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Design and Construction of Highway Underpasses Used by Mountain Goats

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ABSTRACT

US-2 was reconstructed in Glacier National Park, Montana, past a natural mineral lick and crossing area regularly used by mountain goats (Oreamnos americanus). A bridge was built over the highway as an underpass for goats (underpass dimensions = 12 to 28 ft high x 90 ft wide x 44 ft through). A second bridge over a stream crossing located 200 ft to the east was improved for mountain goat underpassages. Cyclone fencing 8 ft high and reinforced earth walls 8 to 24 ft high forced goats to use the bridges in a 500-ft crossing zone. Most crossing goats (99.4 percent) used the two bridges. Mountain goats were disturbed less after the bridges were built. Goats extended their season of visits to the lick into fall and winter, and individual goats doubled their number of lick visits per year after the bridges were built.

US-2 enters the southern tip of Glacier National Park for 3.6 miles from Walton to Nimrod. The highway through this steep, narrow canyon was sinuous, steep, and prone to more accidents and winter snow removal problems than adjacent sections (1). Adjacent sections of US-2 were reconstructed and widened in 1967, further contributing to a speed bottleneck in the Walton-Nimrod section.

Before highway construction in 1980-1981, a population of approximately 95 to 120 mountain goats (Oreamnos americanus) from Glacier National Park and 20 to 45 from the adjacent Flathead National Forest crossed US-2 in this area to visit a natural mineral lick (2). Highway crossings occurred primarily from April to August of each year. Goat mortality was low, apparently because of slow vehicle speeds (25 mph) past the 500-ft long goat crossing zone. However, 13 near hits of goats by vehicles were observed in 1975, and increased goat mortality was predicted should highway speeds substantially increase (2). In spite of little advertisement and only primitive access, visitation to the goat lick view area in 1975 was estimated at 66,000 visitors in 24,000 vehicles (2). Passing traffic and GNP visitors in the area disturbed goats. Many initial highway crossing attempts were unsuccessful, some goats altered their initial crossing route, and others hesitated on the highway edge or ran back from passing vehicles (see Figure 1). Three separations of nannies from their kids were observed in 1975, which could have ultimately led to kid mortality. Highway crossing success by mountain goats was lowest when both passing traffic and visitors in a west pullout were present (2). Visitors parking on and walking over the roadside presented additional highway safety hazards. FHWA funded preconstruction studies and construction monitoring of the mountain goats. Concurrence by the National Park Service and other responsible agencies and public support to proceed with reconstruction was received (1). The

FIGURE 1 Goats crossing highway surface before reconstruction of US-2 in Glacier National Park, Montana.

design and construction features of the US-2 underpasses built by FHWA to accommodate crossings by mountain goats are reported in this paper.

HIGHWAY AND BRIDGE DESIGN

A goat bridge was constructed in 1980 on which 80 percent of the 1975 goat crossings had occurred. The underpass area for goats varied from 12 to 28 ft high x 90 ft wide x 44 ft through (see Figure 2). Goats in the upslope approach to this bridge were at eye level with vehicles passing on US-2 (see Figure 2). Although forest cover existed here for goats, additional conifer saplings were planted and metal screening (4 ft high x 90 ft long) was placed on the upslope rail of the bridge to provide a greater sense of security for goats. A second, previously existing bridge over Snowslide Gulch was altered to accommodate goat crossings around its west abutment. A flat bench was gouged from the rock (12 ft high x 12 ft wide x 24 ft through). Existing goat trails were obliterated and new trails were dug leading to the entrances of both bridges.

The highway between both bridges and 200 ft west of the Goat Bridge were restricted to mountain goats by cyclone fencing uphill and a reinforced earth wall downhill of the highway. The cyclone fence was 8 ft high and was placed in a V shape pointed uphill in order to parallel or drift with the general direction of goat movements (see Figure 1). A reinforced earth retaining wall was placed parallel and downhill from the highway, which forced goats moving uphill to use the two bridges. This wall also served to build the highway up ±12 ft for a higher avalanche passage under the Snowslide Gulch Bridge.

National Park Service policy and the great popularity of the goat lick mandated that visitors be accommodated at the site, even though their presence had been demonstrated to disturb goats crossing the highway. An off-road view area and parking lot was constructed east of Snowslide Gulch where visitors could overlook the lick from a viewpoint. Its location away from the bridge area was intended to reduce any interference with goats. The viewpoint's location off-road was intended to reduce the safety hazards associated with faster through traffic and on-road parking and walking by visitors.

Highway design speed and width of the roadway cut were a compromise between conflicting objectives. On the one hand, a wider cut and straighter, more level road (higher design speed) contributes to faster melting of snow and ice, lower highway accident rate, better driver visibility, and facilitates winter snow removal. On the other hand, mountain goats in summer and elk that spend the winter in the area prefer to cross the highway where forest cover is closer to the road (3,4). Aesthetic considerations and National Park Service administrative policy suggest both minimal clearing limits and cut and fill through a more undulating grade-line and gradual curves instead of long tangents (5). The final compromised road width was 24 ft, and paved shoulder width was 5 ft. Reinforced earth walls were used extensively and totaled 1,344 ft in two locations. Highway design speed was 45 mph for 0.6 miles near the goat lick but 50 mph elsewhere.

Aesthetic and National Park Service policy considerations were addressed in a revegetation plan. The plan received input from landscape architects, engineers, plant ecologists, and foresters from the National Park Service, FHWA, Forest Service, and the Bureau of Indian Affairs (BIA). The revegetation plan included the following steps:

1. Initial seeding of cut and fill slopes was achieved by hydraulic slurry of native grasses that approximated adjacent natural vegetation (*Agropyron spicatum*, *Poa canadensis*, *Festuca ovina*);
2. Remedial plantings were conducted on the more severe sites where the initial seeding failed through seeding of the same grass species by hand and also planting of started bunchgrass plugs;
3. Security cover at the upslope approach to the Goat Bridge was increased by planting 2 to 3 ft conifer saplings;
4. Obliteration of the visual fence effect on the abandoned sections of old road and the far upper ends of cut slopes was achieved by planting conifer seedlings (*Pinus contorta*, *Picea engelmanni/glauca*) and shrub seedlings (*Cornus stolonifera*, *Symphoricarpos albus*, *Acer glabrum*, *Sambucus racemosa*). The project area was the source of seeds. The U.S. Department of the Interior (USDI) and the BIA nursery at Ronan, Montana, started the seedlings and provided planting crews. The plantings emphasized shrub species rather than conifers on sites less than 40 ft from the highway edge to minimize shading of the road surface. Revegetated zones resemble the natural bunchgrass-shrub-conifer mosaic with scattered patches of bare ground, instead of an artificial, monotonous carpet of exotic grasses.

CONSTRUCTION SCHEDULE

A number of restrictions were placed on the contractor in order to minimize disturbances to mountain goats: (a) construction on the Goat Bridge was not permitted between May 15 and August 1, 1980, in order to avoid conflict with most goat visits to the lick; (b) blasting was confined to the times of least daytime goat activity, 0800 to 1200 hr; (c) construction activity was restricted during the peak goat crossing hours of 0600 to 0730 hr and 1800 to 2200 hr; (d) no equipment was parked along the most significant 130-ft long goat crossing zone. Work areas and equipment were surrounded by temporary fencing to avoid goat injuries or entanglements; (e) the

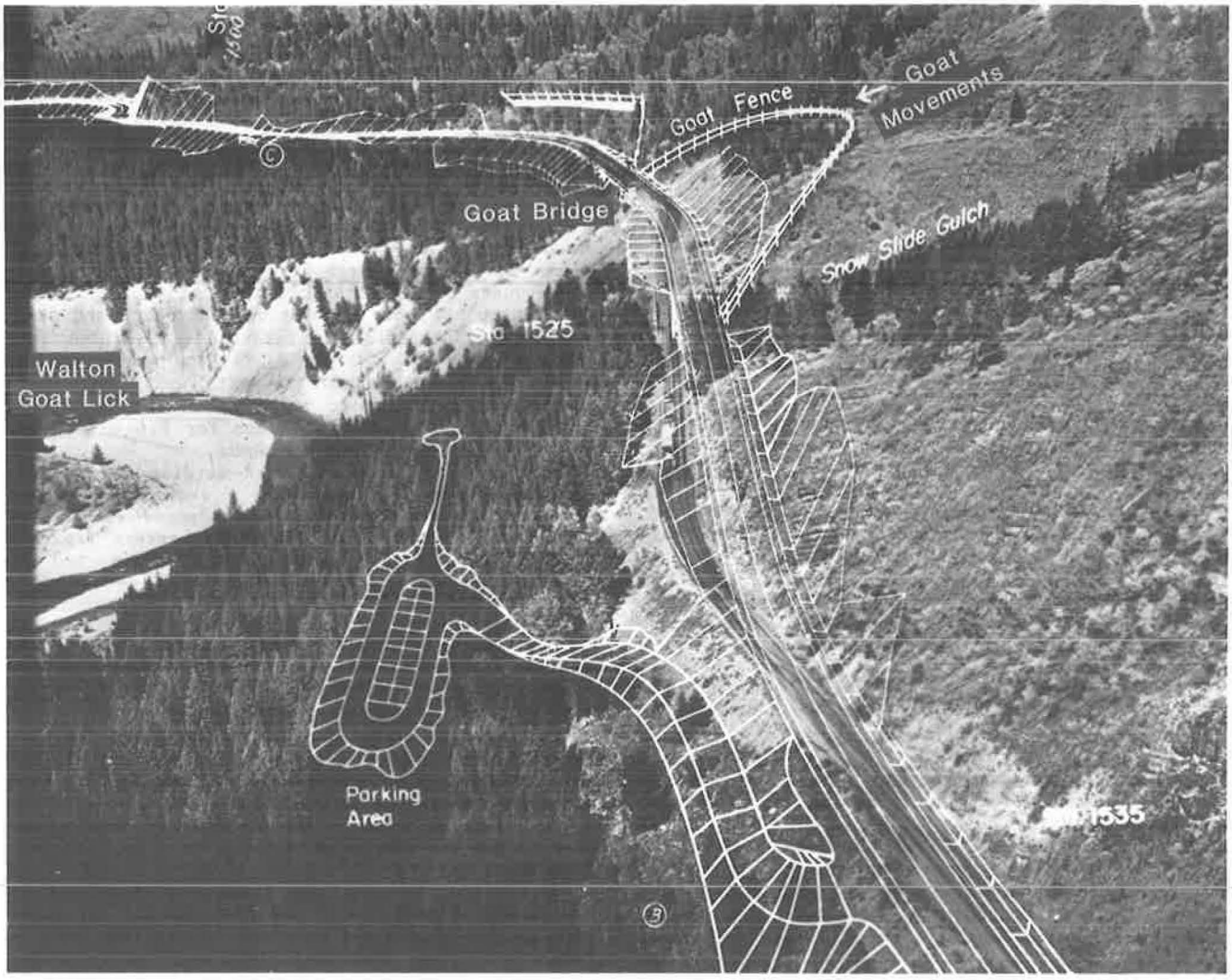

FIGURE 2 Reconstruction alterations to the mountain goat crossing area of US-2 at the Walton Goat Lick, Glacier National Park, Montana.

project area was checked for goats before equipment start up; (f) passing traffic was stopped by flag people to allow goats to cross the highway; (g) because of the open crossing route left near the Goat Bridge, construction on the Snowslide Gulch Bridge was not terminated because of the presence of goats (6). A National Park Service wildlife biologist (F. Singer) monitored the highway project for any serious disruptions or injuries to the goats and to warn the contractor and flag people of any impending goat crossing. During construction goat disturbances actually decreased as a result of less visitor activity and slow speeds of automobiles. Consequently, goat route preferences changed and the more exposed but steeper Route 3 received greater use by goats (see Figure 3).

PRELIMINARY ASSESSMENT OF THE PLAN FOR GOATS

After completion of the goat underpasses, 99.4 percent of 924 observations of mountain goats crossing the highway were under either of the two bridges (see Figure 4). Only 0.6 percent of the goats passed around either end of the structures and fencing to cross the highway surface (7). Physical contact was made initially (charges, head butts, stand on hind legs) against the fencing, but goats rapidly adapted and eventually drifted along the fence and under the bridges with fewer hesitations (7). The underpasses apparently removed much of the stress associated with highway crossings. The following relaxations in goat behavior were observed: (a) lick visits per goat in 1981 doubled over 1980, and the lick season was extended into fall and winter; (b) highway crossing success increased by 16 percent, and hesitations and run-backs per crossing attempt declined; (c) the incidence of erect tails in goats, which indicate fear, declined for goats crossing under the bridges; and (d) the rate of potentially lethal nanny-kid separations declined by one-third (7). Some goats even spent time bedded, licking eroded road salts, or feeding under the bridges. Vehicles passing over the bridges while goats were at eye level in the upslope approaches continued to cause goat disturbances. Both the Goat Bridge and the Snowslide Gulch Bridge received about equal passage by goats. Some visitors parked and stood on top of the bridges, disturbing the goats, instead of using the off-road view area.

Mountain goats readily adapted to the noise of normal construction activity such as operating payloaders, graders, and bulldozers, but were alarmed by blasts and high-frequency drilling (7). The only severely disturbed goats were nine groups that moved downhill to cross when heavy equipment was operating

FIGURE 3 Goats crossing the more exposed and steeper Route 3.

on the Goat Bridge. These goats were held up for 3 to 6 hr and crossed only after the equipment shut down. A total of eight groups, crawled through or entered inadvertent gaps in temporary fencing. Several of these goats were trapped for 1 to 6 hr before finding a way around, and one of the groups crossed the road and encountered the 8 ft drop-off of the downhill reinforced earth wall. This group walked along the top of the wall until an approaching truck precipitated them to jump off--but none apparently received injuries. Mountain goats made little use of one-way deer gates (8) erected to allow goats to escape when they were caught inside the fencing. Visitors who crawl off the bridges, however, are often forced to exit the fencing through these gates.

Small groups (1 to 4) of mountain goats persisted in use of the Snowslide Gulch Bridge during all of 1980 in spite of the presence of low-level concrete work by one to four men. It should be emphasized that the low goat disturbance rates observed were a result of the frequent monitoring of the construction zone, the stringent restrictions on the contractor, the contractor's benevolent attitude toward the goats, the lack of harassment of the goats, and the protected status of goats in Glacier National Park. Mountain goats that are hunted or harassed might not have habituated as well.

DISCUSSION

The decision to build a highway underpass for goats was based on a review of the published literature on ungulate-highway relations and also an on-site inspection of highway-ungulate problems in the Rocky Mountain National Parks of Canada (4). The following information was gathered:

1. Mountain goats used a highway overpass (highway snowshed) in Glacier National Park, British Columbia. However, goats had been hit by vehicles at the snowshed approaches due to low driver reaction times. Also, the shaded snowsheds encouraged dangerous black ice, required lighting, and had been the scene of serious vehicle accidents.
2. Natural mineral licks along Trans-Canada 1 and 16 were the scene of a number of ungulate kills by vehicles. Also vehicle collisions occurred between very fast (60 to 70 mph) Trans-Canada traffic and park visitors pulling in and out of view areas or parked along the highways.
3. Ungulates known to use underpasses of highways or pipelines include elk, Cervus canadensis

FIGURE 4 Nanny with twins at side passing under the Goat Bridge of US-2, Glacier National Park, Montana.

(Halle Flygare, personal correspondence, Banff National Park; staff of Yoho National Park, British Columbia, personal correspondence), mule deer, Odocoileus hemionus (8,9), moose, Alces alces (10), and caribou, Rangifer tarandus (11), although pronghorn antelope, Antilocarpa americana (8) refuse underpasses.

A crossing structure of some type was deemed necessary to protect goats and humans. An overpass for goats was ruled out because of the Canadian experiences with safety problems. This information coupled with limited observations of mountain goats using a confined space under the Snowslide Gulch Bridge in 1975 (2) suggested that goats would likely accept an underpass. In addition, it was concluded that degree of acceptance of an underpass was likely to increase if it was not confining (9), if it was accompanied by restrictive lead-in fencing (8,9), if it was situated on a goat movement route (12), and if conifer covering or other shielding was present in the underpass approaches (2). The construction plan for US-2 followed these guidelines as closely as was feasible and resulted in very high (99.4 percent) acceptance of the two underpasses. In addition, a significant decrease in disturbances to the mountain goats was achieved.

Three design questions are posed by the 1981 observations of mountain goats using the two underpasses:

1. How critical was conifer cover near the bridges?
2. Was construction of the Goat Bridge necessary or would all goats have used the new Snowslide Gulch Bridge?
3. What were the minimum size dimensions for the Goat Bridge?

Conifer cover was a critical factor during highway crossings in 1975 (2), but with the reduction in disturbances in 1980 and 1981, goats made more use of the exposed approach routes. Cover on the downhill approach to the Goat Bridge still appeared to be important to at least some goats (7). The Snowslide Gulch Bridge and the Goat Bridge were used about equally in 1981, but the Snowslide Gulch Bridge was only about two-third the height and one-seventh the width of the Goat Bridge. This initially suggests some of the space under the Goat Bridge was superfluous. However, the overall visual window under a bridge may be more critical than that for the crossing path. The overall dimensions of the Snowslide Gulch Bridge are far greater than the Goat Bridge because goats cross on a relatively small bench near the west abutment of a large (60 ft high x 60 ft wide) crossing of the Snowslide Gulch. Only 3 percent of goats in 1975 used the Snowslide Gulch Bridge, but 50 percent used it in 1981.

It is not possible to predict if all goats would have used the Snowslide Gulch Bridge thereby precluding building the Goat Bridge. Longer fencing to the west would likely have been required. Additional fencing would have been expensive, and fencing in this area requires maintenance because of frequent avalanching. Previous experiences and learning during construction were apparently critical to route preferences by goats. Use of the Snowslide Gulch Bridge by goats developed slowly but steadily during construction in 1980 as other avenues of access were alternately blocked. Thus, if goats had been forced around the far western end of the fences during construction, that tradition might have proved difficult to break even after the Snowslide Gulch Bridge and all structures were later in place.

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