by default for all filters. Backwatered structures also receive a passable classification by default for all filters and are favorable for upstream fish passage.

Sites with more than one crossing structure (e.g. culverted site with multiple pipes) were commonly encountered during the surveys. At these sites each individual structure was numbered sequentially from left to right when facing downstream. Each individual structure was then surveyed and classified, which could result in a single site having multiple classifications for a given filter. Under those circumstances the location was classified based on the structure that received the best passage rating. For example, in a crossing location with two circular culverts where one was classified as impassable and one indeterminate by Filter B, the location would receive an overall classification of indeterminate for that filter rather than impassable.

Data Analysis

The elevation and distance measurements for the crossing inlet, crossing outlet, tailwater control, and water surface were used to calculate residual inlet depth, outlet drop, outlet perch, slope, and slope x length values for each crossing (Figure 3).

Residual inlet depth is calculated as

$$P_3 - P_1,$$

where P_3 is the tailwater control elevation of the outlet pool and P_1 is the crossing inlet elevation. Residual inlet depth values greater than zero indicate the structure is completely backwatered, allowing fish passage.

Outlet drop is calculated as

$$P_2 - P_3,$$

where P_2 is the crossing outlet elevation and P_3 is the tailwater control elevation of the outlet pool.

Outlet perch is calculated as

$$P_2 - Ws,$$

where P_2 is the crossing outlet elevation and Ws is the water surface elevation immediately downstream of the outlet. Outlet perch is used in place of outlet drop when a tailwater control is not present and outlet drop cannot be calculated. Excessive outlet drop or outlet perch values indicate the presence of jump barriers.

Slope is calculated as

$$(P_{1elev} - P_{2elev}) / (P_{1dist} - P_{2dist}) * 100,$$

where P_{1elev} is the crossing inlet elevation, P_{2elev} is the crossing outlet elevation, P_{1dist} is the crossing inlet distance, and P_{2dist} is the crossing outlet distance. Steep slope is an indicator of velocity barriers.

Slope x length is calculated as

$$[(P_{1elev} - P_{2elev}) / (P_{1dist} - P_{2dist}) * 100] * (P_{1dist} - P_{2dist}),$$

where P_{1elev} is the crossing inlet elevation, P_{2elev} is the crossing outlet elevation, P_{1dist} is the crossing inlet distance, and P_{2dist} is the crossing outlet distance. High slope x length values indicate an exhaustion barrier.

Percent of crossing structure bottom with natural substrate, residual inlet depth, outlet drop, outlet perch, slope, and slope x length values for each crossing were applied to each of three regional coarse filters (Figures 4 – 6) to determine upstream passage status. Threshold values for each parameter differ by filter and were set according to published swimming and leaping abilities of representative species in each filter group, and relationships among crossing dimensions, species presence/absence data, and movement data (Coffman 2005). Filter A (Figure 4) classifies crossings for species with strong swimming and leaping abilities, such as the adult brook trout (*Salvelinus fontinalis*). Filter B (Figure 5) classifies crossings for species with moderate swimming and leaping abilities such as juvenile trout or species in the minnow family (Cyprinidae). Filter C (Figure 6) classifies crossings for weak swimmers and leapers, such as species in the darter (Percidae) and sculpin (Cottidae) families. Crossings are classified as passable, impassable, or indeterminate for each of the three filters at base flows. Biological sampling or computer modeling is required to determine passage status for crossings classified as indeterminate.

Results

We completed surveys at 8 (23 structures) of 14 (37 structures) documented road-stream crossings in January 2006 (Table 1). The majority of all crossings were rated passable for all filters. Only two crossings (3 structures) were rated impassable by each Filter (Table 2). Pipe slope did not exceed 2% for any of the passable crossings, and sand was the dominate substrate at all crossings. Characteristics of each crossing are presented in Table 3.

Fisher Creek (A376)

The crossing at the intersection of Fisher Creek and FR376 consisted of three annular CMP steel pipes in good condition. Filters A, B and C classified all three pipes passable. All three pipes were backwatered and had gradients less than or equal to 1.0%.

Unnamed tributary to Fisher Creek (A373)

The crossing at the intersection of an unnamed tributary to Fisher Creek and FR373 consisted of five annular CMP steel pipes in fair condition. Filters A, B and C classified all five pipes passable.

Unnamed stream (A325)

The crossing at the intersection of an unnamed stream and FR325 consisted of three annular CMP steel pipes in good condition. Filters A, and B classified all three pipes passable. Filter C classified Pipe 1 indeterminate and Pipes 2 and 3 passable.

Harvey Creek (A326-1)

The crossing at the intersection of Harvey Creek and FR326 consisted of two concrete box culverts in poor condition. Some water was flowing under the structure and pieces of the existing concrete form and previously installed crossing structures were present at the outlet. Large amounts of sand and sediment from road runoff/washout and failing sediment fences were present downstream. The channel was highly entrenched downstream of the crossing with banks over 10 feet high. Both pipes were rated impassable by all three filters. Pipe 2 conveyed all of the flow and had an outlet drop of 53.76 inches. Pipe 1 carried no water flow and had an outlet drop of 79.56 inches.

Unnamed tributary to Harvey Creek (A360)

The crossing at the intersection of an unnamed tributary to Harvey Creek and FR360 consisted of four annular CMP steel pipes in good condition. Filters A, B, and C classified all four pipes passable.

Unnamed tributary to Harvey Creek (A326-2)

The crossing at the intersection of an unnamed tributary to Harvey Creek and FR326 consisted of two open bottom arches in good condition. The crossing was not surveyed because open bottom arches are classified passable by default. Pipe 1 carried all the flow, and pipe 2 had deep sand deposits.

Unnamed tributary to Harvey Creek (A326-3)

The crossing at the intersection of an unnamed tributary to Harvey Creek and FR326 consisted of an open bottom arch in good condition. The structure was not surveyed because open bottom arches are

classified passable by default. Six individuals of a species of darter were observed just upstream of the crossing inlet.

Unnamed tributary to Black Creek (A107-1)

The crossing at the intersection of an unnamed tributary to Black Creek and FR107 consisted of three annular CMP steel pipes in fair condition. Filters A, B, and C classified all three pipes passable.

Black Creek (A107-2)

The crossing at the intersection of Black Creek and FR107 consisted of three annular CMP steel pipes in fair condition. The structure was not surveyed because all three pipes were obviously backwatered and passable by default.

West Prong New River (A114-1)

The crossing at the intersection of the West Prong New River and FR114 consisted of four annular CMP steel pipes in good condition with some road-fill erosion. The structure was not surveyed because all four pipes were obviously backwatered and passable by default.

Black Creek (A181C)

The crossing at the intersection of Black Creek and FR181C consisted of a concrete low water bridge. The structure was not surveyed because bridges are assumed to be passable by default.

Unnamed tributary to New River (A114-2)

The crossing at the intersection of an unnamed tributary to the New River and FR114 consisted of three spiral CMP steel pipes in good condition. The structure was not surveyed because all three pipes were obviously backwatered and passable by default. Topminnows were observed in the outlet pool.

Big Cypress Swamp (A115)

The crossing at the intersection of Big Cypress Swamp and FR115 consisted of a concrete slab ford in fair condition. Filters A, B, and C classified the ford impassable. The ford had an outlet drop of 24.6 inches.

Fields Branch (A123)

The crossing at the intersection of Fields Branch and FR123 consisted of two concrete box culverts in good condition. Filters A, B and C classified both pipes passable. Fish were observed upstream and downstream of the crossing.

Discussion

Although our sample size was small, we encountered relatively few crossings that would impede upstream fish passage on the Apalachicola National Forest. Twelve of the fourteen crossings we visited were classified as entirely passable. All of the crossings we surveyed were within the Gulf Coast Flatwoods subecoregion. This subecoregion is characterized by flat plains with large areas of standing water, elevations between 0-40m, and relief between 0-30m (Griffith et al. 1994). Land cover of the Apalachicola NF and this subecoregion is dominated by evergreen forests and forested wetlands (Griffith et al. 1994). Streams in the Gulf Coast Flatwoods are generally low gradient channels with sandy substrates that connect bays and swamp areas; characteristics that likely contribute to the high percentage of passable crossings.

Outlet drop triggered passage failure at the two impassable sites (A326-1 and A115) for all three filters, but it was not the only factor that would have prevented upstream passage at site A326-1. The slope of 5.53% would have resulted in passage failure for at least two of the three filters. Even if fish managed to find a way into this structure they would encounter water velocities and a structure length that likely exceed their swimming abilities or result in exhaustion. Harvey Creek at Site A326-1 showed extreme channel incision downstream of the crossing. An increase in erosional forces produced by the undersized crossing constricting flow and increasing water velocity; along with the road concentrating and accelerating runoff most likely caused the channel incision at this site (Castro 2003). This crossings structure is probably acting as a control point preventing the channel incision from proceeding farther upstream. Careful considerations should be given to the potential for upstream migration of the head cut if the crossing is replaced or removed.

Site A115 would have been classified passable for all three filters if it did not have an excessive outlet drop (24.6in). Excessive outlet drops typically develop when crossing structures do not mimic natural channel characteristics such as bankfull channel width, slope, and substrate. The result is increased water velocity within or across the structure and scouring immediately downstream creating an outlet drop (Castro 2003). The concrete slabs used in fords such as the one at site A115 can essentially act as low head dams, backing up water upstream and scouring the downstream channel as water plunges from the outlet. The depth of scour at the downstream end increases over time resulting in a jump barrier.

Current Limitations and Future Improvements

The coarse filters presented here apply to several general categories of fish including strong swimmers and leapers (Filter A), moderate swimmers and leapers (Filter B), and weak swimmers and leapers (Filter C). We assigned adult trout to represent Filter A, minnows and young trout to represent Filter B, and darters and sculpins to represent Filter C, however there are a range of swimming and leaping abilities represented within each family. For example some minnow species are strong swimmers

and therefore may be most appropriately assessed by Filter A, whereas other weak swimming minnows may be candidates for Filter C. Still other families or species, such as those that are strong swimmers but weak to moderate leapers may require the creation of additional filters. Currently, few data are available regarding swimming and leaping abilities of non-game fish species in the Southeast making it difficult to refine or expand the existing set of filters. Members of the sucker (Catostomidae), catfish (Ictuluridae) and sunfish (Centrarchidae) families may fit into such filters, but clearly more research is needed.

Biological sampling can provide important information for evaluating fish passage at sites classified indeterminate and generally with little expense relative to the cost of replacing a crossing structure. Mark-recapture sampling designs can vary in complexity and effort depending on project goals (Warren and Pardew 1998) and provide direct evidence of fish passage without the assumptions of fish passage models. The mark recapture design can be as simple as marking and releasing a sample of fish downstream of a crossing, and then sampling for marked fish about the crossing on subsequent sampling trips. Collection of marked fish above the crossing would indicate that crossing is passable for the species in question. More elaborate designs to detect if movement through the crossing is the same or similar to movement through the unobstructed natural stream channel can also be implemented (Coffman 2005). The use of mark-recapture studies at indeterminate sites would not only allow Forests to classify these sites as passable or impassable, but would also provide data necessary to refine the filter thresholds and reduce the number of indeterminate classifications.

Forests have opportunities to improve fish passage at road-stream crossings both during routine maintenance when crossing structures reach the end of their serviceable life, and when funding becomes available to replace crossings outside of the regular maintenance schedule. Forests should always consult with their biologists and hydrologists to determine whether routine replacements should include aquatic organism passage considerations. Selection of sites for replacement outside of the routine maintenance schedule can be more challenging. Currently, Forests can use the information from our surveys to locate impassable crossings that are candidates for replacement; however our survey results only provide passage status and exclude other factors that should be considered when prioritizing crossings for replacement. Information such as miles of habitat upstream of a crossing, cost of replacement, exotic species presence, and species status (i.e. threatened, endangered, exotic invasive) need to be included in the decision process.

A full inventory of all road-stream crossings in the Apalachicola National Forest is needed to determine the extent of fish passage problems, however the results of our preliminary site visit suggests that the Forest has relatively few passage problems when compared to other Forests in the Southern Region (Coffman et al. 2005; Coffman et al. 2007). Most Forests in the Southern Region face a backlog of hundreds of sites in need of remediation or replacement; a task that will no doubt stretch over decades.

It is likely that after a complete inventory the Apalachicola National Forest will have a more manageable workload of impassable crossings in need of remediation that could be completed over a shorter time frame helping achieve national and regional strategic goals.

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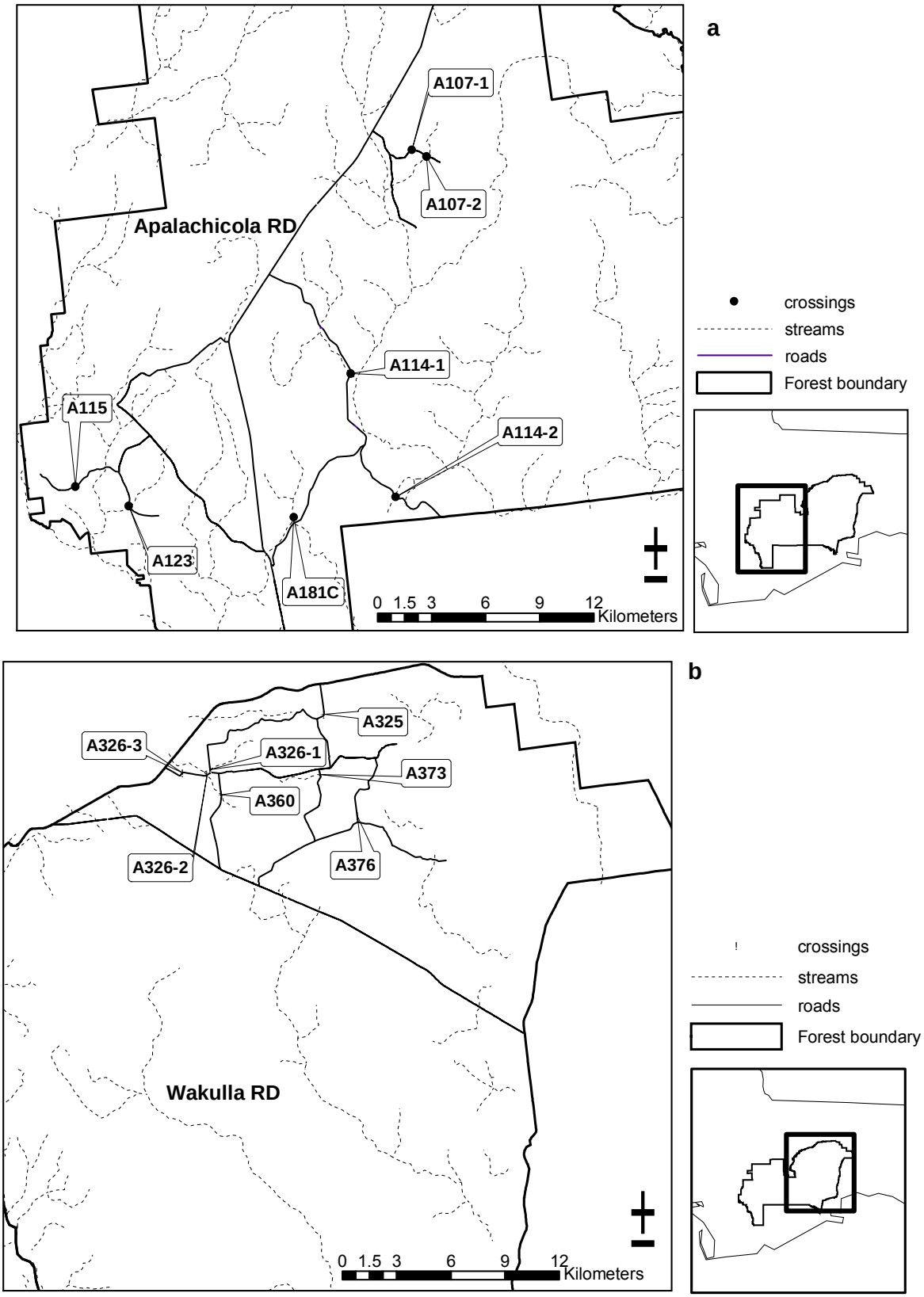

Figure 1. Location of road-stream crossings inventoried and surveyed on the Apalachicola National Forest in Florida, January 2006 panel a: Apalachicola Ranger District; panel b: Wakulla Ranger District.

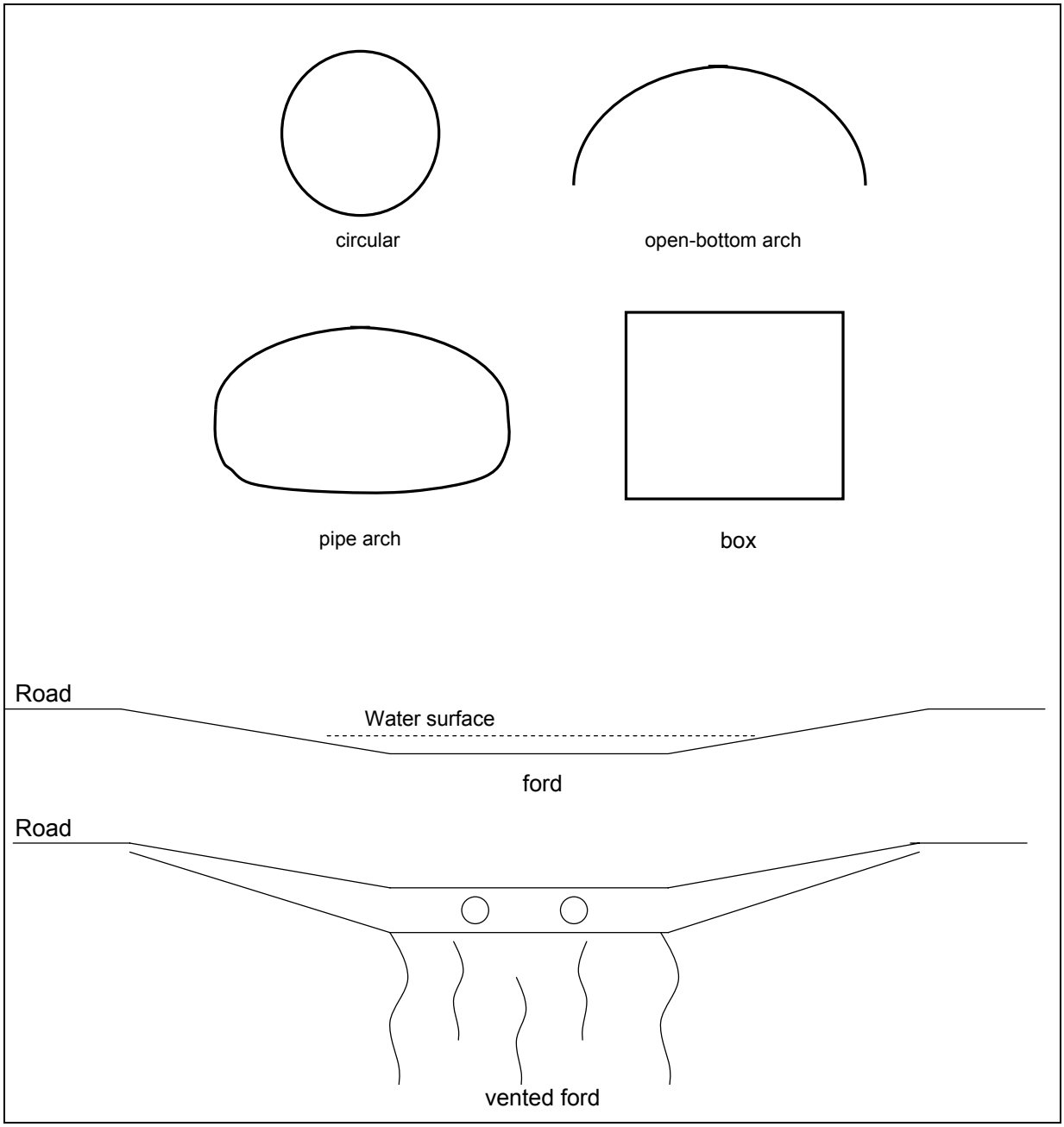

Figure 2. Common crossing shapes encountered during road-stream crossing inventories conducted in the ANF, January 2006.

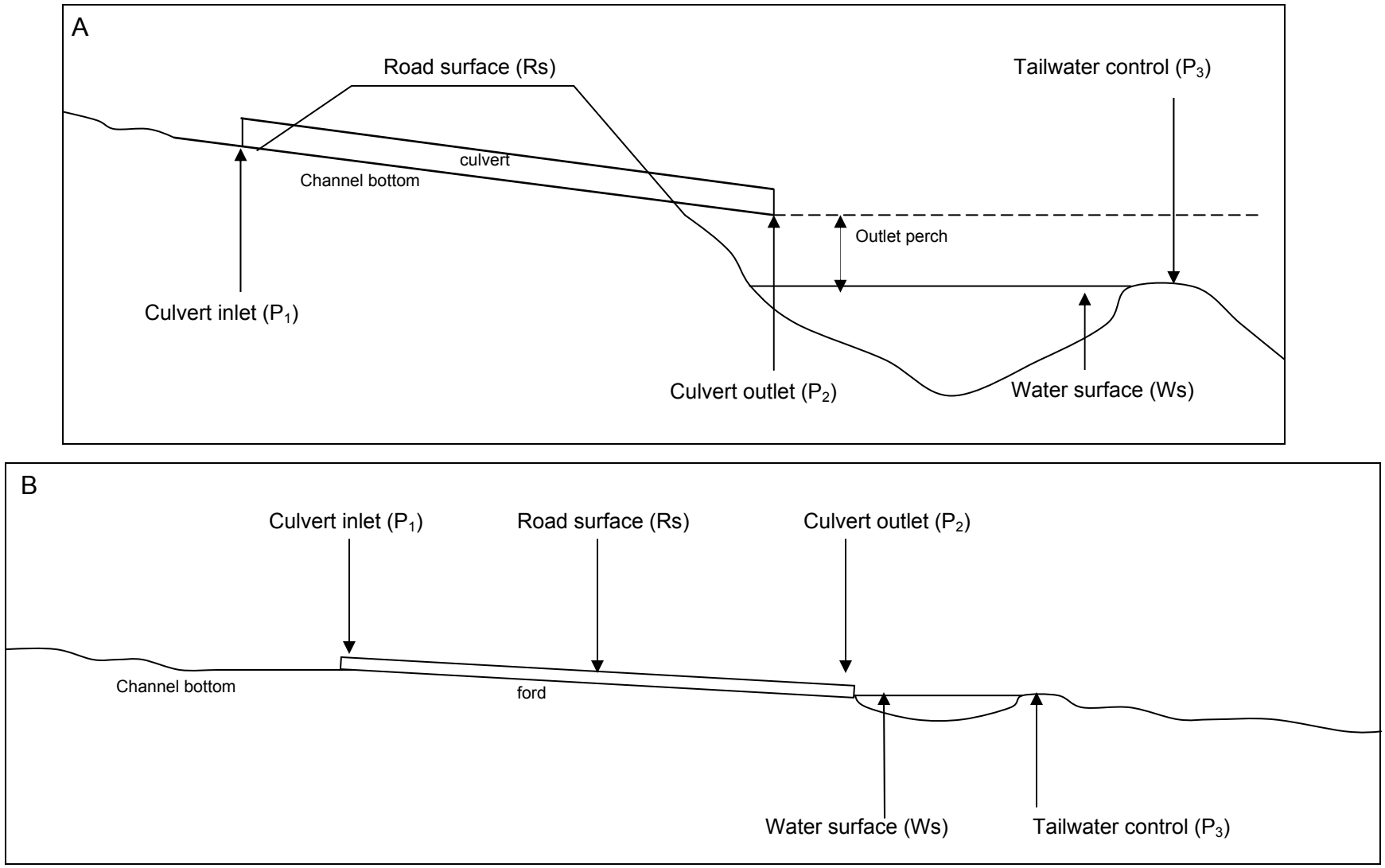

Figure 3. Survey points measured on culverts (A) and unvented fords (B) to calculate parameters used in coarse filters for upstream fish passage Adapted from Clarkin et al. 2003. Parameters are calculated as follows: Residual Inlet depth= $P_3 - P_1$; Outlet drop= $P_2 - P_3$; Outlet perch= $P_2 -$ Ws; Slope= $(P_{1elev} - P_{2elev}) / (P_{1dist} - P_{2dist}) * 100$; Slope x Length= $[(P_{1elev} - P_{2elev}) / (P_{1dist} - P_{2dist}) * 100] * (P_{1dist} - P_{2dist})$.

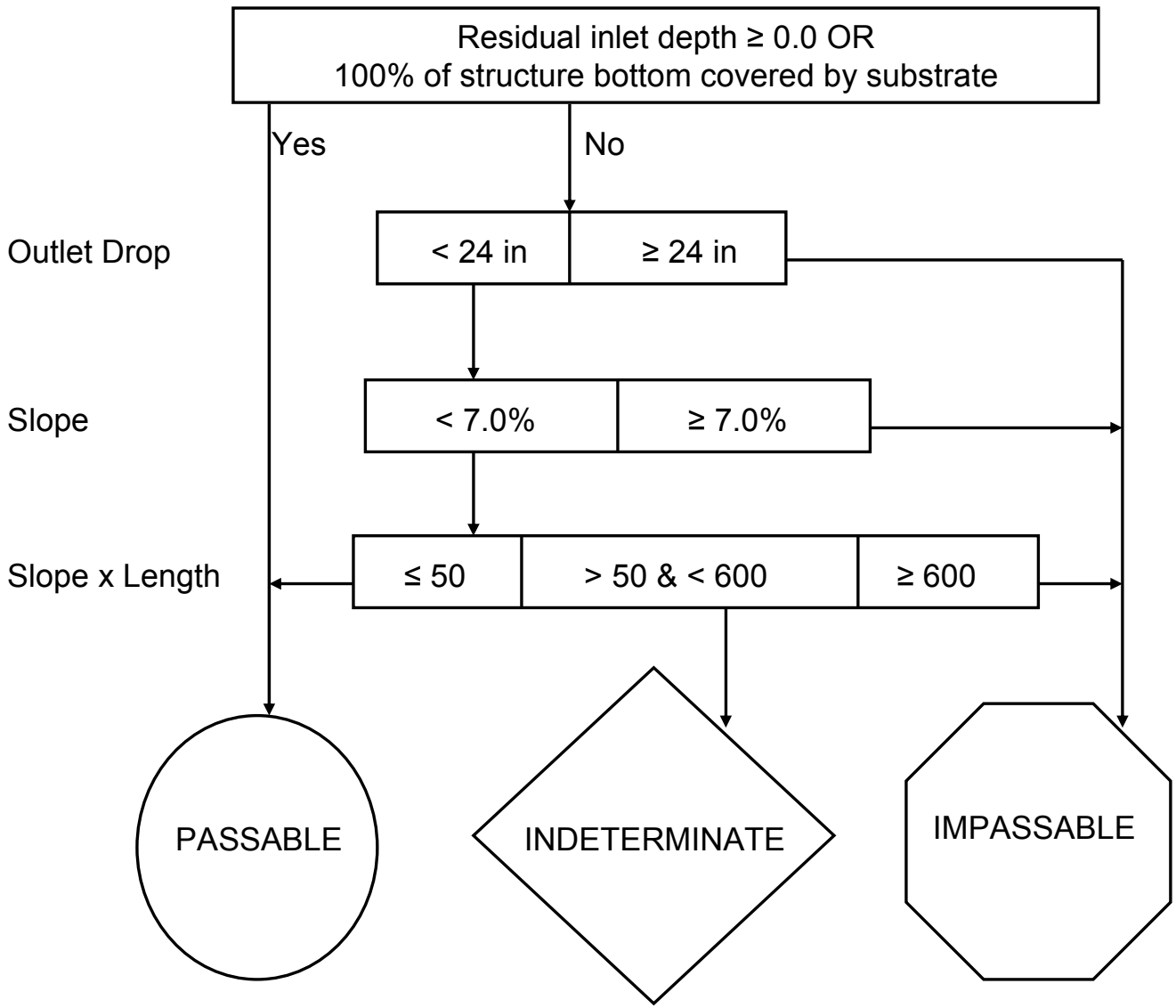

Figure 4. Coarse Filter A: Predictive model used to determine upstream passage for fish with swimming and leaping abilities similar to adult trout. A residual inlet depth ≥ 0.0 (Figure 2) indicates structure is fully backwatered. An outlet perch of 14 in was used when outlet drop could not be calculated (Coffman 2005).

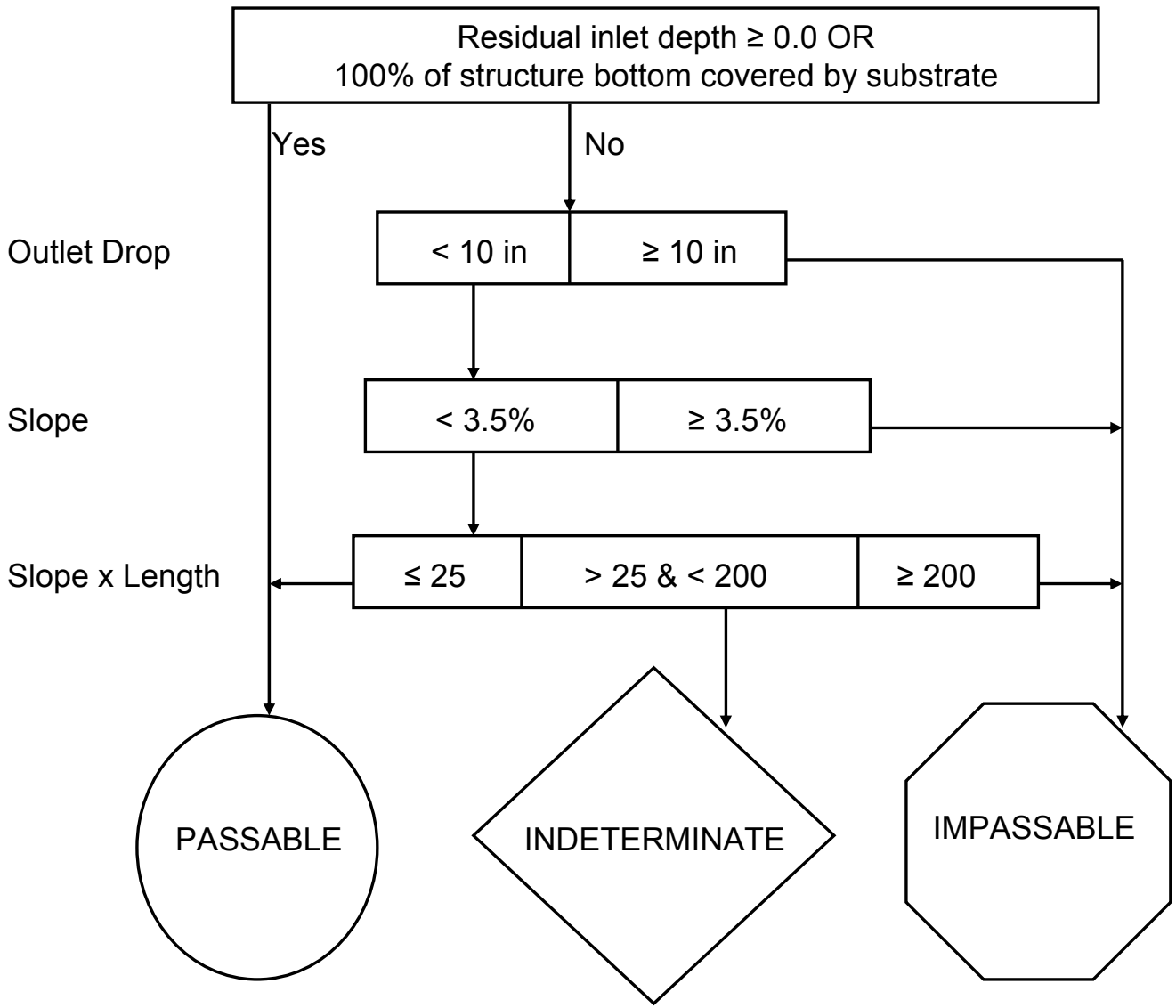

Figure 5. Coarse Filter B: Predictive model used to determine upstream passage for fish with swimming and leaping abilities similar to minnows and juvenile trout. A residual inlet depth ≥ 0.0 (Figure 2) indicates pipe is fully backwatered. An outlet perch of 5 in was used when outlet drop could not be calculated (Coffman 2005).

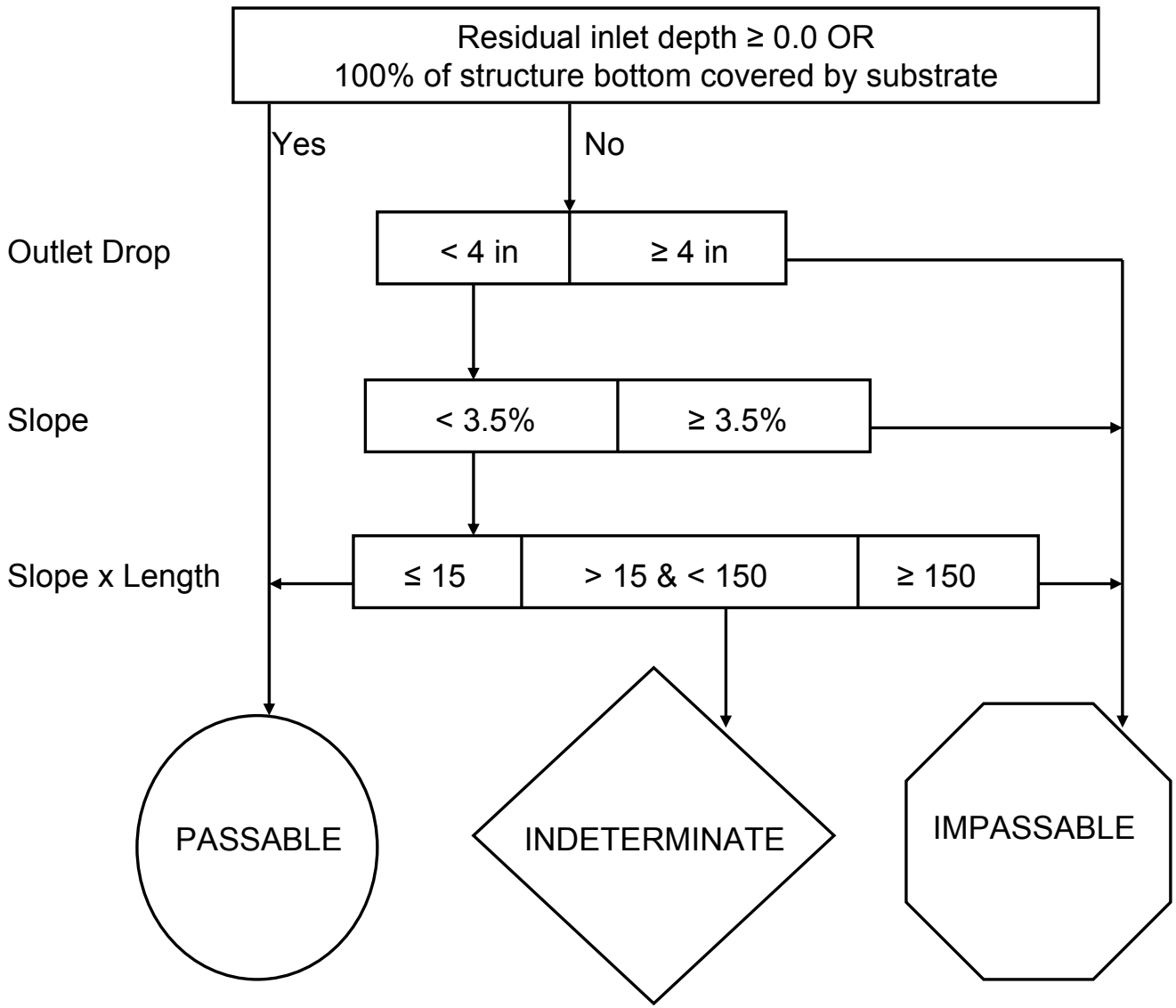

Figure 6. Coarse Filter C: Predictive model used to determine upstream passage for fish with swimming and leaping abilities similar to darters and sculpins. A residual inlet depth ≥ 0.0 (Figure 2) indicates pipe is fully backwatered. An outlet perch of 2 in was used when outlet drop could not be calculated (Coffman 2005).

Table 1. Location of crossings surveyed on the Apalachicola National Forest, January 2006. Site ID consists of the Forest abbreviation (A), road the crossing is on (376), and in cases of multiple crossings on one road an additional unique number.

Site ID	Pipe #	District	Stream Name	Quad
A376	3	Wakulla	Fisher Creek	Midway
A373	5	Wakulla	unnamed tributary to Fisher Creek	Midway
A325	3	Wakulla	unnamed stream	Midway
A326-1	2	Wakulla	Harvey Creek	Lake Talquin
A326-2	2	Wakulla	unnamed tributary to Harvey Creek	Lake Talquin
A326-3	1	Wakulla	unnamed tributary to Harvey Creek	Lake Talquin
A360	4	Wakulla	unnamed tributary to Harvey Creek	Lake Talquin
A107-1	3	Apalachicola	unnamed tributary to Black Creek	Queens Bay
A107-2	3	Apalachicola	Black Creek	Queens Bay
A114-1	4	Apalachicola	West Prong New River	Sumatra
A181-C	1	Apalachicola	Black Creek	Sumatra
A114-2	3	Apalachicola	unnamed tributary to New River	Sumatra
A123	2	Apalachicola	Fields Branch	Kennedy Creek
A115	1	Apalachicola	Big Cypress Swamp	Kennedy Creek

Table 2. Coarse filters A, B, and C, classifications for surveyed crossings on the Apalachicola National Forest, January 2006. For sites with multiple structures the lowest pipe number indicates the structure farthest left when looking downstream.

Site ID	Pipe #	Filter A	Filter B	Filter C
A376	1	passable	passable	passable
A376	2	passable	passable	passable
A376	3	passable	passable	passable
A373	1	passable	passable	passable
A373	2	passable	passable	passable
A373	3	passable	passable	passable
A373	4	passable	passable	passable
A373	5	passable	passable	passable
A325	1	passable	passable	indeterminate
A325	2	passable	passable	passable
A325	3	passable	passable	passable
A326-1	1	impassable	impassable	impassable
A326-1	2	impassable	impassable	impassable
A326-2	1	passable	passable	passable
A326-2	2	passable	passable	passable
A326-3	1	passable	passable	passable
A360	1	passable	passable	passable
A360	2	passable	passable	passable
A360	3	passable	passable	passable
A360	4	passable	passable	passable
A107-1	1	passable	passable	passable
A107-1	2	passable	passable	passable
A107-1	3	passable	passable	passable
A107-2	1	passable	passable	passable
A107-2	2	passable	passable	passable
A107-2	3	passable	passable	passable
A114-1	1	passable	passable	passable
A114-1	2	passable	passable	passable
A114-1	3	passable	passable	passable
A114-1	4	passable	passable	passable
A181-C	1	passable	passable	passable
A114-2	1	passable	passable	passable
A114-2	2	passable	passable	passable
A114-2	3	passable	passable	passable
A123	1	passable	passable	passable
A123	2	passable	passable	passable
A115	1	impassable	impassable	impassable

Table 3. Description of crossings surveyed on the Apalachicola National Forest January 2006. Shape abbreviations: C= circular, PA= pipe arch, OBA= open bottom arch, B= box culvert, F= ford, and BRDG= bridge. N= no natural substrate and Y= continuous natural substrate. An NS (not surveyed) indicates calculations were not made because a full survey was not conducted. Negative outlet drop values indicate a submerged outlet (structure partially backwatered). Residual inlet depth values ≥ 0.0 indicate the structure is fully backwatered.

Site ID	Pipe #	Shape	Pipe Condition	Continuous Substrate in Structure	Pipe slope (%)	Outlet Drop (in)	Residual Inlet Depth (in)	Pipe Length (ft)	Slope (%) * Length (ft)
A376	1	C	good	N	1.00	-15.36	10.32	42.2	42.0
A376	2	C	good	N	0.82	-14.76	10.62	42.2	34.5
A376	3	C	good	N	0.21	-12.24	11.16	42.2	9.0
A373	1	C	fair	N	0.73	-8.52	5.04	39.5	29.0
A373	2	C	fair	N	0.20	-13.86	14.82	39.5	8.0
A373	3	C	fair	N	1.14	-19.38	13.98	39.5	45.0
A373	4	C	fair	N	0.84	-10.92	14.88	39.5	33.0
A373	5	C	fair	N	0.42	-4.68	6.66	39.5	16.5
A325	1	C	fair	N	0.40	2.28	0.00	44.5	18.0
A325	2	C	fair	N	1.20	1.32	5.10	44.5	53.5
A325	3	C	fair	N	0.58	0.36	2.76	44.5	26.0
A326-1	1	B	poor	N	2.75	79.56	0.00	26.2	72.0
A326-1	2	B	poor	N	5.53	53.76	0.00	26.2	145.0
A326-2	1	OBA	good	Y	NS	NS	NS	NS	NS
A326-2	2	OBA	good	Y	NS	NS	NS	NS	NS
A326-3	1	OBA	good	Y	NS	NS	NS	NS	NS
A360	1	C	fair	N	1.04	1.26	0.00	36.6	38.0
A360	2	C	fair	N	1.04	0.84	3.72	36.6	38.0
A360	3	C	fair	N	1.17	-2.88	8.04	36.6	43.0
A360	4	C	fair	N	0.04	-0.36	0.18	36.6	1.5
A107-1	1	PA	fair	Y	1.13	-9.96	13.62	27.1	30.5
A107-1	2	PA	fair	Y	0.18	-16.44	15.84	27.1	5.0

Table continued next page...

Site ID	Pipe #	Shape	Pipe Condition	Continuous Substrate in Structure	Pipe slope (%)	Outlet Drop (in)	Residual Inlet Depth (in)	Pipe Length (ft)	Slope (%) * Length (ft)
A107-1	3	PA	fair	Y	0.74	-10.68	13.08	27.1	20.0
A107-2	1	C	fair	N	NS	NS	NS	NS	NS
A107-2	2	C	fair	N	NS	NS	NS	NS	NS
A107-2	3	C	fair	N	NS	NS	NS	NS	NS
A114-1	1	PA	good	N	NS	NS	NS	NS	NS
A114-1	2	PA	good	N	NS	NS	NS	NS	NS
A114-1	3	PA	good	N	NS	NS	NS	NS	NS
A114-1	4	PA	good	N	NS	NS	NS	NS	NS
A181-C	1	BRDG	good	Y	NS	NS	NS	NS	NS
A114-2	1	C	fair	N	NS	NS	NS	NS	NS
A114-2	2	C	fair	N	NS	NS	NS	NS	NS
A114-2	3	C	fair	N	NS	NS	NS	NS	NS
A123	1	B	good	N	0.57	-0.42	2.46	29.8	17.0
A123	2	B	good	N	0.49	-1.08	2.82	29.8	14.5
A115	1	F	fair	N	1.09	24.6	0.00	13.8	15.0