4. ENVIRONMENTAL CONSEQUENCES

An evaluation of environmental impacts from the proposed construction and subsequent operation of Section 8B of the Foothills Parkway is presented in this section of the ER. The analysis is based on information regarding the existing environment (Sect. 3) and a set of the conceptual designs of Section 8B provided by the FHWA.

The build alternatives identified in Sect. 2 exhibit similar environmental impacts because of the limitation of the width of the ROW. All build options include two variations of construction in the Rocky Flats area and a tunnel option near SR 416. Major differences occur at the western terminus interchange at either SR 416 or U.S. 321 and on Webb Mountain (with or without the spur road).

4.1 GEOLOGY AND SOILS

This section summarizes the potential impacts on geology and soils of construction of Section 8B of the Foothills Parkway and describes how geology and soils could influence the engineering design and construction to mitigate the impacts as much as possible. All the potential impacts described apply to the four options for conceptual alternatives described in Sect. 2. All the impacts would apply to options 2.1.1 (no interchanges) and 2.1.2 (western terminus options) similarly. A decision not to build the Webb Mountain spur, option 2.1.3, would result in a minimum decrease in exposure of pyritic material along the route. Much of the rock that would be excavated to construct the Webb Mountain spur route is mechanically stronger than the siltstone and slate along most of the route. Table 54 provides a comparison of the different impacts that could occur for each option.

Table 54. Comparison of conceptual alternatives

	Conceptual alternative[a,b]				
Type of impact	2.1.1	2.1.2	2.1.3	2.1.4	2.2
Slope stability	Yes	Yes	Yes	Yes	No
Pyritic rocks	Yes	Yes	Yes, slightly less	Yes	No
Deep weathering	Yes	Yes	Yes	Yes	No
Brittle faults	Yes	Yes	Yes, slightly less	Yes	No
Colluvium	Yes	Yes	Yes, slightly less	Yes	No

[a]"Yes" means the impact would be present.

[b]Construct Section 8B with no interchanges (2.1.1), Western Terminus Options (2.1.2), Webb Mountain Options (2.1.3), Operation Timing Options (2.1.4), and No-action (no-build) (2.2).

Potential impacts would affect slope stability and groundwater and surface-water systems. Factors that influence impacts include bedrock geology (composition and structure) and residual soils (derived from bedrock units beneath), geologic structures (faults, fractures), transported surficial geologic units (colluvium, stream deposits, and landslide materials), and short-term intense precipitation events. Adequate measures in both planning and engineering design can be implemented to mitigate these potential impacts in Section 8B and prevent them from having a detrimental long-term effect on the physical environment of the parkway corridor.

Bedrock and surficial geology along the corridor (Fig. 79) is dominated by slate and metasiltstone of the Pigeon Siltstone; lesser amounts of massive sandstone, slate, and clay shale in other bedrock units are represented (Snowbird, Great Smoky, and Walden Creek Groups). No karst features produced by limestone dissolution or large amounts of pyritic rocks are present along most of the route. Although the metasiltstone unit contains numerous fractures with several different orientations, landslides during and after construction are not likely, unless deeply weathered sections of this rock unit are exposed on steep slopes. The massive sandstone unit that underlies Webb Mountain and Big Ridge would present minor problems that would impact the environment. The light sandy soils produced by weathering of this unit should be relatively thin on the upper slopes of the main and subsidiary ridges traversed by most of the route. Some pyritic material may be present locally, but the amount should be relatively small.

Because very little pyritic slate occurs along the Section 8B corridor, the potential for acidic materials from weathering of pyrite and other sulfide minerals to impact the groundwater and surface-water system would be limited to those areas. The area where most of the pyritic material has been observed is on the south flank of Webb Mountain (segment 3) on the main route and on the Webb Mountain access road (Fig. 79). The water chemistry of nearby creeks and springs (see Sect. 3.2) reflects this acidic influence.

Several major faults are present along the proposed Section 8B route. These ancient faults pose no potential earthquake hazard (see Sect. 3.1). Some of them, however, contain zones (1 to 2 m maximum thickness) of more intensely fractured rock that may serve as groundwater conduits and could require some additional attention during planning and construction to mitigate any long-term seepage, erosion, or instability problems. Brittle fault zones are likely to be encountered in the vicinity of the Webb Mountain Access Road and on the main route (segment 3) (Fig. 79).

Soils and surficial deposits present only minor problems along Section 8B. Soils developed on metasiltstone and slate are relatively thin, and relatively fresh bedrock for the most part is located within a few meters of the surface. Thick saprolite could develop from weathering of the massive sandstone deposits present on Webb Mountain and Big Ridge, but its thickness would be minimized by the occurrence of this rock unit mostly on upper slopes. Locally, however, saprolite can attain thicknesses of 5 to 10 m, but even at maximum thicknesses it should not pose a problem because it is cohesive and easily stabilized by seeding.

Surficial deposits of colluvium, landslide deposits (debris flow and possibly rock avalanche), and alluvium are present along part of the route. A few small bodies of colluvium are present along the proposed Section 8B route along the south slopes of Webb Mountain. These materials appear to be relatively thin (<3 m) and should pose little threat for mobilization as landslides if the toes of any of these units are cut during construction. Relatively few colluvium bodies are likely to be

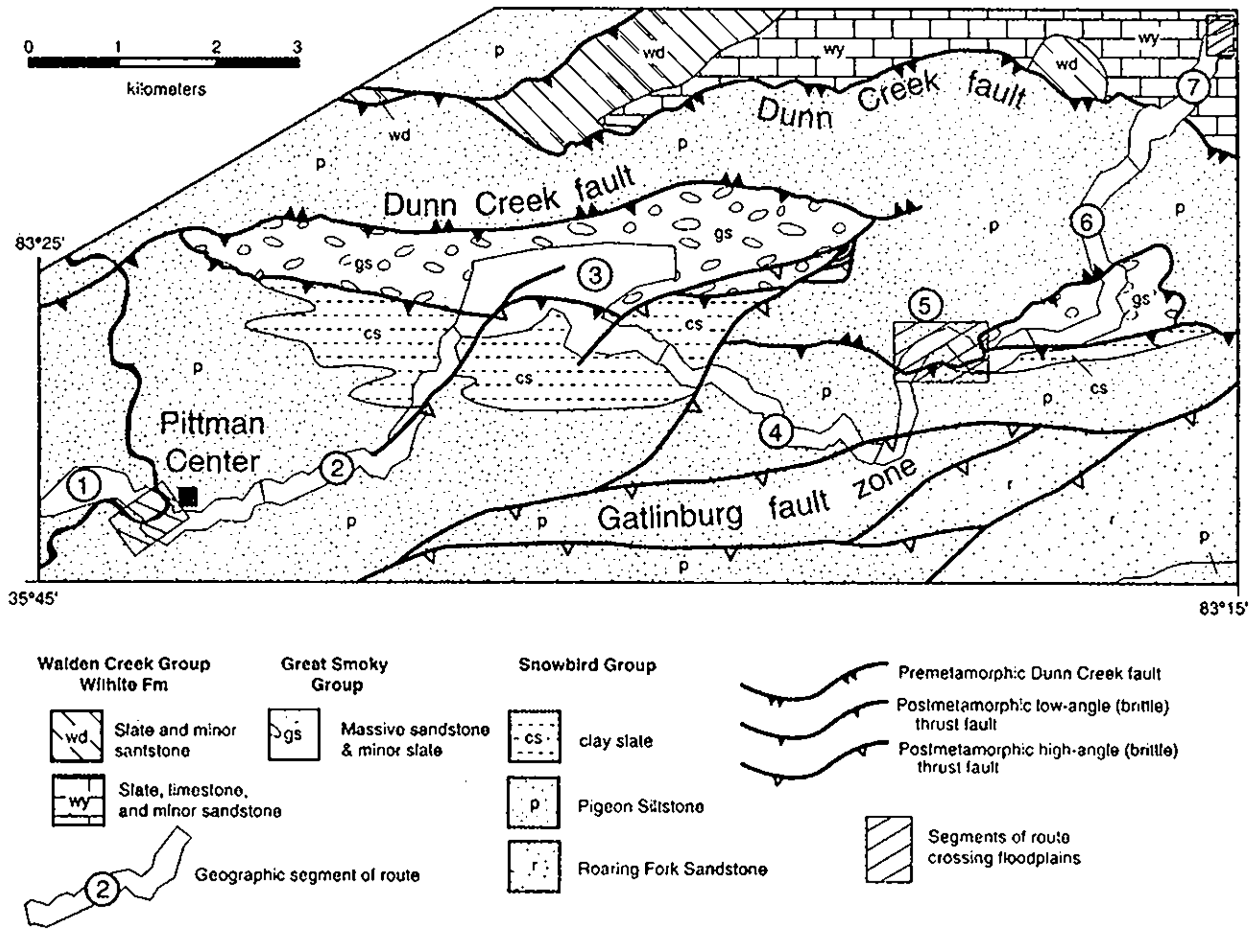

Figure 4.1-1: Simplified bedrock geologic map of the Webb Mountain area. Segmented 8B ROW is lightly shaded. Numbers indicate geographic segments

Fig. 79. Simplified bedrock geologic map of the Webb Mountain area.

cut along steep slopes because the ROW mostly follows ridge crests. Thus, landslide potential from cutting bodies of colluvium is of little concern. Alluvium is present along the route crossing the Little Pigeon River near Pittman Center (segment 1), along Webb Creek near Pittman Center (segment 1), crossing Dunn Creek (segment 5), and crossing Cosby Creek (segment 7) (Fig. 79). Dunn Creek Valley contains debris flow (from the south). Some of the boulders in the proposed route exceed 6 m (20 ft) in length and are remarkably fresh. They rest on top of older debris flow deposits that are more thoroughly decomposed. Current designs indicate that these deposits would be traversed by elevated roadways on top of fills that would be constructed above reasonable maximum flood level, and with adequate culverts and bridges to accommodate anticipated flooding over the lifetime of the highway. Thus, there would be little need to excavate surficial deposits in stream valleys.

The susceptibility of this region to exceptionally large rainfall events, many hurricane-generated, is worthy of note. Moneymaker (1939) described the impacts of a large rainfall event that occurred on August 5, 1938, and particularly affected the south slopes of Webb Mountain and Matthew Branch. This drainage is located immediately north of the primary roadway and east and southeast of the Webb Mountain spur. The impact was described additionally by Koch (1974). The effects of the 1938 event were locally devastating but are today largely healed by the rapidly growing vegetation and slope processes.

The important lesson to be learned here is that the event(s) that brought the large boulders from Greenbrier Pinnacle into the lower reaches of Dunn Creek would have had enough energy to dwarf the 1938 event, and others like it that have occurred in recent years. Hatcher and others (1996) suggested that an additional possible cause of these very large debris avalanches could be prehistoric earthquakes in the East Tennessee seismic zone, either independently or in concert with melting of icefields, storm-generated debris and rock avalanches, other mass-wasting processes, or combinations of all. The impact on Section 8B of a storm of the magnitude that Moneymaker (1938) and Koch (1974) described would depend on the design and long-term stability of cuts and fills along this section of the Foothills Parkway. If such a storm occurred during or immediately after construction, severe impacts could occur in the form of erosion fills, dislodging of rock material in cuts, and extensive sedimentation in drainages. The roadway could potentially be damaged if fills or cuts collapse, but the probability of this occurring is small considering both the magnitude of these cloudbursts and their areal extent.

4.1.1 Summary

The potential impacts would follow the means described as follows. Problems with construction of proposed Section 8B of the Foothills Parkway are anticipated to be relatively small. The main impacts are related to slope stability problems in moderately to deeply weathered Pigeon Siltstone along the mine route, and locally in Great Smoky Group sandstone along the Webb Mountain spur. These problems should be soluble without taking extraordinary engineering measures (e.g., additional bridging along ridge crests or along steep slopes) by incorporating standard benching, lower cut slope angle, etc., techniques into engineering design of cuts, and rapid stabilization of open cuts and fills during times of the year when thunderstorms are likely. Additional impacts might be anticipated where unstable slopes related to construction of the deep cut (rather than the tunnel) alternative on Section 8B west of Cobbly Knob from Stations 1 + 840 through 2 + 075 could create both short- and long-term problems if the material being excavated is deeply weathered. Deep weathering is more likely at low elevations than on high ridgetop segments of Section 8B because of the greater availability of water in the deep valley. This turned out to not be a problem, however, in construction of the westbound lanes of the four-lane version of U.S. 441 just east of Pigeon Forge, but remains a problem with the eastbound lanes of the highway in the same area. Recent (summer 1997) problems with major collapses of cuts in Pigeon Siltstone along I-40 at the Tennessee-North Carolina line clearly illustrate the potential impact some 25 years after construction of I-40.

The impact of pyritic materials should be minimal. These materials, once located, can be effectively sealed throughout the construction period and afterwards so that they should remain stable enough that impact on streams can be minimized. Greater impact on streams should be anticipated from improperly controlled sediment derived from construction that from pyritic materials, and the former can be more easily controlled.

Brittle fault zones that will be crossed by the route could create minor impacts with ground-water seepage or more likely produce unstable rock during construction, but mostly will cause no problems at all. If these impacts do occur, the zones can readily be sealed (for ground-water seepage), or excess loose rock removed during construction.

The largest potential impact in this area is from a major, short-duration thunderstorm of the kind that occurred on the upper reaches of Matthew Creek in 1930. Impacts could range from severe damage to cuts and fills, as well as to the paved roadway.

4.2 WATER RESOURCES

Construction and operation of Section 8B of the Foothills Parkway could affect the surface and shallow subsurface hydrology and surface water quality of the area in several ways. The most important potential effects on hydrology would include alteration of the amount and timing of surface runoff, erosion of streambeds receiving higher stormflows, and reductions in shallow subsurface flow as a result of reduced infiltration and blockage of lateral flow in areas where the surface soils have been compacted. The most important potential effects on water quality would include roadway runoff of contaminants, increased sediment loads and siltation of streambeds, and stream acidification if sulfide-bearing rock were exposed during construction. However, it is unlikely that any of the build options will result in water quality changes severe enough to warrant changes in state classification of streams in this area (see Sect. 3.2.2), assuming that the best mitigation measures are enacted during construction.

4.2.1 Construction of Parkway with no Interchanges

4.2.1.1 Hydrology

Construction and operation of the parkway could significantly alter the surface water and shallow subsurface hydrology of the area within and immediately downgradient from the ROW. Rapid runoff from areas that are disturbed during construction (vegetation removal and compaction of soil) and from the pavement and adjacent grassy margins would increase the variability of hydrographs (flows) in streams into which swales, gutters, and culverts are directed. Surface runoff from paved and grassed portions of the ROW during storms would be increased substantially, and shallow subsurface runoff under the roadway would be reduced as a result of effects of compaction. The increased high flows generated likely would cause increased incision or erosion of streambeds downgradient from the roadway into which runoff is directed. Interception of subsurface flows by extensive cuts through colluvial and alluvial materials would result in reduced flow (and perhaps drying up) of streams under baseflow conditions downgradient. The hydrology changes and streambed erosion are likely to be greatest in the smaller streams draining the roadway, particularly those in the Pittman Center area (Copeland Creek, Lindsey Creek), those draining the south side of Webb Mountain (Sheep Pen Branch, Mill Dam Branch, Warden Branch, Butler Branch, Matthew Creek, and several unnamed tributaries to Webb Creek), and Carson Branch, which drains the southwestern portion of Big Ridge. For the upper portions of the Webb Mountain south-side streams and Carson Branch, the paved surface and grassy margins of the roadway could comprise up to about 5–10% of their catchment areas; thus hydrologic changes could be significant (e.g., increases in peak storm flows from increased surface runoff). If the tunnel option were used in the Pittman Center area (near SR 416), hydrologic changes would be lessened somewhat in Copeland and Lindsey Creeks (the latter referred to as Tunis Branch in the roadway design sheets). Hydrologic changes would likely be minimal in the larger streams, with the exception of Webb Creek, which would receive the cumulative effects of any changes in the smaller streams draining the south side of Webb Mountain.

The cut and fill alternatives in the western portion of the Rocky Flats area (Fig. 15) could have a substantial effect on the hydrology of the wetland areas in the valley adjacent to Dunn Creek at the base of this segment of Webb Mountain. Placing the roadway farther up on the slope would minimize fill in the valley bottom, but it would result in extensive cut and fill on the hillslope which would increase surface runoff during storms and reduce subsurface runoff during baseflow periods. The increased surface runoff from the ROW could result in some erosion in the wetlands downgradient. The alternative that places the roadway in the valley at the base of the hillslope would involve extensive fill. Although this alternative should result in lesser effects on surface runoff during storms, it might result in reductions in shallow subsurface drainage into the wetlands during baseflow. The subsurface hydrology in the Rocky Flats area is unknown; thus, the source of the water supplying the wetlands is uncertain, as are potential effects of the valley fill on subsurface hydrology.

As the roadway ascended the hillslope in the eastern portion of the Rocky Flats area at the southwestern end of Big Ridge (Fig. 15), the extensive cut and fill might alter the hydrology of the riparian wetlands adjacent to Carson Branch. Increased surface runoff from the pavement and grassy compacted areas of the ROW might lead to erosion within some wetland areas. The reduction of hillslope resulting from soil compaction in the ROW might reduce recharge during baseflow and result in drying out of portions of these wetlands.

4.2.1.2 Water Quality

Runoff from a roadway surface and adjacent landscaped or maintained areas during rainfall can impair water quality. Potential contaminants include oils and other organic materials, heavy metals, de-icing chemicals, septic leachate, acidity, residual particles, herbicides and fertilizer, and silt or sediments. The FHWA has researched methods for assessing and mitigating highway runoff (Strecker et al. 1990; Dupuis et al. 1985a, b, c, d, e; Burch, Johnson, and Maestri 1985a, b, c, d).

The conclusion of this research is that highways traveled by fewer than 30,000 vehicles per day generally exhibit minimal impact on receiving water ecology (Lord 1987). Therefore, roadway runoff during operation of the parkway is expected to have relatively little impact on water quality.

The greatest potential for adverse impact on water quality would likely be increased sediment loads, primarily at high flow, and subsequent siltation of streambeds during parkway construction and stabilization of cut and fill areas. Construction would require clearing vegetation and excavating and filling in very steep terrain. There is great potential for the fine, silty soils to be washed into streams and other low-lying areas over most of the ROW. Nominal "best management practices" typically do not eliminate these types of impacts; therefore, additional mitigation should be considered (see Sect. 5.2).

Increased sediment loading and siltation impacts would primarily affect the smaller streams crossing the ROW or having their headwaters in the ROW. Streams affected would likely be Copeland and Lindsey Creeks in the Pittman Center area, the streams draining the south slopes of Webb Mountain (Sheep Pen Branch, Mill Dam Branch, Warden Branch, Butler Branch, Matthew Creek, and unnamed tributaries of Webb Creek), and streams draining Big Ridge (Carson Branch, Chavis Creek, and Sandy Hollow Creek). Although somewhat larger in size, Webb Creek would also be affected by increased sediment loads and siltation because it receives the discharge from many of the smaller streams draining the ROW. Segments of the roadway that require extensive cut and fill are likely to experience the most severe impacts during construction. Because of the steep terrain traversed by much of this segment of the parkway, extensive areas of cut and fill are planned in the catchments of all of these streams. However, sediment loading and siltation impacts from parkway construction would be less severe in Copeland Creek and Sandy Hollow Creek because these streams presently experience substantial impacts from extensive areas of livestock grazing adjacent to the stream channel. Similarly, sediment loading and siltation impacts from parkway construction would be less severe in Lindsey Creek and Chavis Creek because these streams presently experience substantial impacts from residential development (unpaved roads and cleared land).

The most potentially harmful sediment loading and siltation impacts from parkway construction would be to (1) Matthew Creek, because of its small size and relatively pristine, high quality condition; (2) Webb Creek, because of its important fish populations and extensive drainage of areas disturbed by construction; (3) Dunn Creek, because of its high-quality condition; and (4) Carson Branch, because of its relatively undisturbed riparian wetlands. Matthew Creek and Webb Creek would be impacted by roadway construction involving extensive cut and fill on the steep slopes of Webb Mountain between Rocky Flats and Pittman Center. Dunn Creek would be impacted by roadway construction involving extensive cut and fill on the steep slopes of Webb Mountain near the Rocky Flats area or by fill at the foot of these slopes (see below). Carson Branch and its riparian wetlands would be impacted from construction activities involving extensive cut and fill required on the steep slopes of the southwest end of Big Ridge where the roadway must climb up from Rocky Flats. Slope stabilization and revegetation would likely reduce, but not eliminate, impacts from sediment loading and siltation on these streams during parkway operation.

Variations in the base alternative for parkway construction involving a tunnel in the vicinity of SR 416 in the Pittman Center area and positioning of the roadway in the Rocky Flats area would result in differing sediment loading and siltation impacts. If a tunnel was excavated by boring, less cut and fill would be required, reducing the potential impacts on Copeland and Lindsey Creeks. If a tunnel was excavated using cut and cover techniques, then short-term impacts to Copeland and Lindsey Creeks are expected to be similar to those resulting from open cut construction. In the Rocky Flats area, if the roadway were constructed on the lower slope of the southeastern end of Webb Mountain adjacent to Dunn Creek, extensive cut and fill would be required, resulting in potentially severe sediment loading and siltation from storm runoff into the West Branch of Dunn Creek, a high-quality trout stream. The alternative option which places the roadway at the base of the hillslope would involve extensive fill adjacent to the West Branch of Dunn Creek, but would likely result in somewhat less severe sediment loading and siltation in the West Branch of Dunn Creek because a smaller area would be disturbed and require revegetation. However, each of these alternatives would likely result in some adverse impact on the West Branch of Dunn Creek and perhaps on Dunn Creek from increased sediment loading and siltation.

The geological survey (Sect. 3.1.4.3) and the stream water quality data (Sect. 3.2.3.2) point to the presence of sulfide-bearing rock (pyrite) in the Cobbly Knob area of Webb Mountain. The pyrite content in the Webb Mountain clay slate unit is thought to be relatively low, but it appears to have resulted in somewhat higher sulfate concentrations in several streams draining Webb Mountain (Sect. 3.2.3.2, Fig. 22) and may be sufficient to produce significant amounts of acidity if exposed during construction activities. At the time of the stream survey (1994–1995), alkalinity in the Webb Mountain streams was not significantly lower than in other streams in the area, indicating that acidification is not now a problem. However, these streams are relatively low in alkalinity (and thus have low capacity to buffer additional acid inputs). Roadway construction activities in the Webb Mountain area might expose pyritic materials and lead to significant stream acidification.

4.2.2 Western Terminus Options

4.2.2.1 Hydrology

The options for the western terminus of the parkway involve adding a parkway interchange at either SR 416 at Pittman Center or U.S. 321 to the east of Pittman Center (two options for each). Each of the design option alternatives would probably present somewhat larger hydrologic consequences than the base option (construction with no interchanges, see 4.2.1.1), primarily because of the increased land area that would be disturbed, generating additional surface runoff during storms, requiring increased fill in several floodplains, and altering any surface flows and subsurface drainage.

The SR 416 interchange options would require extensive fill in the Little Pigeon River floodplain to the west of Pittman Center and would require additional bridges across the river. The floodplain fill would constrain flood waters in this area, reducing expansion into the floodplain at high flow and resulting in increased scour of the streambed and adjacent river banks. The fill might also alter subsurface drainage through the floodplain because of compaction of the alluvial soil, thus creating wetter conditions upgradient and somewhat drier conditions downgradient from the fill.

The U.S. 321 interchange options would result in either extensive fill in the Webb Creek floodplain to the east of Pittman Center (interchange to the west of Webb Creek alternative) or extensive cut and fill on the sideslope of the western end of Webb Mountain (interchange east of

Webb Creek alternative). The western interchange option would require extensive fill in the Webb Creek floodplain that would constrain flood waters at high flow and might lead to increased erosion of the streambed and stream banks. This option would also require an additional bridge over Webb Creek and a wall along the eastern side of Webb Creek downstream of U.S. 321. The floodplain fill might reduce subsurface drainage toward Webb Creek in this area as well, but its effect should be minor. The eastern option for the U.S. 321 interchange would likely have greater impacts to the hydrology of Webb Creek than the western option because it would require extensive cut and fill on the steep sideslopes bordering Webb Creek along U.S. 321 (over a distance of approximately 500 m along U.S. 321). This option would result in greater surface runoff from the pavement and compacted cut and fill areas, and the higher storm flows might lead to erosion of ephemeral streams and the Webb Creek streambed in the vicinity.

4.2.2.2 Water Quality

The western terminus options involving an interchange at SR 416 near Pittman Center would result in minimal additional impact on water quality. An increase in sediment loading to the Little Pigeon River and some siltation would likely occur during construction as a result of placing fill in the floodplain, but the impacts to the river likely would be very localized and relatively small because of the large size of the river at this point. Stabilization (physical and revegetation) of the fill should eliminate impacts to the river after construction.

The options involving an interchange at U.S. 321 to the east of Pittman Center are likely to have somewhat greater impacts on water quality than those for the SR 416 interchange. The easternmost option involving an access road descending from the parkway while it is on the lower slope of Webb Mountain would likely result in significant increases in sediment loads and siltation of Webb Creek during construction because of the extensive cut and fill on steep slopes needed. Sediment loads and siltation might continue to be a problem during parkway operation if slope stabilization were not completely effective. The western terminus option involving an access road in the Webb Creek floodplain would also have substantial impacts on Webb Creek water quality during construction. Placement of fill in the floodplain and construction of a retaining wall along the side of Webb Creek to stabilize the access road would result in both increased sediment loads and streambed siltation in Webb Creek. However, these impacts might be somewhat lower than those for the access road descending from the hillslope farther to the east.

4.2.3 Webb Mountain Options

4.2.3.1 Hydrology

The Webb Mountain options involve adding (1) a parking area along the parkway on the sideslopes of Webb Mountain (and a trail system to the top of and around Webb Mountain) or (2) a spur road leading to an overlook facility and associated parking area on top of Webb Mountain. The first option (parking area along parkway edge) would result in additional surface runoff from the paved area and compacted grassy areas adjacent to it. This might result in erosion of the ephemeral stream draining this area during high stormflows and perhaps some erosion of the upper portion of Matthew Creek into which the ephemeral stream drains. The second option (spur road and overlook) would result in considerably greater hydrological impacts due to the more extensive roadway, grassed margins, the larger parking area, the overlook area, and the grassed adjacent areas. These areas would produce substantial surface runoff during storms which likely would lead to erosion of ephemeral streams and the upper portion of Matthew Creek. In addition, the spur road would cross Matthew Creek and one of its tributaries, and installation of a box or pipe culvert under the roadway might also result in erosion of Matthew Creek in the vicinity.

4.2.3.2 Water Quality

The first Webb Mountain option (construction of a parking area along the parkway and a trail to the top of Webb Mountain) should have a small additional impact on stream water quality, assuming that restroom facilities involving a septic system are not also constructed. Adding a parking area would result in slightly larger sediment loads and siltation in Matthew Creek during construction. While this impact would be negligible in most streams, it might be somewhat greater in Matthew Creek because of its very high quality condition. Adding a parking facility also would increase slightly the likelihood of exposure of pyritic materials and, consequently, the acidification of Matthew Creek. However, the pyritic bedrock appears to be located somewhat to the west of the proposed parking area, and the water chemistry of Matthew Creek does not suggest the presence of pyritic materials in its catchment. A trail system in this area would also result in the potential for a small direct human impact on water quality in Matthew Creek due to discarding of litter or access to the stream.

The second Webb Mountain option (construction of a spur road to an overlook facility at the top of Webb Mountain) would have substantially greater impacts on the water quality of Matthew Creek because of the much larger area that would be disturbed and the installation of culverts to allow the spur road to cross Matthew Creek and one of its tributaries. Impacts from increased sediment loading and siltation could be substantial to Matthew Creek during construction. Impacts would be lower during operation, assuming that the disturbed areas would be stabilized and revegetated. However, runoff from the roadway and parking area during storms and leachate from septic systems if restrooms were constructed might result in significant deterioration of the high water quality in Matthew Creek during parkway operation.

4.2.4 Operational Timing Options

4.2.4.1 Hydrology

The operational timing options would result in no adverse hydrological impacts beyond those previously described.

4.2.4.2 Water Quality

The operational timing options would result in little change in the adverse impacts on water quality relative to those described. Delay in operation of the parkway would likely reduce the operation impacts during the period of delay, but operation impacts on water quality are relatively minor compared with construction impacts. Delay in paving the road surface would likely increase sediment loads and siltation of streams compared with paving immediately, because of the greater erodibility of an unpaved roadway.

4.2.5 No-action Alternative

The no-action alternative would result in no hydrological impacts because land surface disturbances altering surface and subsurface drainage would not occur. The no-action alternative also would result in no impacts on stream water quality, assuming that NPS retains control of the ROW and allows no development of it.

4.2.6 Cumulative Impacts

Parkway construction could add significantly to the sediment load of area streams for a period of 5–10 years during construction and stabilization of cuts and fills. Sediment load would be expected to decline rapidly after construction was completed and to contribute only minimally to long-term area/regional sediment loads if slopes were properly stabilized and revegetated.

Roadway runoff would contribute incrementally to the water quality degradation of downslope streams. Because of the relatively light use of parkways and because of the management practices expected to be used by NPS, long-term water quality degradation should be minimal compared with that contributed by other roadways and sources in the area. However, even such minimal water quality degradation could have moderate cumulative impacts on the sensitive, high-quality streams and wetlands along the ROW. If extensive areas of pyritic materials were encountered during parkway construction in the Webb Mountain area, water quality degradation to streams draining this area could produce relatively high cumulative impacts.

4.2.7 Summary

The major impact of parkway construction and operation on surface water and subsurface hydrology would be an increase in rapid surface runoff from paved and adjacent grassy areas resulting in increases in peak flows during storms, primarily in the smaller streams draining the ROW. The increased high flows might cause increased incision or erosion of streambeds. The most severe impacts would likely be to Webb Creek, because of cumulative effects, and to the small streams in the Cobbly Knob area, Matthew Creek (particularly if the Webb Mountain overlook were built), and Carson Branch and its riparian wetland.

The major impact of parkway construction and operation on water quality would be significant increases in sediment loads and siltation of streams below the ROW. The most significant impacts likely would be to Matthew Creek (because of its very high quality), Webb Creek (because of its trout fishery and cumulative drainage from Webb Mountain), Dunn Creek (because of its very high quality and trout fishery) and Carson Branch (because of its riparian wetlands). Impacts to Matthew Creek would be greater if the spur road and overlook facilities on Webb Mountain were constructed. Impacts to Webb Creek would be greater if the U.S. 321 interchange were constructed, particularly if the option involving an access road from the sideslopes of Webb Mountain directly to U.S. 321 were chosen. Impacts to Dunn Creek would be greater if the roadway were located on the lower slopes of Webb Mountain near the Rocky Flats area (requiring much greater cut and fill) than if it were located on fill at the base of the slope. Stream acidification caused by exposure of pyrite is possible in the Webb Mountain area, but careful monitoring during construction and remediation of exposed materials could reduce the impacts. Roadway runoff during operation of the parkway is expected to result in minimal impact on most streams, with the exception of Matthew Creek, if the spur road and overlook were constructed. However, even minimal water quality degradation over the long term could cause significant cumulative effects on the sensitive softwater stream ecosystems along much of the ROW.

4.3 AQUATIC ECOLOGY

4.3.1 General Description of Highway Construction Impacts on Aquatic Communities

Construction of Section 8B would require clearing and removal of vegetation, grading, and cutting and filling of slopes. There would be a potential for eroded soil to be washed into the streams, particularly where these activities occur near stream crossings. Stabilization of erodible slopes and effective revegetation should reduce the amount of soil delivered to the streams, but there would be an increase in turbidity and sedimentation during the construction period (Sect. 4.2). Subsequent highway maintenance activities (e.g., application of fertilizers and herbicides to roadside vegetation) also pose a potential threat of water quality degradation, especially where they would occur in the immediate vicinity of streams.

The effects of increased turbidity and sedimentation on aquatic communities are well understood (Hynes 1970, 1974; Wiederholm 1984). Small soil particles (e.g., clays and fine silts) that do not settle readily would reduce light penetration and thereby hinder the growth of aquatic plants and the activities of sight-feeding fishes. Very high concentrations can clog the gills of aquatic animals and interfere with respiration. Eventually, soil particles would settle out on the stream bottom and fill pools and spaces between rocks. Only larger soil particles (e.g., sand and gravel) would settle in the upstream, high-gradient areas, but farther downstream, where gradients and water velocities are lower, silts and clays would also drop out of suspension. If severe, sedimentation can smother bottom-dwelling organisms and fish eggs. However, even chronic, low-level sedimentation can have significant impacts on aquatic biota by reducing the diversity and amount of habitat available for aquatic insects and fish spawning. For example, Wohl and Carline (1996) reported substantially higher densities of benthic invertebrates and trout in a Pennsylvania stream that was protected from livestock grazing, compared with two other streams with elevated temperatures and sediment loads resulting from livestock access.

The immediate effect of sediment addition to a stream may be to initiate the downstream drift of benthic insects; the effects of prolonged turbidity and sedimentation are to reduce the number of species (richness) and density of aquatic biota (Wiederholm 1984). Moderate sedimentation may not affect tolerant organisms such as oligochaetes (aquatic worms) and chironomids (midges), but numbers of pollution-intolerant taxa such as mayflies, stoneflies, and caddisflies (EPT taxa) often decline (Etnier 1972; Lenat 1983, 1984). As a consequence, sedimentation can reduce not only the biodiversity of the benthic invertebrate community, but also the food base for fish.

Water quality could also be degraded by construction spills, fertilizer runoff, and leaching from exposed bedrock. Spills of oils and toxic chemicals could have immediate impacts on fish and benthic invertebrates; such impacts would be limited to the construction period and would be relatively easy to prevent by the use of proper construction management procedures. On the other hand, runoff of fertilizer, herbicides, and pollutants leached from exposed bedrock is a longer-term, non-point source problem that could continue long after construction of Section 8B was complete. Fertilizers might increase the productivity of stream communities, whereas herbicides and leachates could be toxic.

Clearing, cutting, and filling activities along the Section 8B corridor could alter the hydrology of small streams (Sect. 4.2.1), which in turn would degrade fish and benthic invertebrate habitats. This alteration would occur in stream reaches within and immediately downgradient from the proposed ROW. Runoff intensity could be increased during storms; high flows could wash aquatic organisms downstream and/or erode the stream bed which provides habitat. On the other hand, streamflows and habitats could be reduced under baseflow conditions (Sect. 4.2.1).

Clearing of the tree canopy at each of the stream crossings would allow increased sunlight penetration and could increase water temperatures. However, because the area of clearing at stream crossings would be small relative to the amount of undisturbed tree canopy along the remainder of the stream, water temperatures are not expected to be significantly altered.

Post-construction vehicle traffic would contribute small amounts of particulates, organic materials, metals, nutrients, and de-icing salts to nearby streams. Based on studies summarized by Lord (1987), average daily traffic of less than 30,000 vehicles per day is not likely to cause significant degradation of water quality or toxicity to fish and aquatic invertebrates.

4.3.2 Impacts to Aquatic Communities of Constructing Section 8B with no Interchanges

Alterations to water quality, water quantity, and physical habitat associated with inadequately mitigated highway construction could change the fish and benthic invertebrate communities in streams crossed by Section 8B. Presently undisturbed sites downstream from parkway construction might begin to resemble other sites in the watershed that are already impacted by pastures, residential and commercial developments, and other disturbances. While it is likely that most of these sites have some capacity to absorb small increases in sediments and nutrients without major changes, uncontrolled erosion and runoff could seriously degrade aquatic communities.

In terms of parameters used to describe the benthic invertebrate community, the streams along the Section 8B corridor appear to be more uniform than the streams along proposed Section 8D of the Foothills Parkway, which were surveyed in 1991 (ORNL 1992). For example, the EPT taxa to total invertebrate taxa ratios of Section 8D streams ranged from 0.28 to 0.68. The recently surveyed streams near Section 8B, on the other hand, exhibited ratios of EPT taxa to total invertebrate taxa ranging from 0.39 to 0.60 (Table 9). Even stream sampling sites along Section 8B that appeared to be stressed based on abiotic indicators (Table 8) had a rich benthic invertebrate and fish fauna. These uniformly high values along Section 8B indicate that at present the benthic invertebrate communities are (1) relatively unimpacted at all surveyed sites, and (2) have some resistance to minor increases in siltation, nutrient, and chloride levels.

All of the streams that are considered to be most susceptible to changes in hydrology, streambed erosion, and water quality degradation (i.e., Sheep Pen Branch, Copeland Creek, Lindsey Creek, Mill Dam Branch, Warden Branch, Butler Branch, Matthew Creek, Carson Branch, Chavis Creek, and Sandy Hollow Creek; Sect. 4.2.1) have high values for ratios of EPT taxa to total invertebrate taxa (range: 0.41 to 0.6). Thus, the benthic invertebrate communities at these sites have a relatively high proportion of pollution-sensitive taxa that could be impacted by changes in hydrology and water quality. With the exception of Sheep Pen Branch, all of these streams also support fish.

It can be expected that hydrologic changes, erosion, turbidity, sedimentation, and other forms of water quality degradation associated with construction of Section 8B would reduce benthic invertebrate habitat. Generally, the effect would be to reduce first the numbers of the most pollution-sensitive organisms (mayflies, stoneflies, and caddisflies, i.e., the EPT taxa). For example, two headwater sites in Cove Creek, along Section 8D, were already affected by siltation and nutrient enrichment at the time of pre-construction surveys (ORNL 1992). These sites had relatively few pollution-intolerant (i.e., EPA) taxa, and the EPT taxa to total invertebrate taxa ratios were the lowest of all the sites sampled. It was suggested that turbidity and sedimentation from road construction along Section 8D could cause other, unaffected streams to resemble the Cove Creek sites unless soil erosion was mitigated.

If water quality/habitat degradation worsened, the benthic community could be simplified to only pollution-tolerant chironomids, worms, and snails. In terms of the benthic invertebrate community parameters discussed in Sect. 3.3, the aquatic communities in all portions of the streams below the corridor would show decreased ratios of EPT taxa to total invertebrate taxa, increased ratios of orthoclad taxa to total chironomid taxa, and increases in the proportion of particular pollution-indicating taxa (*Cricotopus, Orthocladius, Microtendipes, Hydropsyche betteni/depravata*, and *Stenacron interpunctatum*). The degree of change could be minor given adequate mitigation (see Sect. 5.3). On the other hand, uncontrolled erosion or toxicity arising from spills or stream acidification could severely reduce the numbers of all aquatic organisms.

The fish community in the streams along Section 8B would be expected to follow the same trends as the benthic invertebrates, that is, loss of species and individuals in response to simplification of the habitat and food base. Improperly designed bridges and culverts used at stream crossings might constitute a barrier to fish movements.

If erosion were controlled effectively, the impacts of turbidity and sedimentation on the ecology of streams crossed by Section 8B could be minimized during the construction period. Successful slope stabilization and revegetation would prevent continuing erosion so that sediments unavoidably deposited during the construction period could be flushed out of the streams. Normal movements of fish and aquatic invertebrates would then repopulate stream reaches that had been impacted by construction activities.

The tunnel option in the Pittman Center area (near SR 416) would be expected to lessen the hydrologic impacts of parkway construction (Sect. 4.2.1). Assuming that tunnel spoils are properly disposed of, this option would have lesser effects on aquatic organisms as well. Similarly, the cut-and-fill options in the Rocky Flats area that would have the least effect on the hydrology of Dunn Creek, Carson Branch, and wetlands in this area (i.e., roadway construction at the base of the hillslope) would also have the least impact on associated aquatic communities.

Monitoring during construction would be important to ensure that aquatic fauna were not impacted by changes in hydrology or water quality. Most of the streams (and sampling sites) are within or below the proposed corridor, so there are few upstream areas that can be used as long-term reference sites for assessing the downstream effects of proposed road construction and maintenance. Consequently, comparisons of benthic community parameters and taxonomic lists may have to be based on before-after comparisons (i.e., results of surveys made in 1994 and during construction), rather than upstream-downstream comparisons.

4.3.3 Impacts of Western Terminus Options on Aquatic Communities

This option would include the impacts of all the activities described in Sect. 4.3.1, plus additional cutting and filling activities near lower Webb Creek or the Little Pigeon River. These additional activities could alter the hydrology in the two streams and increase turbidity and sedimentation.

The Little Pigeon River near Section 8B has a taxonomically rich benthic invertebrate fauna, a high proportion of pollution-sensitive taxa, and the largest number of fish species of any of the sites sampled in the 1994 surveys. The Little Pigeon River sites were labeled as pristine according to the abiotic indicators of stream condition. Lower Webb Creek (site 8) also has a high proportion of pollution-sensitive EPT taxa and many fish species, but it was classified as an "affected" site based on compromised stream bank stability, streambed siltation, and high phosphate and nitrate levels (Table 8).

Because the Little Pigeon River sites are among the largest surveyed near Section 8B, they would likely be more resistant to flow alterations than the other, smaller streams. Similarly, the higher streamflows at these sites would allow eroded sediments to be flushed downstream more readily than in smaller streams. As with water quality considerations (Sect. 4.2.2), an interchange at SR 416 near Pittman Center would have a lower potential for impacts to aquatic organisms than the option involving an interchange at U.S. 321 to the east of Pittman Center. Considerable slope stabilization and construction monitoring would be necessary to minimize impacts from this option.

4.3.4 Impacts of Webb Mountain Options on Aquatic Communities

This option would include the impacts of all the activities described in Sect. 4.3.1, plus additional clearing, grading, and paving near the top of Webb Mountain. These additional activities could add to the effects of the base option on the hydrology, turbidity, and sedimentation of Matthew Creek and an unnamed ephemeral tributary.

Within this option, constructing a parking area along the parkway edge would be expected to have smaller effects on both hydrology and water quality than the spur road/overlook option (Sect. 4.2.3). Consequently, the parking area option would have fewer impacts to aquatic organisms as well. Mitigative measures used to control the hydrology and water quality impacts of the activities in this option would also serve to protect fish and benthic invertebrates in Matthew Creek.

4.3.5 Impacts of Operational Timing Options on Aquatic Communities

The timing of Section 8B construction relative to the construction of Section 8C would not alter the impacts to fish and aquatic invertebrates. However, constructing the roadway and not paving it could result in considerable soil erosion, which in turn could increase the amount of turbidity and sedimentation in all the streams along Section 8B. Within this option, delays in paving the roadway should be minimized.

4.3.6 Impacts of No-Action Alternative on Aquatic Communities

If Section 8B were not constructed, potential changes in hydrology and increases in soil erosion, turbidity, sedimentation, and water quality degradation from construction described in Sect. 4.2 would not occur. Assuming that NPS allowed no development of the Section 8B corridor, the aquatic communities described in Sect. 3.3 would not be altered.

4.3.7 Cumulative Impacts on Aquatic Communities

As noted in Sect. 4.2.6, construction of Section 8B could add significantly to the sediment load of nearby streams for a period of 5 to 10 years during construction and stabilization of cuts and fills. Exposure of pyritic materials could acidify streams in the Webb Mountain area; acidification would have toxic effects on both fish and benthic invertebrates. Proper stabilization and revegetation of slopes would be expected to minimize soil erosion so that construction and operation of Section 8B would contribute only minimally to long-term sediment loads in the area. As a consequence, fish and benthic invertebrate communities in the streams near Section 8B would also be expected to be minimally impacted. Based on the 1994 surveys, even the sites that show evidence of anthropogenic impacts (e.g., streambed siltation, unstable streambanks, high levels of phosphates and nitrates) have diverse and abundant fish and invertebrate communities. It is expected that presently unimpacted headwater streams have some capacity to absorb minor changes in streamflows and sediment loads without significant alteration of aquatic communities, although this capacity would be lesser than at the downstream sites because the headwater streams are smaller. Monitoring during construction and appropriate measures to prevent soil erosion and stream acidification would be necessary to ensure that the capacity to absorb stresses was not exceeded.

4.3.8 Summary of Impacts to Aquatic Communities

Expected effects of the construction of Section 8B on aquatic organisms stem from potential changes in hydrology, sediment load, and exposure of pyritic materials. No loss or rerouting of streams is expected. Unless hydrologic changes and sedimentation were adequately controlled, adverse effects would include decreases in the relative proportions of pollution-sensitive taxa (i.e., the EPT taxa), increases in particular pollution-tolerant taxa (e.g., chironomids and tubificid worms), and decreases in diversity and abundance of fish.

Based on surveys performed in 1994, the streams along Section 8B support uniformly healthy fish and benthic invertebrate communities. All surveyed sites have a rich and abundant aquatic fauna, and none appears to be unusually sensitive or resistant to habitat or water quality degradation. The aquatic communities that are expected to be most susceptible to impacts of the build alternative are those in streams that are most susceptible to adverse changes in hydrology and water quality—Sheep Pen Branch, Copeland Creek, Lindsey Creek, Mill Dam Branch, Warden Branch, Butler Branch, Matthew Creek, Carson Branch, Chavis Creek, and Sandy Hollow Creek. In addition, the Western Terminus construction options could impact fish and benthic invertebrates in Webb Creek and the Little Pigeon River.

Proper mitigative measures and construction monitoring, discussed in detail in Sect. 5, would be expected to prevent significant impacts to aquatic biota.

4.4 TERRESTRIAL RESOURCES

4.4.1 Construction Options

The Final Conceptual Plans from FHWA were used to determine the location of the planned route of the roadbed, cuts and fills, tunnel option, and bridges and culverts. Generally, the effects of the options would be additive because of the increasing area affected by construction of interchanges and the spur road that would result in a greater loss and alteration of habitat. Impacts associated with specific natural resources in response to the different options are discussed at the end of each of the following sections. Operational timing would not be expected to affect terrestrial resources unless a delay in final construction also were to delay final revegetation, which is not anticipated.

4.4.1.1 Vegetation

Impacts to vegetation on the ROW from construction and operation of the parkway would consist of direct mortality of vegetation during construction, indirect effects of changes in microclimate as a result of removing surrounding canopy, establishment of edge or disturbance communities in previously interior forest, effects of erosion and changes in hydrology, invasion of exotic species, and air pollution damage from vehicles using the parkway. About 40 ha (100 acres) of mostly native forest vegetation would be cleared, assuming about a 20-m (60-ft) cleared roadway. Two to three times as much area could actually be cleared of forest in large cut and fill areas, and an additional temporarily cleared strip about 3 to 7 m (10 to 20 ft) would be needed in most areas on each side of the roadway to allow for work on cuts and fills. A comparison of the estimated area affected by different construction options is given in Table 55. Construction and operation of the parkway would result in further reduction in forest patch size in areas surrounding the GSMNP, an increase in edge communities in the region, and establishment of a new corridor for invasive exotic plant species (Ambrose and Bratton 1990). It would also create another potential source of fires caused by smokers. In the past, most smoker-caused fires in GSMNP have occurred along roads on the GSMNP boundary, Tennessee SR 73, and U.S. 441 (Covell 1977).

Comparison of options. Construction of the main roadway would require the same amount of forest clearing and would therefore impact vegetation to the same extent for all options. Addition of interchanges or the Webb Mountain options would impact slightly more native vegetation. Because of their location in the floodplain of the Little Pigeon River, the options involving a western terminus at SR 416 would result in greater impact to native floodplain forest than the no interchange or U.S. 321 interchange options.

4.4.1.2 Wildlife

Many species of birds, mammals, reptiles, and amphibians are affected by roads. Although wildlife would probably not be uniformly affected by the roadway along the length of the corridor, impacts to wildlife would generally be independent of location along the ROW because of the relative homogeneity of wildlife forest habitat throughout most of the ROW and relative homogeneity of

Table 55. Comparison of cleared areas for construction options. These estimates do not include total area disturbed during slope rounding.

Basic alignment	Surface area (cut, fill, and roadbed) (ha)
Centerline without tunnel	76
Centerline with tunnel	75
Comparison of additional options[a]	
Rocky Flats	
Center alignment	6.9
Fill alignment	5.6
Interchange with SR 416	
Ramp L&M	11
Ramp I&J	11
Interchange with Webb Creek Rd.	
Ramp A Interchange 1	0.43
Ramp B Interchange 1	0.44
Interchange 2	1.5
Interchange with SR 32	
Ramp A, A1, A2	1.4
Ramp B, B1, B2	1.5

[a]Data for Webb Mountain options were not available.

habitat loss. Impacts of roads on wildlife include providing dispersal corridors, creating dispersal barriers, adding to mortality through road kills, increasing noise, altering habitats, and altering predation (Adams and Geis 1981; Van der Zande, ter Keurs, and vander Weijen 1980; Oxley, Fenton, and Carmody 1974; Carr and Pelton 1984; Rich, Dobkin, and Niles 1994). Fragmentation of local gene pools by roads may also be important in small populations but would not be expected to be a significant problem along the parkway. Barriers would be created by lack of cover, temperature gradients, and road deaths (Van der Zande, ter Keurs, and vander Weijen 1980; Oxley, Fenton, and Carmody 1974).

Although roads may provide dispersal corridors (e.g., grassy roadways through woodlands) for some species, they can also act as an effective dispersal barrier to small mammals, such as mice, or even some butterflies and birds (Van der Zande, ter Keurs, and vander Weijen 1980). Road width, including non-forest road edges, is the most important factor in determining whether or not wildlife would cross roads. If a species is adapted to open country, it is much more likely to cross a road. Small forest mammals are reluctant to cross roadways more than about 20 m (60 ft) wide (forest to forest) while skunks, groundhogs, raccoons, and larger mammals cross wider roads (Adams and Geis 1981). The proposed roadbed of the parkway would be about 7 m (20 ft) wide, with about a 5 to 7 m (15 to 20 ft) wide cleared buffer area on each side of the roadbed. This permanently cleared space, approximately 17 to 21 m (50 to 60 ft) wide, would be an effective barrier to small forest mammals. About 3 to 7 m (10 to 20 ft) additional width would be cleared in most areas to work on the cut and fill on both sides of the roadway but would not be grubbed of roots and tree stumps and would revegetate rapidly.

Mammals, birds, turtles (especially the box turtle), frogs, toads, and snakes are frequently killed by vehicles. More than 500,000 deer were killed by vehicles in 1991 in the United States (Romin 1996). The eastern screech owl often frequents roadsides and is the most frequently road-killed bird in GSMNP (Alsop 1991). In some instances road death can be high enough to influence local populations (Van der Zande, ter Keurs, vander Weijen 1980). (Shrubs planted close to roads would encourage some species to cross the road, but this practice could increase road deaths.) Animals suffer greater mortality with higher traffic volume and speed. Relatively low traffic volume and slow speeds would probably minimize animal mortality on the parkway.

Just as some species would cross roads while others would not, some species are attracted to roadsides while others avoid them. Some species avoid the roads because of noise or exposure to predators; other species, such as deer, are attracted to grassy roadsides, increasing the frequency with which they are hit by vehicles (Oxley, Fenton, and Carmody 1974). In contrast, roadsides provide improved habitat for some small rodents, allowing them to flourish (Oxley, Fenton, and Carmody 1974). Roadside habitat is attractive not only to grassland species but also to many species which use several habitats including the ROW, edge, and adjacent forest. Overall diversity of wildlife in the parkway vicinity would probably increase as a result of increased variety of habitats, but increased fragmentation of interior forest habitat by construction of the parkway would probably reduce populations of interior species (e.g., the ovenbird and Swainson's warbler) on the ROW.

Some species that require forested areas, especially neotropical migratory warblers, could also be adversely affected by increased predation and parasitism from species adapted to fields, forest openings, and edges (Rich, Dobkin, and Niles 1994; Askins 1995; Robinson et al. 1995). Roads can have either negative or positive effects on predation. For instance, some species of raptors, such as the American kestrel and red-tailed hawk, hunt along ROWs, and roadkilled animals might provide additional food for the black vulture (Adams and Geis 1981). Some predators, such as foxes, raccoons, skunks, and coyotes avoid interstate ROWs but not smaller roadway ROWs.

Bears are often killed by hunters on roads, and, in areas open to hunting, bears avoid roads (Carr and Pelton 1984, Brody and Pelton 1989). Hunting with dogs is traditional and popular in the southern Appalachian Mountains, and an extensive road system increases the efficiency of hunters (Brody and Pelton 1989). For protected bear populations, roads may attract bears if food supplies are enhanced by the presence of the road (e.g., blueberry and huckleberry patches on roadsides) (Carr and Pelton 1984). Response to seasonally available food supplies, rather than other influences of roads on bear behavior, determines whether or not bears cross roads or use areas around roads in GSMNP (Carr and Pelton 1984). The location of the ROW close to areas inhabited by dogs and people probably already limits the suitability of the area for bears. None were seen during the field surveys, although park staff report they are present. Although the parkway would not be open to legal hunting, it would provide greater access to poachers.

Comparison of options. Construction of the main roadway would impact wildlife to the same extent for all options. Addition of interchanges and the Webb Mountain options would have a slightly greater impact because of increased access and loss of habitat. Impacts to wildlife of special concern are discussed in the following sections.

4.4.1.3 Protected Rare Species

Vascular plants with federal status. No species with federal status were found growing on the ROW. Butternut, ovate catchfly, and Fraser fir, previously federally listed as under review or C2 candidate species (58 *Fed. Regist.* 51143–89; 61 *Fed. Regist.* 64481–85), are also state listed and are discussed below.

Vascular plants with state status. Construction and operation of the parkway would affect most populations of the state listed vascular plant species found on the ROW to some extent. Some species could be affected by destruction of populations, others by reduction or alteration of habitat, and others by increased access for collection.

The population of the state-threatened butternut could be affected by construction in the Little Pigeon River floodplain, either through direct destruction of individual trees or habitat alteration. Although all the butternut trees in the ROW appear to have disease cankers, the mature trees are vigorous enough that they would probably fruit. The known locations of the state-threatened ovate catchfly plants are in upper drainages of streams and are downslope from the proposed roadbed. These plants would not be directly affected by construction and operation of the parkway but could be adversely affected by alteration of habitat due to forest canopy removal and cut and fill or movement of rocks and soil downslope. The sapling of the threatened Fraser fir on the ROW is not of conservation concern (see Sect. 3.4.3.1).

The location of the endangered southern nodding trillium appears to be directly within the proposed construction area. This population would be eliminated, but there would be relatively little impact on state populations.

Construction in the Webb Mountain segment of the ROW could affect existing populations of the state-threatened ash-leaved bush-pea (see Sect. 3.4.3.1). Because it grows and blooms in disturbed areas, construction could, however, provide more habitat for this species. The plant is quite showy in bloom and, if the population survived construction, it might be threatened by illegal collection as a result of increased access from the parkway. This species was previously reported in the GSMNP at only one location (Section 8D of the Foothills Parkway), is known to inhabit only four counties in Tennessee, and is not widely dispersed in the rest of its known distribution in North Carolina, South Carolina, and Georgia (Appendix E).

One of the known maple-leaf alumroot populations is located in the Webb Mountain segment slightly downslope from the proposed area of construction of the main roadbed. This population might be affected should construction result in rocks and soil moving down slope and damaging the site. The microclimate of the site could also be affected by removal of nearby trees and cut and fill.

Both the endangered pink lady's-slipper and threatened ginseng are listed by Tennessee as commercially exploited and are protected by regulating their harvest and sale. Because habitat for these species is relatively abundant in the state, habitat destruction would have less impact than the possibility of increased access from building the road. The pink lady's-slipper is widespread in pine and pine oak areas, and some plants could be directly impacted by road construction (see Sect. 3.4.3.1). Some ginseng plants, which probably grow throughout the ROW in rich woods, could also be affected. Because of relative abundance of these two species throughout Tennessee, there would be relatively little impact on state populations.

Mammals with federal status. Although not seen during field surveys, the endangered Indiana bat might be present along the ROW in summer (see Sect. 3.4.3.3). Upland and riparian hardwood forest are foraging and maternity roost habitat for this species. Clearing of forest could adversely affect this species, if it were present.

The small-footed bat, woodrat, rock vole, northern pine snake, hellbender, and Allegheny snaketail dragonfly are species which could or do occur on the ROW and were previously federally listed as under review (C2) (59 *Fed. Regist.* 58981–9028; 61 *Fed. Regist.* 64481–85). All but the Allegheny snaketail dragonfly are also state listed as in need of management and are discussed in the following sections. Although Tennessee does not currently list any insect species, the Allegheny snaketail dragonfly, which does occur on the ROW, is of concern to GSMNP and is discussed in Sect. 4.4.1.4.

Mammals with state status. Several small mammal species listed by Tennessee as needing management would be impacted by construction and operation of the parkway through destruction of their habitat or through disturbance (e.g., noise) (Sect. 3.4.3.3, Table 16). Populations of these species could be reduced on the ROW. Overall, however, there would probably be relatively little actual impact on these species because they are distributed over a very large area of the foothills and GSMNP region (Appendix G).

Birds with federal status. The threatened peregrine falcon is not known to be using the ROW at the present time, and suitable potential nesting habitat is not present on the ROW. Preference for cliffs and bridges as nesting sites could make potential nesting sites more available after construction of the parkway if structures, such as tunnel faces or bridges, appeal to the birds and they decide to move in as nesting populations expand. Suitable foraging habitat is already present in surrounding farmlands. Road construction and operation would not result in a decrease in availability of this habitat.

No bird species were previously federally listed as under review (C2) were found on the ROW. However, the cerulean warbler, which was previously listed as C2, was observed in forest close to the ROW. This species is of concern to GSMNP and is discussed in Sect. 4.4.1.4.

Birds with state status. Construction and operation of the parkway is not expected to have a negative impact on birds listed by Tennessee (see Sect. 3.4.3.3). Habitat may be improved for

Cooper's hawk, Bewick's wren, and Bachman's sparrow, if they are present. These species use open pastures, fields, and edges, which would increase following construction of the parkway.

Comparison of options. Construction of the main roadway would impact protected rare species to the same extent for all options. For the ramp option at the western terminus intersection with SR 416, there is probably room to site the ramp in the Pigeon River floodplain without directly impacting the population of state threatened butternut, if fill for the ramp is far enough to the west. In the Webb Mountain segment, plants of the maple-leaf alumroot may be more widespread (see Sect. 3.4.3.1) and could be affected by construction of the spur road. However, the known population is not close to proposed construction and probably would not be affected. One of the two known populations of ginseng is on the Rocky Flats segment of the upper slope (cut) option, and would be lost during construction.

4.4.1.4 Additional Species of Interest to NPS

GSMNP is responsible for protecting the unique plant and animal taxa that are native to the Park. Although the species discussed in this section do not have legal status, impacts to these species are of interest to NPS because of the GSMNP role in preserving biodiversity. Some of these species were previously listed as under review or candidates (C2) for listing under the Endangered Species Act (61 *Fed. Regist.* 64481–85).

Vascular plants. Other than state listed species, most of the vascular plants considered rare in the GSMNP and found on the ROW are relatively abundant in other areas of the park and Tennessee (see Sect. 3.4.4). The majority of species new or rare to GSMNP found on the ROW are in wetlands or floodplains. Because of the relative abundance of these species throughout the state and because wetland and floodplain habitats would preferentially be avoided or protected, most of these species would not be affected by construction.

Bryophytes and lichens. Currently, Tennessee does not give legal protection to rare bryophytes. Bryophytes discussed in this section are those considered rare in both Tennessee and GSMNP (see Sect. 3.4.4). They contribute to the biodiversity of GSMNP and the surrounding region. Several species of rare bryophytes would probably be affected by road construction. Of the six species rare both in GSMNP and in Tennessee, all but the moss *Fissidens bushii*, which is a temporary occupant of highly disturbed sites, would probably be affected by construction. Three of the mosses (*Brachethelium rutabulum, Fissidens appalachensis,* and the sphagnum, *Sphagnum affine*) and the hornwort (*Megaceros aenigmaticus*), which grow in or near streams and wetlands, could be affected by disturbances to groundwater flow patterns and siltation from upslope construction. *Brachethelium rutabulum* and the hornwort grow inside proposed construction areas in the Rocky Flats segment of the ROW, and construction could potentially reduce or eliminate these populations. Although the extremely rare hornwort species does not currently have legal status, it is especially noteworthy because of its national rarity (see Sect. 3.4.4). Construction could also affect many of the additional 23 species rare in GSMNP (see Sect. 3.4.4), but these species are more common in suitable habitats elsewhere in the park and Tennessee (see Appendix H).

Populations of all of the above-mentioned bryophytes could be adversely affected by construction of the parkway. Because bryophyte distribution and abundance is generally not as well known as for larger species, it is difficult to assess the significance of adverse impacts to these populations.

Invertebrates. The Allegheny snaketail dragonfly was found in streams throughout the Pigeon River Terraces segment. Habitat for this species could be affected by siltation during construction and by changes in hydrology downstream from the roadbed. Streams where this species is reproducing could also be directly impacted by construction of stream crossings, which have the potential for the greatest disturbance to habitat for the dragonfly larvae.

Small mammals. As is true for Tennessee listed species, construction and operation of the parkway would probably impact populations of the small mammals considered rare in GSMNP by destroying portions of their habitat or by disturbance (e.g., noise) during construction and operation. Overall, however, there would probably be relatively little actual impact on the status of these species since they are quite likely present in significant numbers on the ROW and are distributed over a very large area of the foothills and GSMNP region (Appendix G). Some of the GSMNP rare mammals are much more common in surrounding areas outside the park and are not threatened by construction of the parkway.

Birds. Neotropical migratory songbirds are of concern to GSMNP because many of these species have undergone regional or range-wide declines resulting from habitat loss and fragmentation in both summer breeding and tropical wintering areas (Terborgh 1989; Hagan and Johnson 1992; Robinson et al. 1995; Askins 1995). Construction and operation of the parkway would result in some habitat loss and fragmentation. Although the extent of declines in populations of neotropical migrants is debated and more data are needed, precipitous declines in populations of some species, such as the wood thrush and cerulean warbler, are known to have occurred in the last few decades. Species reported to have experienced a decrease in populations include those which nest in forest edges and old fields as well as those that nest in interior forests, but most attention has been focused on effects of habitat fragmentation on successful reproduction of interior forest birds, especially in the eastern United States. Predators and parasites such as brown-headed cowbirds thrive in fragmented forested landscapes with abundant edge and field vegetation. Populations of brown-headed cowbirds, which lay their eggs in nests of other songbirds, have been shown to increase when forests are fragmented by roadway corridors as narrow as about 16 m (50 ft) wide, especially if roadway corridors include mowed grass edges or median strips (Rich, Dobkin, and Niles 1994).

Cerulean warblers are undergoing precipitous population declines throughout their range and are reported to have the maximum probability of occurrence in blocks of contiguous deciduous forest greater than 3000 ha (1200 acres) (Robbins, Fitzpatrick, and Hamel 1992). This species might nest on the ROW, but the Blue Ridge Province is not a center of abundance and the species is not likely to occur as more than an occasional breeding pair.

Of the 16 species of neotropical migrants of very high concern or vulnerable and likely in need of management and/or monitoring in the Blue Ridge physiographic province, 14 that were observed on or near the ROW require large blocks of interior forest to nest successfully. The Blue Ridge Physiographic Province is the center of distribution for nine of these forest nesting bird species—hooded warbler, Kentucky warbler, black-throated green warbler, ovenbird, wood thrush, Acadian flycatcher, northern parula, eastern wood-pewee, Louisiana waterthrush—that are undergoing significant population declines (Hunter, Pashley, and Escano 1993; Hunter et al. 1993; Roedel, Miles, and Ford 1996). The ROW is currently more than 95% forested and is part of extensive contiguous forest tracts of suitable neotropical migrant songbird habitat that are greater than about 400 ha (1000 acres) in extent (Table 56; Fig. 80; Appendix E, Part 2). Populations of all interior forest (i.e., area-sensitive) birds (Sect. 3.4.4, Table 17) would be adversely affected by loss of interior forest habitat and its fragmentation resulting from construction and operation of the parkway.

Table 56. Landcover and potential habitat for area sensitive forest songbird species within the right-of-way (ROW) and in the surrounding region

	ROW		Region[a]	
Description	Hectares (acres)	Percent	Hectares (acres)	Percent
	Landcover			
Forest	744 (1,837)	97.5	30,899 (76,295)	92.1
Fields and opening	17 (43)	2.3	2,544 (6,281)	7.6
Urban	1.6 (4)	0.2	107 (263)	0.3
	Forest habitat tract size			
Tracts 100 to 999 acres	30 (75)[b]	4	1,050 (2,592)	3.1
Tracts greater than 1000 acres	600 (1,482)	78.7	21,251 (53,139)	64.1
Unsuitable, including tracts < 100 acres	132 (326)	17.3	10,992 (27,140)	32.7

[a]Approximately 130 mi^2 (335 km^2) surrounding the ROW.
[b]Suitability of tracts within the ROW was determined from suitability of the entire habitat tract, including contiguous area outside the ROW boundary.

The other two neotropical migrant species—gray catbird and northern prairie warbler—and the temperate migrant field sparrow nest in fields and forest edges and would probably benefit from an increase in preferred habitat.

Non-native (exotic) invasive species. The NPS is responsible for protecting the unique plant and animal taxa that are native to the GSMNP. In addition to valued native species, there are also more than 300 non-native (i.e., exotic or alien) species in GSMNP (Remaley 1996). Most of these exotics have not become well established and do not spread. Some, however, are indefinitely persistent once established, take up competitive space, and alter visitor perception of the park. Some are able to interbreed with closely related native species. Many of the problem exotics in the park are only successful in disturbed habitats, which means that these species can become abundant along roads, especially immediately after construction. Rapid reproduction by exotics in disturbed areas can crowd out those rare native plants that can only survive in disturbance habitats such as rock outcrops and slides, floodplains, and gravel or cobble bars in major streams or rivers. A few non-native plant species (e.g., garlic mustard, Japanese grass) that are found in the park are completely shade-tolerant and are invading closed canopy forest.

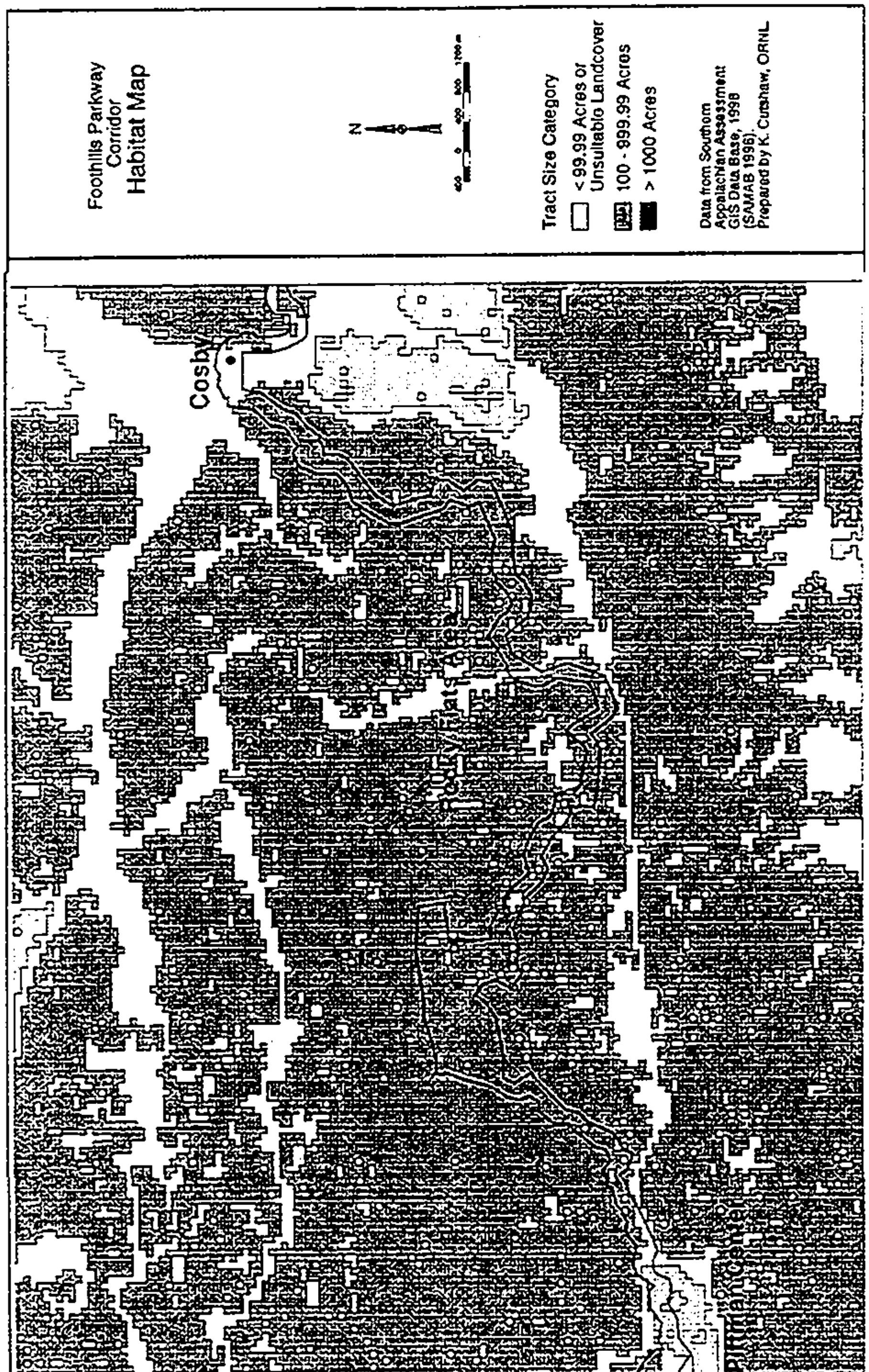

Fig. 80. Habitat map in the approximately 130 mi² (335 km²) region surrounding the right-of-way.

Exotic or alien species are of concern on the ROW because construction of the proposed parkway would create disturbed habitats that could promote their expansion in this area. Although corridors, such as the Foothills Parkway, outside the main body of the park receive lower priority for control of exotic species than corridors within the rest of the park (NPS 1987), these areas are still of concern, especially if they provide large reservoirs for propagules dispersal.

Of the 33 species listed by Remaley (1996) as presenting a significant threat to GSMNP natural resources, seven were found in or near the ROW (Table 57). Several of these species currently established on the ROW could expand populations following construction of the parkway (see Sect. 3.4.4).

Table 57. Exotic species on or near the right-of-way of concern in GSMNP (see Sect. 3.4.4) [adapted from Remaley (1996)].

Level of concern		
High	Moderate	Little or none
Garlic mustard	Chinese yam	Coltsfoot
Japanese grass	Japanese honeysuckle	Ivy-leaved speedwell
	Kudzu	Periwinkle
	Multiflora rose	
	Privet	

Japanese grass and garlic mustard can be very difficult to eradicate once established. Populations of Japanese grass are well established in most moist shady areas along the ROW. This species has high potential to spread into moist disturbed areas following construction and would persist after establishment of forest canopy. Garlic mustard was not found on the ROW but was found south of the ROW along Rocky Flats Road. This species is rapidly spreading in other regions of the United States and can spread into established forests, crowding out native herbaceous species. Seeds are readily spread on the fur of animals and by flowing water. Since this species grows primarily in woodlands, construction and operation of the ROW is not expected to enhance its establishment, but the road corridor could provide an avenue for increased dispersal of seeds.

Kudzu is the best known of the aggressive exotics currently growing on the ROW. It can grow up to 20 m (60 ft) per year and can blanket roadsides (Remaley 1996). Without eradication, the vines of kudzu near Chavis Road would expand and continue to smother vegetation whether the parkway is built or not.

Privet is well established along disturbed stream drainages adjacent to the ROW, especially along the tributaries to Webb Creek west of Mill Dam Branch in the Webb Creek Ridge and Little Pigeon River Terraces segments. There is considerable potential for this species to spread into moist, disturbed areas after construction. The fruits are eaten by several species of songbirds in late fall and winter, which facilitates spread of seeds. Privet also roots quite easily in moist areas and produces abundant sprouts. It could continue to expand populations into moist, disturbed areas after construction.

Multiflora rose and Chinese yam or cinnamon vine are currently abundant in the two major floodplains of the ROW—Cosby Creek and Little Pigeon River. Multiflora rose is also abundant in floodplains near Webb Creek. Both species are likely to spread and become more abundant after construction during revegetation of disturbed areas in the floodplains.

Japanese honeysuckle is abundant in many areas of the ROW, especially in areas of past disturbance. It would undoubtedly spread in woodlands along the ROW in areas that receive additional light as a result of removing forest canopy for the roadway. This species is an aggressive weed, crowding out other ground cover, but is not as competitive in dense shade.

Although periwinkle can smother low-growing native vegetation where it is well established, it is usually found only where it was planted in rural cemeteries and old home sites. Because it propagates primarily vegetatively, it is not expected to be affected by establishment of the parkway.

Ivy-leaved speedwell and coltsfoot were found on the ROW in disturbed areas near existing roadsides. The effects of these two species on native biota are not known, but they probably do not pose a serious threat.

Comparison of options. Compared with the no-interchange option, the western terminus options involving a SR 416 interchange would result in greater disturbance to the Little Pigeon River floodplain. Disturbance in the floodplain would increase the potential for establishment of exotic species such as multiflora rose, Chinese yam, and privet. The SR 416 interchange options would also increase potential impacts to the Allegheny snaketail dragonfly.

The Webb Mountain options would increase the probability of impacts to vascular plants rare in GSMNP, such as clasping milkweed, arrow-leaved aster, and slender muhly (see Sect. 3.4.4). The Webb Mountain spur road and parking area options could also adversely affect GSMNP-rare wetland species in the Webb Mountain segment. The potential for adverse effects is greater with the spur road option than with the parking area option because of the increased potential for changes in hydrology and siltation from construction and operation of the spur.

The Webb Mountain segment contains the largest block of intact forest on the ROW. Forest clearing for the spur road and overlook would substantially increase forest fragmentation in this segment of the ROW and would reduce suitable interior forest nesting bird habitat.

4.4.1.5 Unique or Sensitive Habitats Including Wetlands

Wetlands. As described in Sect. 3.4.5, most wetlands on the ROW are less than 1 ha (2.5 acres). The largest wetland areas on the ROW are in the Little Pigeon Terraces segment on cobble bars of the Little Pigeon River, in the Webb Creek Ridge segment along a tributary to Webb Creek, and in the Rocky Flats segment near seeps and streams along Dunn Creek and Carson Branch. Biologically important wetlands are present on the ROW in three drainages containing fairly extensive networks of seeps (see Sect. 3.4.5 for further description of wetlands).

Impacts to wetland areas could be caused by changes in hydrology resulting from cut and fill, by alteration in runoff or recharge patterns resulting from changes in vegetation and pavement, and by compaction of permeable layers under the roadbed (see Sect. 4.2). These changes could have a significant impact on all of the wetlands either on the ROW or below it. Wetlands likely to be affected the least are those far enough downslope that total water availability may not change following construction. All wetland areas downslope of the ROW also have the potential to be adversely impacted by sediment eroding during construction, and biologically significant wetlands could be adversely affected. In addition, small wetlands may be created on the upper side of the roadbed if lateral water flow is blocked. Although impacts to wetlands on the ROW would probably be significant, the total wetland area likely to be affected is less than about 4 ha (10 acres).

Other unique habitats. The cobble bar in the Little Pigeon River could be affected by sediment moving downstream from construction of the bridge crossing the river. Since this habitat is a highly disturbed one, created and maintained by erosion and deposition, it is unlikely that upstream construction would have a long-term adverse effect.

Some of the calcareous area of the ROW on the Big Ridge segment would be affected by cut and fill. This area contains the state endangered southern nodding trillium and an established patch of the invasive exotic kudzu plant. Construction of the parkway would adversely affect the habitat of the trillium and would increase opportunity for the spread of kudzu. Although calcareous soils are relatively rare in GSMNP and therefore provide habitat for many plant species that are rare in the park, this particular site was not noted to contain species rare in the park other than the state endangered trillium.

Air pollution sensitive vegetation. The NPS is concerned that vegetation in GSMNP is being damaged by air pollutants (Neufeld et al. 1992; Chappelka, Renfro, and Somers 1994; Shaver, Tonnessen, and Maniero 1994). These studies indicate that ozone has the most immediately visible impacts, and nitrogen oxides are precursors to ozone formation. Ozone levels in GSMNP rarely exceed the NAAQS. Air monitoring has indicated only one exceedance of the NAAQS in the park, but ambient ozone levels below the standard can have adverse effects (Neufeld et al. 1992). The NPS has an ongoing ozone plant exposure testing program to determine sensitivity of species to levels of ozone in the GSMNP. Eleven of the 31 species tested are extremely sensitive to currently occurring levels of ozone (Neufeld et al. 1992). Ninety-five species growing in GSMNP have been observed to have foliar ozone damage, including more than 30 species of trees.

Specific surveys for air pollution damage or plant species sensitive to air pollution have not been conducted on the ROW. However, of the species of trees found to have foliar damage in other areas of GSMNP, most are found on the ROW. Tulip poplar, red maple, Table Mountain pine, sycamore, and black cherry are common tree species on the ROW that are extremely sensitive to ambient levels of ozone in fumigations of seedlings (Neufeld et al. 1992).

Operation of the parkway would introduce only slightly higher levels of ozone from automobile exhaust, no more than about 0.5% above ambient levels in the area (see Sect. 4.5). This increase would presumably result in only slightly higher frequency and extent of foliar injury, and the resulting additional impacts should be minimal.

Comparison of options. The Webb Mountain options could adversely affect the biologically important mountain wetland seep on the Webb Mountain segment of the ROW. This wetland would probably be affected by changes in hydrology, including surface runoff (see Sect. 4.2.3).

In the Rocky Flats segment (from engineering map coordinates 15+100 to 15+500), building up a wall along the slope west of the creek and using some form of supported span across the creek would probably have less impact on hydrology and water quality of wetlands than the raised causeway (Parkway Fill) option. The Dunn Creek valley (map coordinate 15+500 to Rocky Flats Road) has several seeps and wetlands that would be affected by construction and fill for the raised causeway. Fill in the valley itself would probably have more long-term effect on wetlands than the option of construction on the slope. Similarly, extensive fill from about 15+800 to about 16+000 would adversely affect the hydrology of Spring Branch tributaries and the riparian zone. Fill around the stream crossing at 16+300 and along the roadbed that parallels Carson Branch from 16+300 to about 16+600 could also adversely affect wetlands along Carson Branch, especially where fill extends to the stream.

The Little Pigeon River and Cosby Creek floodplains could be affected by fill associated with the base option and with additional fill associated with the SR 416 ramp options.

Boulder or talus slopes and rocky areas in the Webb Mountain segment of the ROW could be affected by massive cut and fill for the base option and for the Webb Mountain spur road option. However, these rocky areas were not found to contain a rich community of biota of special concern, and resulting impacts to these areas are not of high conservation concern.

4.4.1.6 Cumulative Impacts

Vegetation and wildlife. Land development in the counties around the parkway has resulted in changes in land use from native forest ecosystems to residential and other uses. These changes are expected to continue in the future and result in a loss of wildlife associated with these forests. Effects on wildlife are generally additive; that is, as more forest is converted to other uses, fewer forest dwelling species would be present, and populations of forest species would decrease. Some wildlife species (e.g., the cerulean warbler, which requires large areas of undisturbed forest) are affected by fragmentation of native forest due to intrusions of cleared areas and development, but others are not. In general, as more areas within the surrounding counties are removed from forest, populations of species that require large forested areas would be reduced in the region. Populations of other species, that utilize openings and edges of forests, would increase. Some species that require forested areas, especially neotropical migratory warblers, are also adversely affected by increased predation and brood parasitism from species that live in openings and edges and hunt in surrounding forest (Askins 1995; Robinson et al. 1995).

The overall impact of the parkway on wildlife would be relatively small compared to impacts from current and future commercial and residential development, because the entire acreage of the ROW is relatively small. Although the ROW is somewhat unusual because of its location in the foothills around the GSMNP and because of the presence of unique habitats and rare species, loss of native forest habitat due to construction and operation of the parkway would be much less than impacts to the forest from current and future development in the surrounding area. If the parkway were not built and the land reverted to private ownership, the area would likely experience development similar to that in surrounding areas, which would have a greater cumulative impact on forests in the region.

The parkway would provide increased access for illegal collecting of wildlife (e.g., bears, deer, and raccoons) and plants (e.g., ginseng, lady slipper orchid, and ash-leaved bush-pea). Although the parkway would add 22.7 km (14.2 miles) of road that could potentially be used by bear poachers, the absence of den sites on the ROW in contrast to other areas of the region (e.g., GSMNP, Cherokee National Forest) would result in little cumulative impact. Although the ROW has not been fully inventoried for the presence of bears, most suitable bear habitat in the region is located in either GSMNP or in national forest, where future residential or commercial development is not expected to take place.

Plant poaching is a problem in GSMNP, where visitors remove plants from roadsides and nature trails, and commercial diggers illegally collect medicinal plants, such as ginseng (Bratton and White 1980). The ROW does not have as rich and tempting a flora as GSMNP proper, but completion of the parkway could increase poaching of some state-protected species. If the population of the ash-leaved bush-pea, which is rare throughout the state, is still present, collection of plants would have a significant cumulative impact. The other two species of concern, lady's-slipper orchid and ginseng, are protected by the state, not because of rarity or lack of habitat, but because of current collection pressure. Loss of habitat for these species on the ROW is not expected to have a significant impact, but increased access for poaching could be significant.

Protected species. Protected wildlife and plant species are under threat from human population expansion and resultant loss of habitat. The distribution of many protected species is scarcely known in the surrounding counties; therefore, it is difficult to assess cumulative impacts. However, the presence of protected species, especially in the Webb Mountain and Rocky Flats segments, reflects the relatively high habitat quality of the ROW and points out the potential for a significant contribution to cumulative impacts for some species, such as the ash-leaved bush-pea. Mitigation to protect these species would result in little to no cumulative impact compared with current and future effects of commercial and residential development in the surrounding region.

Wetlands and sensitive habitats. Most wetlands located on the ROW would be affected by construction; but the total acreage is quite small. The impact to biota in small wetlands and seeps could be significant, but cumulative impacts to wetland function would be negligible, especially with restoration of additional wetlands to mitigate for wetlands lost to construction. Future commercial and residential development in the surrounding area would probably have much larger impacts to wetlands than the parkway.

Most of the sensitive habitats on the ROW, including some of the wetlands, are relatively unique, as reflected in the rare species present. Therefore, loss of these environments, especially biologically significant wetlands in the Rocky Flats and Webb Mountain segments, could have a significant cumulative impact if mitigation did not occur. Mitigation adequate to provide protection of wetlands in the Rocky Flats area may be very expensive.

Comparison of options. Because of the suitability of floodplains for development and agriculture, native floodplain vegetation is threatened throughout the United States (Noss, LaRoe, and Scott 1995). These ecosystems are representative of types that were once abundant and widespread in the United States but are increasingly threatened by human development. Construction of the western terminus options involving an interchange at SR 416 would contribute to cumulative loss of floodplain forest in the region.

The ROW is a relatively narrow corridor through land that is currently mostly contiguous native forest but that is likely to undergo extensive development in the future (see Sects. 3.6 and 4.6). As surrounding areas develop, even if Section 8B of the parkway is not built, the narrow ROW corridor would no longer provide habitat suitable for successful nesting of most interior forest neotropical migrant songbirds. The Webb Mountain segment contains more than 250 ha (600 acres) and would continue to provide suitable nesting habitat for some neotropical migrant songbirds if it were not fragmented. The Webb Mountain spur option would contribute both to cumulative loss of habitat in the region and total loss of suitable habitat on Webb Mountain if the surrounding area were also fragmented by development.

4.4.1.7 Summary of Cumulative Impacts to Terrestrial Resources

Construction and operation of the parkway could affect some important biotic components of the ROW (see Sects. 3.4.3.2 and 3.4.4). The ROW has two major floodplains; several important wetlands, especially in the Rocky Flats segment; and state-protected plants and wildlife throughout, especially in the Webb Mountain segment. Most of these resources could be impacted by the parkway. Forest habitat fragmentation could affect wildlife, especially forest habitat area-sensitive breeding birds, but other impacts to wildlife and vegetation on the ROW are expected to be minor.

Impacts to floodplain resources would be greatest with the western terminus options at SR 416. The Webb Mountain spur road options would increase forest fragmentation impacts to some neotropical migrant songbirds. Cumulative impacts to terrestrial ecology from construction and operation of the parkway are expected to be minor except for possible impacts to rare biota and habitats on the ROW. Little is known about sensitivity of many plant species, especially bryophytes, to habitat alteration, value to the habitat, or potential uses to humans. There are unknown but potentially significant impacts to populations of plants on the ROW.

4.4.2 Impacts of the No Action Alternative

Impacts on terrestrial communities present along the ROW discussed in Sect. 4.4.1 would not occur if the ROW were not developed for other purposes. Species that require open, disturbed areas could be replaced if natural succession establishes forest canopy in areas that are not currently forested.

4.5 METEOROLOGY AND AIR QUALITY

4.5.1 Effects of Road Construction on Air Quality

Pollutants regulated by the NAAQS include CO, SO_2, NO_2, lead, ozone, and PM-10. Some CO, SO_2, and NO_2, would result from exhaust emissions of heavy construction vehicles, diesel generators, and other construction equipment. However, because these emissions would be small and temporary and would be released near ground level, they would have negligible impacts on ambient air quality outside of the immediate construction area. Emissions of lead are expected to be negligible. Emissions of PM-10 from vehicle exhaust are included in the discussion of particulate matter, below.

Ozone is a secondary pollutant formed by photochemical reactions involving hydrocarbons and NO_x. Because the time required for ozone formation is large compared with the time its precursors remain near their source, appreciable increases in ozone concentration due to construction would not be expected near the construction site. Ozone concentrations result from precursor emissions within a larger region, and the precursor contribution of exhaust from vehicles and other equipment involved in parkway construction would be less than 1% of the regional contribution from nearby Knox County.

Although regional ozone increases from the proposed construction are expected to be very small, existing ozone levels in the region have been close to the NAAQS in recent years. Additionally, data available from the NPS indicate that 8-hour concentrations in recent years would have exceeded the new standards (Joseph 1999). Therefore a contribution as small as that from the proposed construction could possibly contribute to another exceedance in or near GSMNP.

The greatest air-quality impacts that would be expected to result from parkway construction would be associated with fugitive dust from excavation and earthwork, possibly in conjunction with burning of wood materials along the construction route. Smaller dust particles (PM-10 and PM-2.5) are of primary interest because they can move easily into the lower respiratory tract and because they typically have the greatest impact on visibility through the atmosphere. Standards for PM-10 and PM-2.5 exist for annual and 24-hour averaging periods. However, PM-2.5 standards have only recently become effective, and a sufficient data base does not yet exist for analysis of impacts of construction activities on concentrations of particulate matter in this size class. Because heavy construction is not expected to occur at any single location for an entire year, the 24-hour average PM-10 concentrations are of primary concern. The NAAQS for 24-hour averaged PM-10 concentration is 150 $\mu g/m^3$, not to be exceeded on more than 3 days in a 3-year period. The fourth-highest background value measured near GSMNP during any 3-year period from 1991–1995 was 53 $\mu g/m^3$; therefore, up to 97 $\mu g/m^3$ could be added without exceeding the limits for attainment. The standard for an annual average PM-10 concentration is 50 $\mu g/m^3$, and the highest annual average background value measured near GSMNP during 1991–1995 was 31 $\mu g/m^3$. Those background values were included with the modeled increments due to construction to arrive at the cumulative PM-10 concentrations considered in the discussion that follows.

The area of most intense construction was assumed to be the site about 1 km (0.6 mile) east of Pittman Center where cut and fill operations would take place if the tunnel option were not pursued. This area of 2.1 ha (5.2 acres) was taken to represent hypothetically the largest area over which intensive construction activities would take place for an extended period of time. The emission factor for TSP was assumed to be 0.3672 $g/m^2/hr$ (1.2 tons per acre per month), corresponding to heavy construction according to EPA (1985). This emission rate was scaled to an hourly rate based on 167 hours worked per month (2000 hours per year). The fraction of TSP consisting of PM-10 was assumed to be 30% (EPA 1988a). The simplifying assumption of flat terrain, while unrealistic, applies best to receptors at the same elevation from which the emissions originate and provides more conservative (upper bound) concentration estimates at other elevations. Emissions of fugitive dust and vehicle exhaust were all assumed to originate at ground level.

The EPA-recommended Industrial Source Complex Short-Term (ISCST3) air dispersion model (EPA 1995) was used to calculate PM-10 concentrations resulting from construction activities under worst-case daylight meteorological conditions [low dispersion (Stability Class D), wind speed equal to 1 m/sec (2.2 mph)]. The use of pessimistic meteorological scenarios was necessary throughout this report because of the lack of actual meteorological data to represent the variety of atmospheric conditions that can occur along the proposed roadway. Maximum hourly concentrations obtained from the modeling were multiplied by 0.7 to obtain 8-hour averages (for construction hours) according to EPA (1988b), and the results were divided by 3 to obtain 24-hour averages for comparison with NAAQS (i.e., emissions from construction were assumed to be confined to an 8-hour construction period). Although an 8-hour-per-day construction period was assumed for this analysis, longer construction periods during summer hours are possible and will be addressed in Sect. 5.5. For annual averages, the maximum daily concentrations obtained were multiplied by 0.25 to allow for varying meteorological conditions, and the results were multiplied by 5/7 to account for the fraction of days in a typical work week during which construction would occur.

Results indicated that with no dust suppression measures employed, the 24-hour PM-10 standard could be exceeded at distances up to and exceeding 500 m (0.3 mile) from the edge of the construction site, but would not be exceeded or closely approached at distances of 1000 m (0.6 mile) or greater. Estimated exceedances of the annual-average PM-10 standards were confined to shorter distances from the construction site. Sprinkling with water twice per day could reduce fugitive dust by 50% (EPA 1985). When such emissions reductions were incorporated into the model input, predicted exceedances of PM-10 standards were all within 300 m (0.2 mile) of the edge of the construction site, and all exceedances between 150 m (0.1 mile) and 300 m (0.2 mile) were along or close to a straight-line extension of the long axis of the disturbed area.

The modeling and conclusions apply to intensive construction operations in a single area where most of the material removed from one location can be dumped at another location in the immediate vicinity. In some cases, material might have to be hauled several hundred meters from one location to another. In such cases, most fugitive dust would arise from the disturbed surface over which material is hauled. Emissions factors for a variety of transportation scenarios, taken from EPA (1985), were used as input for the modeling procedure described above. If 80 Mg/hour (88 tons/hour) were hauled over 1 km (0.6 mile) of loose dirt, exceedances of PM-10 standards could occur as far as 3 km (1.9 miles) from the downwind edge of the haul route. Transport over a gravel road would reduce the amount of very fine particulate matter that would be suspended. Up to 200 Mg/hour (220 tons/hour) could be hauled over 1 km (0.6 mile) of a gravel surface without exceeding PM-10 standards at distances greater than 1 km (0.6 mile) from the downwind edge of the haul route, and, except under very extenuating circumstances (e.g., work continuing into the early evening hours under worst-case weather conditions) at distances beyond 500 m (0.3 mile) from the edge of the haul route. Mitigation, which could include sprinkling with water, for their type of road would likely depend on the rate at which material would be hauled and the downwind distance at which an exceedance of the 24-hour PM-10 standard would be acceptable.

One proposed option is to have no interchange with SR 416, but instead to construct an interchange with U.S. 321. Because detailed plans for such an interchange have not been developed, it is not yet possible to make detailed comparison. However, in terms of temporary noise and other minor disturbances resulting from personnel and equipment being moved around nearby locations, effects of this proposed option on the community around Pittman Center may be less than the effects of the proposed action.

If burning of removed woody plants were permitted along the parkway route during construction, air quality near the fires would be degraded temporarily by particles of incomplete combustion (smoke). Also, the risk of widespread fire would be increased. The amount of degradation of air quality and visibility would depend on the amount of material burned, rate and efficiency of combustion, weather factors, and other variables (e.g., one large fire or several smaller fires) that are not readily quantified. Permits issued for open burning typically specify weather conditions for which burning is allowed, so as to minimize environmental degradation as well as the risk that a fire would get out of control. Mitigation of effects of controlled burning is discussed in Sect. 5.5.

4.5.2 Effects of Road Construction on Visibility

Six integral vista observation points (cf. 40 CFR 51:304) have been designated by the NPS within GSMNP. These are high-elevation sites from which distant scenic features can be viewed over a wide range of directions. The designated vista observation points, and their distances and directions from Webb Mountain, are listed in Table 26 of Wade et al. (1995).

The nearest integral vista observation site to proposed Section 8B is the Mt. Cammerer Tower, located about 5 km (3 miles) southeast of the Cosby interchange. Construction impacts on visibility for a viewer on Mt. Cammerer would be temporary and infrequent. Effects of emissions from road construction activities were analyzed using the EPA VISCREEN visibility model (EPA 1988c). This model requires that emissions input be from a point source, although fugitive dust originates from an area source. Therefore, all the fugitive dust from the construction area was conservatively assumed to originate from a point source, which provides an upper-bound value for modeled visual impacts.

Because construction activity would be limited to daylight hours, neutral (Class D) stability with a wind speed of 1 m/s (2.2 mph) was assumed as the worst-case meteorological scenario. The emissions factors for TSP and PM-10 were the same as given in the preceding section.

Mt. Cammerer is more than 500 m (1641 ft) above the highest point on the proposed route, including Webb Mountain. Because of the rough terrain and the necessity of elevating contaminants more than 500 m (1641 ft) before they would interfere with an observer's horizontal line of vision, the atmospheric stability category was decreased by one [i.e, moved from the assumed worst-case stability category to the next-less-stable category (category C in this case)], for use in the VISCREEN model, according to EPA (1988c).

Visibility is affected by suspended particles of all sizes, but it is primarily affected by smaller particles. Therefore, PM-10 emissions were used as input to the VISCREEN model, according to EPA (1988c). All PM-10 was assumed to remain airborne (no settling out).

Additional parameters necessary to run VISCREEN were specified as follows. Distances from the source to an observer at the integral vista site varied from 5 to 15 km (3 to 9 miles). [Mt. Cammerer is about 13 km (8 miles) east of Webb Mountain.] Distances from the source to the nearest park boundary ranged from 100 m to 4 km (325 ft to 2.5 miles). Visual ranges from 25 km (16 miles) (typical summer day) to 75 km (47 miles) (typically spring day) were used; these values are consistent with visibility studies within GSMNP discussed in Sect. 3.5.3.1 of Wade et al. (1995). Because the median hourly-average background value for ozone near GSMNP is higher than the default value of 0.04 parts per million by volume (ppm), the model was also run with a more appropriate value of 0.07 ppm and with a value of 0.12 ppm, which is the NAAQS for hourly-average ozone concentrations. Results were essentially the same for all ozone concentration values, and the conclusions presented below are consistent with any or all of them.

Results of the modeling depended primarily on three factors: (1) background visibility, which varies from season to season, (2) intensity and type of construction activity, and (3) distance of construction activity from the integral vista site. Visibility impairment is more easily detected when the background visibility is higher and is more difficult to detect when the background visibility is already low. The intensity of construction activity is related to the amount of suspended particulate matter than may impair visibility, and distance of the observer from the construction activity is related to the amount of particle dispersion before a dust plume comes into view.

Even the intensive earth-moving activities that would be necessary if the tunnel option were not implemented would not be likely to cause noticeable visibility impairment during summer, when the median existing visibility is lowest. In addition to the lower existing visibilities in summer, the area where intensive earth-moving activities would be necessary if the tunnel were not constructed [about 1 km (0.6 mile) east of Pittman Center] is relatively distant, about 15 km (9 miles) west of Mt. Cammerer. Also, most of the excavated material would not have to be moved far enough to suspend the large amounts of dust associated with trucks moving several hundred meters over unpaved surfaces. However, if the same activity occurred in spring, when existing visibility is more likely to be over 75 km (47 miles), visibility of distant terrain features from the integral vista site could be noticeably impaired. The same general conclusions hold for activity around Webb Mountain. Some material might be hauled by rock at either location, but the trip distance and/or the number of trips per hour might have to be limited to avoid visibility impacts, with the limits at each site being dependent on background visibility (i.e., likely to be least stringent during summer). In portions of the proposed Section 8B nearest to Mt. Cammerer, heavy activity could noticeably impair visibility of terrain features from the integral vista site, even during periods of low background visibility.

Because of the conservative assumptions inherent in the VISCREEN model, these results represent an upper bound of expected visual impacts. However, the results do suggest that a temporary impairment of visibility could occur if intensive construction occurred during worst-case meteorology (including worst possible wind direction) and/or when background visibility was high. In such cases, the plume arising from construction-related dust would probably be visible, and sometimes annoying, to many observers. The duration of each particular visibility impairment would depend on the duration of construction activities and the duration of the weather conditions involved.

Competing environmental considerations, involving visibility and ozone effects, may arise in the course of construction of the proposed parkway. If the most intensive construction operations were confined to the summer months, for example, effects on visibility would be minimized. However, summer is the time of highest hourly ozone concentrations and is therefore by far the most likely season for construction activities to contribute to an exceedance of the NAAQS for ozone. Also, even if the probability of a visibility impairment is lower in summer, the effect of a single impairment is likely to be greater then because of the large number of people who visit the park in summer.

4.5.3 Effects of Road Use on Air Quality

Atmospheric pollutants that would be emitted as a result of opening the proposed Section 8B include CO, NO_2, VOCs, and fine particulate matter (PM-10) which would originate primarily as road dust. There are NAAQS for CO, NO_2, and PM-10. The VOCs would combine with NO_2 and NO, in the presence of sunlight to form ozone, another pollutant regulated by NAAQS. The remaining pollutants regulated by NAAQS are SO_2, and lead. Automobiles and other vehicles likely to use the parkway are not major sources of SO_2 in the atmosphere (EPA 1996), and the local area is well within attainment of the NAAQS for SO_2. Use of unleaded gasoline has led to a decline in Pb emissions from on-road vehicles, to less than 1% of their 1970 values (EPA 1996), and measured Pb concentrations during the last 5 years have not exceeded 7% of the NAAQS. Therefore, the remainder of this section will address potential increases in concentrations of CO, O_3, NO_2 and PM-10.

The time and space scales of air quality analysis depend on the pollutant considered. Time scales appropriate to each pollutant are evident in the averaging period(s) for which standards exist. Some discussion of the appropriate space scale for monitoring each pollutant regulated by NAAQS appears in 40 CFR 58, Appendix D, and the space scales used in this report are consistent with that discussion. The NAAQS for CO are hourly and 8-hour averages, and maximum values usually occur at roadway intersections. Therefore, members of the general public most likely to experience exceedances of NAAQS for CO would be spending from 1 to 8 hours in close proximity to a roadway intersection, and the appropriate space scale for air-quality analysis is only a few meters. Although the only NAAQS for O_3 is an hourly average, the space scale for air-quality analysis is several kilometers because the VOCS and oxides of nitrogen involved (NO and NO_2, collectively known as NO_x) travel far from their source(s) during the time required (typically a few hours) to complete the O_3-forming reactions. The only NAAQS for NO_2 is an annual average. Because it takes some time, and distance, for directly emitted NO to oxidize to NO_2, and because members of the general public are not expected to spend an entire year at a single location within 100 m (330 ft) of an NO_2 source, the appropriate space scale is at least 100 m (330 ft) from the source. The NAAQS for PM-10 consist of 24-hour and annual averages, and recommended monitoring is "near inhabited buildings or locations where the general public can be expected to be exposed to the concentration measured" (40 CFR 58, Appendix D). This could conceivably be as close as 20 m (66 ft) from the road where the parkway would intersect another route, but it was taken as 100 m (330 ft) from the nearest edge of the proposed Section 8B at distances of more than 100 m (330 ft) from any likely intersection.

Potential effects of road use on air quality are evaluated by calculating the expected maximum ground-level concentrations of pollutants that would result from opening Section 8B to traffic, including effects of existing background concentrations and reasonably foreseeable future actions, and comparing results with the corresponding NAAQS (summarized in Table 58). If the highest estimated total concentration does not exceed the NAAQS for the corresponding averaging period, it is concluded that the standard would be attained if the proposed action were implemented. Because pollutant emissions from the proposed Section 8B would be at ground level, the assumption of flat terrain was invoked in all analyses so as to provide maximum concentration estimates. To be consistent with the traffic projections of the traffic study (Chin 1996), increases in pollutant concentrations were estimated for years 2006 and 2026. The greatest increases were always for year 2026, so results are presented for that year (Table 58). Projected increases 2006 were lower by a factor of about 1.4.

4.5.3.1 Carbon Monoxide

The proposed action includes an intersection with SR 416 near Pittman Center. However, the proposed option involving an interchange with existing U.S. 321 would be expected to produce greater increases in pollutant emissions as a result of interference with about 10 times as much traffic (Chin 1996), especially if the intersection is signalized so that cars might be unnecessarily idling. There are no current plans for installing a traffic signal, but it could conceivably be deemed necessary or convenient to install one at some future date. Therefore, consideration of a signalized intersection with U.S. 321 in the following analysis lead to upper-bound estimates for the proposed action or any associated option including the unlikely possibility of the installation of a traffic signal.

Emissions of CO were estimated using the MOBILE5b model with its default mix of different types of vehicles, and using a scenario mix that was deemed more realistic for traffic that would be expected along the proposed Section 8B. The main difference between the default and scenario mixes of vehicle types was that the percentage of trucks was assumed to be lower for the scenario mix, and the percentage of automobiles was correspondingly higher. The default and scenario vehicle mixes were both used as input to the MOBILE5b computer model to estimate average emissions for moving vehicles (in grams per vehicle mile) and for idling vehicles (in grams per vehicle per hour). The scenario mix was estimated to emit about 96% of the CO emitted from the default vehicle mix. Emissions along U.S. 321 were taken from the default vehicle mix of MOBILE5b; emissions along the parkway were taken from the scenario mix, which includes fewer heavy trucks. Also 2% of the automobiles and 20% of the trucks on the parkway were assumed to be pulling trailers, much higher than the percentage of trailer-pulling vehicles on most roads.

Instructions for the MOBILE5b program indicate that emissions may be calculated for the years 1960 through 2020, but not through 2026. However, the model is insensitive to changes in the year of analysis beyond about a decade into the future. For projections that are far from the present, the effects of replacing older-model cars with later models cannot be estimated with the accuracy that results from knowing the starting year(s) of specific pollution-reducing technologies. Results for 2020 were within 2% of results for 2006, results for 2016 were well within 1% of results for 2010, and so on. Therefore, it was considered reasonable to use emissions estimates for 2020 as surrogates for emissions during 2026 in the following analysis.

Peak hourly traffic expected on the proposed Section 8B was taken to be 250 vehicles per hour in 2006 and 350 vehicles per hour in 2026 (Chin 1996). It was assumed that 10% of the parkway

Table 58. Simulated ambient air concentrations of pollutants resulting from traffic on the proposed parkway Section 8B, compared with National Ambient Air Quality Standards (NAAQS)

Pollutant and averaging time	Distance from roadway (meters)	Background concentration[a] ($\mu g/m^3$)	Effect of proposed action[b] ($\mu g/m^3$)	Total estimated concentration ($\mu g/m^3$)	NAAQS ($\mu g/m^3$)
CO at hypothetical intersection					
CO (1-hr)	2	412	12,305	12,717	40,000
CO (8-hr)	2	412	5,060	5,472	10,000
CO (1-hr)	20	412	5,750	6,162	40,000
CO (8-hr)	20	412	1,081	1,493	10,000
Pollutants along the proposed Section 8B					
CO (1-hr)	2[c]	412	5,520[d]	5,932	40,000
CO (8-hr)	2[c]	412	<5,520[d]	<5,932	10,000
O_3 (1-hr)	Regional[e]	227[f]	0.6–0.7[e]	228	235
O_3 (8-hr)	Regional[e]	—	—	—	157[e]
NO_2 (annual)	100[d]	34	7	41	100
PM-10 (24-hr)	100[d]	49[f]	43	92	150
PM-2.5 (24-hr)[g]	—	—	—	—	65[g]
PM-10 (annual)	100[d]	25	11	36	50
PM-2.5 (annual)[g]	—	—	—	—	15[g]

[a]Estimated regional background for CO, as per Poulida et al. 1991; nearest measured values are given for O_3, NO_2, and PM-10.

[b]Includes CO from vehicles that would be present under no-action. For O_3, NO_2, and PM-10, only the increases from the proposed action are given in this column.

[c]Results for distances beyond 2 m would be less than those given and therefore well within the NAAQS.

[d]Along a straight line extension of a straight stretch of road that extends at least 250 m (820 ft).

[e]Estimates of regional 1-hr average values were obtained by different indirect methods. The first value (0.6 $\mu g/m^3$) was obtained from regional considerations (i.e., the distance from the source of the NO_x and VOCs that produce the O_3 is not specified). The second value (0.7 $\mu g/m^3$) applies to a location 20 km (12.4 miles) from the nearest edge of the pavement. Beginning in year 2000, a standard applicable to 8-hr averages will begin to phase out the current 1-hr standard. Measurements of 8-hr averages are not yet available for analysis of cumulative effects.

[f]For hourly O_3 and 24-hr average PM-10, the fourth highest value for any day within any continuous 3-year period (during 1992–1996), as per 40 CFR 50.

[g]Standards for PM-2.5 have recently become part of the National Ambient Air Quality Standards (*Fed. Reg.* 62:138, page 38652); it will be at least 3 years before sufficient measurements become available for conclusive analyses of that size class of particulate matter. Some tentative analysis of PM-2.5 concentrations is provided in the text.

traffic would enter or leave the parkway at an intersection with U.S. 321, which would carry a peak hourly maximum of 2000 vehicles (1000 vehicles each way). This is consistent with the projected amount of traffic in (Chin 1996), although the assumed number of vehicles on U.S. 321 north of the intersection is somewhat greater than the projected amount. Maximum CO concentrations estimated to result from the hypothetical intersection were calculated for a person spending 1 hour changing a tire 2 m (6.6 ft) from the edge of the pavement and for a worker operating a car wash (or performing other outdoor tasks) at a convenience store located 20–25 m (66–82 ft) from each of two intersecting roads. These time periods correspond to the two NAAQS for CO, and the locations are consistent with monitoring recommendations for CO given in 40 CFR 58, Appendix D.

Convenience stores may be open 24 hours per day, and flat tires may occur at any hour. Weather conditions for this analysis were assumed to be worst-case from the standpoint of atmospheric dispersion [wind speed of 1 m/s with neutral (Class D) stability during the day and very stable (Class F) conditions at night]. Peak hourly daytime traffic volume was assumed to occur during the entire day and during 1 hour of nighttime meteorological conditions when an individual might be changing a tire. The highest 8-hour average traffic volume along U.S. 321 during nighttime meteorological conditions was assumed to occur from 5:00 P.M. until 1:00 A.M., with peak hourly traffic during the first hour followed by 7 hours during which the ratios of traffic volume to peak hourly traffic volume were consistent with data from 6:00 P.M. until 1:00 A.M. on July 3, 1994 (a period for which traffic counts are available for each 15-minute interval along U.S. 321). These assumptions are extremely conservative, but not unrealistic. Many people visit GSMNP in late October when the trees are most colorful and when nighttime meteorological conditions may occur between 5:00 and 6:00 P.M. The high traffic volume for the hours immediately after 6:00 P.M., associated with the longer daylight hours in July, might be equalled on a particular day in October if a special late-fall evening event should attract an appreciable number of people. Because the hour from 5:00 to 6:00 is a time when many people are driving home from work, it is not unreasonable to assume that peak hourly traffic would occur then. The hours of 5:00 P.M. to 1:00 A.M. provide the maximum 8-hour nighttime traffic volume because other 8-hour night-time periods correspond more closely to traditional sleeping hours (ca. 10:00 P.M. to 6:00 A.M.).

Because the purpose of the proposed parkway is to provide scenic views of GSMNP (Sect. 1.3.1), and it would not give motorists any travel-time advantage (Sect. 4.7.2.4), nighttime traffic is expected to be only a small fraction of the traffic during daylight hours. However, traffic around sunset might approach the peak hourly daytime amount; therefore, 1 hour of peak hourly traffic was assumed to occur under nighttime weather conditions (when an individual might be changing a tire). Also, half the peak hourly amount of traffic was assumed to occur during the sunrise hour (i.e., during nighttime meteorological conditions), when departing visitors might wish to view the sunrise from the parkway before continuing their trips. These combined assumptions support estimates of average nighttime parkway traffic, for periods of 8 hours or longer, of less than 25% of the peak hourly daytime value. Therefore, the fractional value used in the remainder of this report was conservatively taken as 25%. Day and night situations were modeled, and the one associated with the highest concentration increase was used in each case.

The CAL3QHC computer model (EPA 1995a), a model specifically designed to estimate CO concentrations near roadways and intersections, was used in conjunction with the input discussed previously to estimate CO concentrations near the hypothetical intersection of the proposed

Section 8B and U.S. 321. The model input included existing traffic on U.S. 321 and reasonably foreseeable future increases as projected by the traffic study (Chin 1996).

Regional background values of CO, not related to local traffic, have not been measured in or near GSMNP. However, estimates for Shenandoah National Park have been published (Poulida et al. 1991). Hourly values averaged about 235 $\mu g/m^3$ (0.2 ppm) with a standard deviation of 59 $\mu g/m^3$ (0.05 ppm) over the course of a year (October 1988 to October 1989). A natural background of 235 $\mu g/m^3$, plus 3 standard deviations (412 $\mu g/m^3$), was included in the estimates of total concentrations for comparison with NAAQS. Results are presented in Table 58, and are discussed.

The greatest expected 1-hour average CO concentration at the hypothetical intersection would be 12,717 $\mu g/m^3$, which is about 32% of the corresponding NAAQS. This would apply to an individual changing a tire 2 m (6.6 ft) from the edge of the roadway during a nighttime hour when traffic is equal to the peak hourly traffic (most likely to be the hour when sunset occurs). The highest 8-hour average concentration at the same location, estimated to occur during peak-traffic daytime hours, was 5,472 $\mu g/m^3$, or about 55% of the corresponding NAAQS. It is unlikely that a member of the general public would spend 8 hours within 2 m of the edge of the pavement, even during the daytime hours.

Workers 20 m from the edge of the pavement would be expected to experience maximum 1-hour and 8-hour CO concentrations of 3517 $\mu g/m^3$ and 1493 $\mu g/m^3$, respectively. These values are less than 15% of their corresponding NAAQS (Table 58).

The projected CO concentrations are likely to be higher than values that might be monitored at similar distances from the hypothetical intersection. The conservatism of the assumptions and rounding-up procedures for input, as well as some aspects of modeling, are unlikely to be replicated in reality. For example, the number of locations at which concentrations can be modeled is large compared with the number of monitors that can be routinely maintained at an intersection. Therefore, the location at which the highest concentration occurs is more likely to be near a modeled "monitor" than a real one. Also, locations of instruments are often constrained by considerations such as physical objects (e.g., buildings), logical pedestrian routes near crosswalks, and an ironic tendency of some people to tamper with instruments designed to protect their own health and welfare.

Most of the parkway route would not be near an intersection but would be in areas conducive to the scenic views of GSMNP for which the parkway was designed (Sect. 1.3.1). Such locations would be far from pollutant emissions from vehicles on intersecting routes, and from increased pollution associated with vehicle interference at intersections. Convenience stores or other inhabited buildings, or other locations where a member of the general public would be likely to spend more than 1 hour, are not expected within 100 m (330 ft) of these portions of the parkway route. The maximum hourly average increase in CO concentration expected to be experienced by any member of the general public [changing a tire 2 m (6.6 ft) from the edge of the parkway during the first hour after sunset] is 5,932 $\mu g/m^3$, which is less than 15% of the corresponding NAAQS. The location of this concentration would be close to the end of a perfectly straight stretch of roadway extending at least 250 m before turning, when the wind direction exactly parallels that straight stretch of roadway. A volume of air moving along a straight stretch of road can accumulate high pollutant concentrations before the road turns and the air continues in the direction of the wind.

Because a member of the general public would not be expected to remain 2 m (6.6 ft) from the edge of the pavement for more than 1 hour, the maximum 8-hour average was not modeled in this case. The maximum hourly concentration given is an upper-bound value for the 8-hour average, and it is less than 60% of the NAAQS for an 8-hour average CO concentration. Because projected CO concentrations at distances much greater than 2 m from the edge of the pavement would be less than the values given, no exceedances of the NAAQS for CO are expected to result from the proposed action or any of the associated options.

The proposed action includes the option of an unventilated tunnel about 200 m (656 ft) long located about 1 km (0.62 mile) east of Pittman Center. CO concentrations inside such a tunnel are likely to be greater than those outside the tunnel, but vehicle passengers would not be likely to spend more than about 20 sec in the tunnel, and such a limited exposure would not contribute appreciably to an hourly or 8-hour average.

An accident in a tunnel could block traffic. To analyze this possible event, we may begin with the following highly conservative set of assumptions: (1) one vehicle per 5 m (16 ft) is stopped for the length of the tunnel, for a total of 40 vehicles (i.e. traffic would be blocked in both directions, but westbound traffic on the west side of the accident, and eastbound traffic on the east side of the accident, would not be blocked); (2) each blocked vehicle is idling for 1 hour (all engines are running constantly; all vehicles are completely stopped); (3) the average vehicle emits 620 g of CO per hour, as per results from the MOBILE5b model; (4) the resulting 24,800 (40 × 620) g of CO is evenly distributed in the tunnel with no further oxidation; and (5) the ventilation rate is low [air is moving through the tunnel very slowly (0.5 m/s)].

If 24,800 g of CO per hour is distributed over a volume of 5,000 m^3 (177,000 ft^3) [assuming the tunnel cross section is a semi-circle with a radius of 4 m (13 ft), and the tunnel is completely flushed 9 times per hour (3,600 s/hr × 0.5 m/s × 1/200 m)], the resulting CO concentration is 0.56 g/m^3 (including the relatively small background concentration of less than 0.01 g/m^3). The National Institute for Occupational Safety and Health (1994, 54) gives 1.38 g/m^3 (1200 ppm) as the threshold value of CO that is immediately dangerous to life and health. Therefore, it is not likely that the existence of the tunnel could lead to any life- or health-threatening situations, although unhealthy conditions could conceivably occur in cases of traffic backups that might result from an accident. As a mitigation measure, signs alerting motorists to turn off their engines in case of a stoppage of traffic in the tunnel for more than a few minutes should be sufficient to prevent buildup of CO to unhealthy levels.

4.5.3.2 Ozone (O_3)

Contributions to the production of O_3, a secondary pollutant formed from complex photochemical reactions involving NO_x and VOCs, cannot be accurately quantified. An alternative strategy is to estimate the amount of NO_x in GSMNP that would result from the proposed action and compare it with an estimate of the amount of NO_x currently in GSMNP. The use of NO_x as a substitute for O_3 is based on work including that of Chameides et al. (1992) which indicates that NO_x correlates well with O_3, at least in non-urban areas where NO_x concentrations are relatively low and are therefore likely to be the limiting (controlling) factor in O_3 formation.

Because NO_x emissions from sources at several different locations are well mixed by the time O_3-forming reactions are completed, total NO_x emissions from a representative area [taken as the State of Tennessee, for which data have been summarized and published (EPA 1996)] were assumed to be homogeneously distributed in the atmosphere by the time they arrived at GSMNP. The total emissions burden of NO_x affecting GSMNP would then be the ratio of the area of GSMNP to the area of Tennessee (about 1/50), multiplied by the total emissions in Tennessee. Total emissions of NO_x in Tennessee during 1995 averaged 1,710 Mg/day (1,885 short tons per day) (EPA 1996). The calculated emissions burden affecting the Park alone would therefore be somewhat over 1.4 Mg/hour (1.55 short tons per hour). Calculated emissions of NO_x (from the MOBILE5b computer model), based on projected peak hourly traffic along the proposed Section 8B in year 2026 (350 vehicles/hour), were 0.008 Mg/hour (0.009 short ton per hour). The estimated increase in NO_x emissions due to the proposed action, expressed as a percentage of the estimated 1995 emissions burden for GSMNP, would therefore be 0.008/1.4 = 0.6%.

This fraction is based on *peak hourly* values for the numerator (projected NO_x from parkway traffic) and the *1995 average hourly* value for the denominator (background NO_x emissions). Air arriving at the parkway any time of day will have been subject to a daily cycle of NO_x emissions over its path during the last 24 hours; maximum hourly NO_2 emissions from the parkway would be expected to have the greatest effect on hourly ozone averages. These figures represent the maximum hourly percentage increase in NO_x concentrations estimated to result from the proposed action.

However, the assumption of a uniform spatial distribution of NO_x in Tennessee may lead to underestimates of background values near GSMNP because of the close proximity of Knoxville and Chattanooga—two of the four largest cities in Tennessee. Underestimates of the denominator produce overestimates (pessimistic estimates) of the fractional increase in O_3 concentration.

Probably the most pessimistic assumption inherent in the calculation is that none of the parkway traffic would be anywhere else in the region if the parkway were not completed. Results of the traffic study (Chin 1996) indicate that about half of the vehicles projected to use the proposed Section 8B of the parkway would be using U.S. 321 if Section 8B were not built. (Vehicles that would use the parkway instead of U.S. 321 would also be likely to move more slowly, which would reduce their NO_x emissions somewhat.) Accounting for vehicles that would be in the area even if Section 8B were not constructed, the percentage increase in NO_x would be reduced from 0.6% to about 0.3% of background. If a typical daily maximum O_3 concentration (during the summer) is taken as around 200 $\mu g/m^3$ (Wade et al. 1995), the corresponding percentage increase in regional O_3 concentration would translate to about 0.6 $\mu g/m^3$.

Another approach to estimating O_3 increases due to the proposed action is based on NO_x concentration estimates that were obtained from the ISCST3 air-dispersion model (EPA 1995b) applied to NO_x emissions from a series of volume sources representing a hypothetical stretch of road. This stretch can be thought of as a perfectly straight line running east to west for 200 m (656 ft) before turning left to run due southwest for 50 m (164 ft) before turning to run due west for another 250 m. This represents a relatively straight stretch of road, over which pollutants may accumulate for a long time if the wind direction is parallel to the roadway (due east or due west in this example). In the following analyses, the wind was assumed to be blowing from east to west, and NO_x concentrations were estimated at locations along and near a straight-line extension of the center line of the westernmost 250 m (820 ft) of road. Emissions from each volume source were obtained from MOBILE5b (1.6 grams of NO_x per vehicle mile, scaled to the length represented by the source) multiplied by the projected peak hourly traffic on the proposed Section 8B in year 2026.

Because the O_3-forming reactions require sunlight, weather conditions were assumed to be the daytime conditions that are least favorable for atmospheric dispersion of pollutants [neutral (Class D) stability, and low wind speed (1 m/s, or 2.2 mph)]. Because the chemical reactions require time to complete, it was assumed that the maximum O_3 generated would appear about 4 km (2.5 miles) from the source, as per 40 CFR 58, Appendix D, Section 2.5. For a wind speed of 1 m/s (2.2 miles per hour), this would allow slightly more than an hour of time for the complete set of O_3-forming photochemical reactions to occur. Atmospheric concentrations of VOCs were assumed to be sufficient to generate the maximum amount of additional O_3 for a given increase in NO_x, as per Graedel and Crutzen (1993). This means that approximately 2 molecules of O_3 form for each molecule of NO_x added. Results indicated that the maximum hourly increase in O_3 concentration at a location 4 km (2.5 miles) due west of the west end of the hypothetical road section described would be about 2 $\mu g/m^3$, or about 1% of the background peak hourly O_3 concentration (taken here as about 200 $\mu g/m^3$ for the average daily maximum during June, July, and August). At 10 km (6.2 miles), the estimated maximum increase would be about 0.7 $\mu g/m^3$, or about 0.35% of background. It should be noted that the hypothetical section of road used in the modeling resembles the proposed parkway route where it approaches the nearest point to the park boundary, and the orientation of the proposed roadway there is such that the highest estimated O_3 concentration would be inside GSMNP.

Pollutant plumes arising from various sections of the proposed parkway would eventually overlap, so that pollutant concentrations from one plume would tend to contribute to concentrations in others. The effect is a reduction in the rate of concentration decrease within any particular plume as it moves away from its source. The result is that the methodology used in the preceding paragraph (considering only a portion of the proposed Section 8B) will tend to underestimate O_3 concentration increases due to the proposed parkway at distances as far as 10 km (6.2 miles) from the source. However, at such distances, plumes from U.S. 321 would also overlap plumes from proposed the Section 8B, so that failure to account for the decrease in O_3 concentrations associated with a projected decrease in U.S. 321 traffic if the proposed action should be implemented (Chin 1996) would tend to overestimate the associated regional increase in O_3 concentration. These opposing influences were crudely simulated by modeling NO_x increases due to the net increase in peak hourly traffic volume (175 vehicles per hour in year 2026) along the approximately parallel routes of U.S. 321 and the entire length of proposed Section 8B. Such modeling, simulating the combined emissions increases as a series of large volume sources, indicated that O_3 concentration increases due to parkway operation would be about 0.7 $\mu g/m^3$ at a distance of 20 km (12.4 miles) from the nearest end of the parkway route. This is about the same as the gross estimate (0.6 $\mu g/m^3$), obtained from regional NO_x emissions, given at the beginning of this section.

Results of the O_3-concentration analysis apply to peak traffic conditions during a time of day that is favorable for O_3 production. This combination of conditions is likely because sunny conditions during the middle of the day would tend to be associated with peak traffic as well as with conditions favorable for O_3 formation. However, the assumption of those conditions occurring simultaneously with worst-case daytime atmospheric (neutral) stability contributes a high bias to the estimates of O_3 increase. Further conservatism was added to the projection at 4 km (2.5 miles) by choosing the wind direction with respect to the roadway orientation so as to produce maximum O_3 concentration estimates, and by calculating concentrations only at points along a straight-line extension of the general parkway route. At similar distances in other directions, the estimated O_3 concentration increases would be considerably less; at greater distances, atmospheric dispersion would cause O_3 concentrations to approach regional values regardless of the wind direction and its effect on O_3 concentration near the source. The modeling did not account for the ruggedness of the terrain and the increased dispersion that it would cause. Background VOC concentrations were assumed to be optimal for ozone formation. Therefore, the estimates are put forth as upper-bound estimates of increases in O_3 concentrations that would occur should Section 8B be constructed.

It is possible that O_3 precursors emitted at night (under stable atmospheric conditions) could be transformed into O_3 during the following day, but this would require more than 2 hours of time during which dispersion would reduce concentrations. Further, the amount of traffic in the pre-sunrise hours would be very small compared with the peak hourly traffic figures (for 11:00 A.M. to noon on weekends) used in the calculations.

No removal of O_3 from the atmosphere was assumed in the preceding calculations. O_3 is a highly reactive substance, a trait related to its harmful effects. Removal of O_3 is associated with plant damage (Evans et al. 1996); as discussed in Sect. 4.4.1.5.

If O_3 concentrations during 1992–1996 are indicative of O_3 concentrations over the next 30 years, then the current NAAQS for O_3 would still be attained if the proposed action were implemented (Table 58). Ozone concentrations have been close to the 1-hour NAAQS in recent years. An exceedance was recorded for GSMNP, although that exceedance was within measurement error. One exceedance of the standard per year, averaged over a 3-year period, is allowed for purposes of determining attainment status (40 CFR 50.9). However, If background values of O_3 increase by even a few percent by 2006 or 2026, then GSMNP could become part of a nonattainment area for O_3. Further, the 1-hour NAAQS for O_3 is currently being phased out and replaced with a lower numerical value applicable to 8-hour averages (62 *Fed. Reg.* 138:38856). This change may affect the attainment status of GSMNP after year 2000, when new standard will begin to be used for determination of attainment status. Because of the regional distribution of sources of O_3 precursors (NO_x and VOCs), mitigation must be largely the responsibility of the community outside the boundaries of GSMNP.

4.5.3.3 Nitrogen Oxides (NO_2)

Because of the time and space scales involved, analysis for NO_2 is much different from the O_3 analysis above. The NAAQS regulate annual average NO_2 concentrations, rather than hourly values, but the space scale for NO_2 is smaller because the time (and corresponding distance from the source) required for NO to oxidize to NO_2 is small compared with that required for NO_x and VOCs to form O_3. Guidance in 40 CFR 58, Appendix D, indicates that NO_2 monitors would likely be placed farther than 100 m (330 ft) from emissions sources; therefore, maximum concentrations were estimated at 100 m (330 ft) from the proposed roadway. At that space scale, no credit was taken for vehicles that would be traveling on U.S. 321 [much farther than 100 m (330 ft) from the proposed Section 8B] if they were not on the proposed Section 8B. Average nighttime traffic volume on the parkway was taken as one-fourth of the peak hourly value, as per Sect. 4.5.1.1. This is conservative because it includes an hour of maximum hourly traffic density during nighttime conditions at sunset, and half the peak traffic density under nighttime conditions during the sunrise hour. [An average of 20 vehicles per hour (1 vehicle per 3 minutes) during the remaining 8 hours of a short summer night leads to an average nighttime traffic of 20% of the peak hourly value.]

Annual average NO_2 concentrations in the immediate vicinity of the proposed Section 8B were estimated by using the NO_x emissions estimates from the MOBILE5b model as input to the ISCST3 air dispersion model. The hypothetical stretch of road used as input for the O_3 analysis in the preceding section was also used for this analysis. The wind speed was assumed to be 1 m/s, in a direction exactly parallel with the part of the road that runs in a perfectly straight line for 250 m, after which the road was assumed to turn. Night and day traffic, under worst-case night and day atmospheric stability classes (Class F and D, respectively) were modeled and the highest resulting hourly concentration was multiplied by 0.1 to obtain an upper-bound estimate of annual average NO_2 concentration. It was assumed that all NO_x emissions are in the form of NO_2 at distances of 100 m (330 ft) or more from the emissions source.

Air dispersion modeling indicated that the highest pollutant concentrations resulting from road traffic are likely to occur along the centerline of a straight stretch of roadway, or along a straight-line extension of that centerline if the road turns, when the wind direction is parallel to the roadway. A volume of air moving along a straight stretch of road can accumulate high pollutant concentrations before the road turns and the air continues in the direction of the wind.

The highest annual average NO_2 concentration estimated to result from the proposed action in year 2026, applicable to a individual residing 100 m (328 ft) from the edge of the parkway along a straight-line extension of the straight stretch of road 250 m (820 ft) long, was 7 $\mu g/m^3$. When added to the highest measured value in the area during the last 5 years (34 $\mu g/m^3$, in Sullivan County) the cumulative concentration is 41 $\mu g/m^3$, which is less than 50% of the corresponding NAAQS.

Appreciable increases in NO_2 concentration would not be expected as a result of constructing an intersection along U.S. 321. Results from MOBILE5b indicate that NO_x emissions from slower-moving vehicles, expected near an intersection, are less than those from faster-moving vehicles, which is the opposite of the case for CO emissions. However, additional NO_x emissions at an intersection would be provided by idling vehicles. Modeling indicated that a slight decrease in NO_x emissions and, by inference, in NO_2 concentrations, would result at locations near the hypothetical intersection with U.S. 321 if such an intersection were constructed.

Therefore, it is not expected that the proposed action would result in exposure of any member of the general public to NO_2 concentrations that would approach NAAQS.

4.5.3.4 Particulate Matter

The primary source of airborne particulate matter from the proposed Section 8B would be road dust. Some road dust is attributable to vehicle carryout from unpaved areas (EPA 1985), suggesting that any parking areas along proposed Section 8B should be paved (this is also a common-sense measure to better accommodate persons with respiratory and ambulatory problems). Other sources of road dust include wear of brake linings and abrasion of tires against the road surface.

Emission factors for non-urban roads (other than freeways) were not presented by EPA (1985), but values for urban areas were given for major streets and highways and for so-called collector streets which are not relevant to analysis of the parkway. Because no emission factors for parkways were available, it was conservatively assumed that the emission factor for the proposed Section 8B would be the same as for a typical major street or highway in an urban area (1.8 g per vehicle kilometer traveled. The emissions factor for freeways is also available, but it is less than the one selected). An extremely conservative exhaust emission factor of 0.25 g/vehicle mile (Davis and McFarlin 1996) was added to the road dust emissions.

The ISCST3 air-dispersion model was used to calculate hourly averages of PM-10 concentration based on the emission factors given, applied to the same hypothetical stretch of road previously used in the analyses of O_3 and NO_2. Other aspects of the analysis were the same as those for the NO_2 analysis given above. Chemical transformations are not a factor in selecting monitoring locations for PM-10; recommended monitoring locations are "near inhabited buildings or locations where the general public can be expected to be exposed to the concentration measured" (40 CFR 58, Appendix D). For 24-hour PM-10 concentrations, this was taken as 100 m from the edge of the roadway.

The highest hourly average increase in PM-10 concentration estimated to result from the proposed action (108 $\mu g/m^3$) was multiplied by 0.1 to obtain an estimate of the corresponding annual average. These estimates apply to an individual spending the entire year at a location 100 m (328 ft) from the edge of the parkway, along a straight line extension of the straight stretch of road 250 m (820 ft) long. The estimated annual average concentration was 11 $\mu g/m^3$. When added to the highest measured background value in the last 5 years (25 $\mu g/m^3$, in Maryville, Tennessee), the result is 36 $\mu g/m^3$, which is well below the NAAQS (50 $\mu g/m^3$).

The corresponding upper-bound estimate of the 24-hour average PM-10 increase that would result from the proposed action is obtained by multiplying the maximum-hourly estimate by 0.4 (EPA 1988a). The result is 43 $\mu g/m^3$, which, when added to highest measured background value in the area during the last 5 years (63 $\mu g/m_3$ from Maryville, Tennessee), gives 106 $\mu g/m^3$, or about 71% of the corresponding NAAQS. Therefore, it was concluded that operating the proposed Section 8B would not result in any member of the general public experiencing exceedances of NAAQS for PM-10.

Annual and 24-hour standards for particulate matter less than 2.5 μm in diameter (PM-2.5) have recently been added to the NAAQS. Estimates of maximum increases in PM-2.5 concentrations that would be expected to result from traffic along the proposed Section 8B can be obtained by applying the same methodology used above for PM-10 to emissions factors for PM-2.5 given by

EPA (1985). The results are estimated maximum increases of 5 μg/m^3 in the annual-average concentration, and 21 μg/m^3 in the 24-hour average. However, the NAAQS for PM-2.5 are based on 3-year averages, and a monitoring network has not yet been established; therefore, it will be at least 3 years before cumulative PM-2.5 impacts can be assessed as completely as those for PM-10.

However, some data from GSMNP are available to provide an indication of what might be expected as more data are obtained. The 3-year average PM-2.5 concentration in GSMNP for March 1992–February 1995 was 11.2 μg/m^3 (Sisler 1996), which is within 4 μg/m^3 of the NAAQS. When added to the estimated increase of 5 μg/m^3, the result is a 1 μg/m^3 exceedance. However, the estimated increases in PM-10 and PM-2.5 given above were based on the assumption that the annual traffic rate would be the same as that on the day of maximum traffic, which is high by a factor of more than two. A more precise estimate for the maximum PM-2.5 increase would be 2 μg/m^3. The additional precision is needed for estimated PM-2.5 increases because current background values are within 4 μg/m^3 of the NAAQS. In contrast, current background values for PM-10 are far enough below NAAQS that the operation of Section 8B would clearly not contribute to an exceedance.

Background concentrations of PM-2.5 near the proposed route of Section 8B would likely be between those in GSMNP, which have been measured, and those in Maryville, which have not been measured but may be estimated. If the percentage of PM-10 that is PM-2.5 is assumed to be the same at Maryville as at GSMNP [68% according to Sisler (1996)], then the estimated PM-2.5 concentration at Maryville is 15.8 μg/m^3, which exceeds the NAAQS. If the appropriate 3-year average background PM-2.5 value for locations near proposed Section 8B is halfway between the measured GSMNP value and the estimated Maryville value, it would be 13.5 μg/m^3.

After adjustment for annual traffic volumes, as explained above, increases in annual-average PM-2.5 concentrations estimated to result from proposed Section 8B would be greater than 1 μg/m^3 at only a few strategically selected locations, which actually occur within only about 2% of the total area within 200 m (660 ft) of the proposed route. Increases in most areas, even in most areas within 100 m (330 ft) of the parkway, would be less than 1 μg/m^3. Therefore it is not expected that the proposed action would cause any member of the general public to experience an exceedance of the NAAQS for annual-average PM-2.5 concentration. However, a more thorough analysis of PM-2.5 concentrations will not be possible until 3 or more years of data become available from monitoring stations outside GSMNP (e.g., Asheville and Maryville).

Attainment of the 24-hour standard for PM-2.5 is based on a 3-year average of each year's 98th percentile value. Background values of PM-2.5 at Asheville and Maryville were estimated as 70% of the corresponding PM-10 value—i.e. 70% of the PM-10 was assumed to be PM-2.5. This percentage is consistent with Sisler (1996). The resulting estimated background 24-hour PM-2.5 concentration at Maryville (and also at Asheville) was 34 μg/m^3. When added to the maximum increase in 24-hour PM-2.5 concentration estimated to result from the proposed action (21 μg/m^3), the result is 55 μg/m^3, which is much less than the NAAQS (65 μg/m^3). The percentage of PM-10 that is PM-2.5 at Maryville (or Asheville) would have to be as high as 90% for an exceedance of the 24-hour NAAQS for PM-2.5 to be predicted at Maryville or Asheville using the above methodology.

The predicted maximum concentration increases would apply to only a few locations, during a coincidence of maximum traffic on a day when meteorological conditions are least favorable for atmospheric dispersion. Further, background values of PM-2.5 concentration near the proposed route of Section 8B are likely to be less than those at Maryville or Asheville. Therefore, no exceedances of the NAAQS for PM-2.5 would be expected to result from the proposed action.

Traffic interference associated with a hypothetical signalized intersection along U.S. 321 could lead to increases in particulate-matter emissions near the intersection. Most traffic-related particulate-matter emissions are road dust, and the amount emitted is determined by input of dust to the roadway. Unlike the situation along the proposed parkway route, no appreciable increase in traffic volume would be expected to result along U.S. 321 near the intersection. Emissions from idling and accelerating vehicles would provide small additional inputs of particulate matter. Increases in road dust due to a traffic signal would include increased wear on brake linings in deceleration zones and on tires and pavement in acceleration zones. A reasonably foreseeable future action, independent of the proposed action, would be a general increase of traffic along U.S. 321. A reasonably foreseeable future action, partly related to the proposed action, might be the appearance of convenience stores at the intersection, particularly if the intersection is signalized. These actions would generate additional fugitive dust, but it is not possible to accurately specify or quantify the resulting emissions increases.

In hypothetical cases where quantitative input terms can be specified for modeling, highest calculated roadway-related concentrations occur at locations along a straight-line extension of a long straight stretch of road. For the particular intersection being considered, either the roadway would curve slightly, or straight-line extensions of any long straight portions would be on some part of the roadway itself (at least within 100 m of the intersection). A volume (e.g., a cubic meter) of air arriving at a convenience store along the side of the road would likely have crossed the road at an angle, which, for angles involving locations as close as 20 m to the roadway, typically reduces the amount of time the air accumulates dust directly from the road by a factor 10 or more.

Measurements of PM-10 at signalized intersections in non-urban areas indicate that PM-10 concentrations are typically well within NAAQS. Therefore, the proposed option involving an intersection of the proposed Section 8B with U.S. 321 is not likely to result in exposure of any member of the general public to an exceedance of NAAQS for PM-10. Because this option is the limiting case (i.e., the case most likely to result in an exceedance), it is not expected that any member of the general public would experience an exceedance of the NAAQS for PM-10 as a result of the proposed action or any of the associated options. Measurements of PM-2.5 near intersections are not yet available for assessment of that particle size class.

In summary, the proposed action would not be expected to cause any member of the general public to experience an exceedance of NAAQS for PM-10, or an exceedance of the 24-hour NAAQS for PM-2.5. Available information is not sufficient to conclude that existing background concentrations of annual-average PM-2.5 near the proposed route of Section 8B do not approximately equal, or exceed, the corresponding standard. Future measurements should provide additional insight as to whether exceedances of NAAQS for annual-average PM-2.5 concentrations would occur with or without the proposed action.

4.5.3.5 Prevention of Significant Deterioration

In addition to NAAQS, there are standards for the prevention of significant deterioration (PSD) of air quality (40 CFR 51:166). These are summarized by Wade et al. (1995) and, to a lesser extent, in the following material. The PSD standards are specified as allowable increments in concentrations of SO_2, NO_2, and PM-10. One set of increments exists for Class II areas, which cover most of the United States, and a much more stringent set of increments exists for Class I areas, which include GSMNP. The PSD concept generally applies only to stationary sources and not to pollutants arising from vehicle traffic. However, a PSD assessment is presented here to provide an additional measure of potential impacts of the proposed action. The same approach used in the modeling of NO_2 and PM-10 for NAAQS assessments was applied to these PSD assessments. As noted in the introduction to this section, SO_2 (the other pollutant for which PSD standards exist) is not a pollutant of concern for the proposed action. As above, results for year 2026 are presented and discussed. The results are also summarized in Table 59.

Table 59. Simulated maximum possible increases in ambient air concentrations of pollutants resulting from traffic on the proposed parkway Section 8B, compared to allowable Prevention of Significant Deterioration increments for Class II and Class I areas

Pollutant	Averaging time	Distance from roadway (meters)	Projected increase due to proposed action ($\mu g/m^3$)	Allowable PSD increment ($\mu g/m^3$)
		Class II Areas		
NO_2	annual	100[a]	7	25
PM-10	24-hour	100[a]	43[b]	30
	annual	100[a]	11	17
		Class I Areas		
NO_2	annual	270[c]	1.2[d]	2.5
PM-10	24-hour	270[c]	7.3[d]	8
	annual	270[c]	1.8[d]	4

[a]The location is along a straight-line extension of the center line of the 250-m (820-ft)-long part of the hypothetical stretch of road described in the text.

[b]Although the proposed Section 8B would not be subject to PSD analysis, it is possible that concentrations in excess of the Class II PSD standards could occur at very few locations, each within 200 m (660 ft) of the parkway, under extremely rare meteorological conditions as discussed in the text. No standards set to protect human health or welfare would be exceeded.

[c]This applies to a stretch of road approximately perpendicular to the GSMNP boundary, near the location of the shortest distance between proposed Section 8B and any part of GSMNP. Parts of the proposed route that are slightly closer to the park are relatively parallel to the park boundary, and modeling indicated that these sources would produce lower pollutant concentrations at the nearest location within the park.

[d]Upper-bound estimates of maximum concentration increases at the nearest park boundary.

4.5.3.5.1 Class II PSD Areas

It is expected that PSD standards would be exceeded within a few meters of most roads. Such standards are exceeded at very small distances from most pollution sources, and sources that emit relatively small quantities of specific pollutants are exempt from PSD regulations (40 CFR 51:166). Operation of a parkway section in a formerly pristine area would almost surely lead to exceedances within a few meters of the roadway. In most cases, there would be no exceedances of Class II PSD standards beyond about 20 m (66 ft) from the roadway; and even for the extreme case of a straight-line extension of a straight stretch of road, as modeled in the NAAQS analysis, only the 24-hour standard for PM-10 (30 $\mu g/m^3$) would ever be exceeded as far as 100 m (328 ft) from any point on the road. Even if the conservative assumptions involved in the modeling were met in reality, any exceedances of the 24-hour PM-10 standard would be localized [the maximum area included would be about 200 m (660 ft) long and less than 20 m (66 ft) wide], infrequent (the cumulative assumptions rarely, if ever, occur in nature), and of short duration (not likely to last more than a day). Further, only about 1% of the area 200 m (660 ft) on either side of the proposed parkway route resembles the modeled situation; maximum concentrations in other areas would be substantially less. For locations along the side of the parkway, the maximum increase in 24-hour average PM-10 concentration would be expected to be less than 20 $\mu g/m^3$ at distances of 20 m or more from the center of the roadway.

Air quality along U.S. 321 would be expected to improve somewhat as a result of the proposed action. For locations close to U.S. 321, or for locations on the opposite side of U.S. 321 from the proposed Section 8B, it would be appropriate to take credit for the effects of traffic reduction along U.S. 321 in the modeling. However, locations of interest for this Class II PSD analysis are close to the proposed parkway route; therefore, traffic reductions on U.S. 321 were not considered.

It is concluded that any exceedances of PSD standards for Class II areas resulting solely from the proposed action would be confined to a few small areas in the immediate vicinity of the roadway and would not include any populated area. If the parkway were subject to PSD analysis, additional modeling might be required to include certain other sources (defined in 40 CFR 51.166).

4.5.3.5.2 Class I PSD Areas

The GSMNP is a Class I PSD area and, as such, is subject to much more stringent PSD regulations than is the surrounding area. The location where a GSMNP boundary is closest to the proposed route is about halfway between Branam Hollow Road and Rocky Flats Road, where the park boundary is about 250 m (820 ft) south of the proposed route. Because U.S. 321 runs between the proposed route for Section 8B and the park boundary, it is appropriate to include the effect of traffic reduction along U.S. 321 in air-quality analysis. As earlier, the maximum concentrations were projected along a straight-line extension of a long straight stretch of road (a realistic situation at this part of the proposed route). Results given below apply to that location; results for other locations in GSMNP, or for other, more distant Class I PSD areas in the region (e.g., Joyce Kilmer Wilderness Area) would be considerably less.

Maximum annual concentrations of NO_2 and PM-10 at the nearest park boundary, projected to result from the proposed action, are 1.2 and 1.8 $\mu g/m^3$, respectively. These values, obtained by multiplying the maximum hourly concentration from the model output by 0.1, are both slightly less than 50% of their allowable PSD increments for Class I areas (2.5 and 4 μg/m^3, respectively). The maximum increase in 24-hour PM-10 concentration projected to occur at any point along the park boundary as a result of the proposed action, obtained by multiplying the maximum hourly concentrations from the model output by 0.4 as per EPA (1988a), is 7.3 μg/m^3, which is slightly less than the corresponding allowable PSD increment of 8 μg/m^3.

It is concluded that no exceedances of Class I PSD standards would occur in GSMNP solely as a result of the proposed action. The high fractions of allowable Class I PSD increments that were projected at the nearest park boundary are almost entirely due to (1) the short distance from the proposed parkway to the nearest park boundary and (2) the very conservative assumptions involved in the analysis (e.g., maximum traffic would occur at a time when a light wind is moving precisely parallel to the nearest straight stretch of road that would run roughly perpendicular to the nearest park boundary). Therefore, these results are upper-bound estimates of the maximum concentrations that might occur at the nearest boundary of a Class I PSD area. If the parkway were subject to PSD analysis, additional modeling might be required to include certain other sources (defined in 40 CFR 51.166).

4.5.4 Effects of Road Use on Visibility

Six integral vistas have been designated within GSMNP. These vistas are high-elevation sites from which distant scenic features can be viewed over a wide range of directions. Designation of integral vistas is discussed in 40 CFR 51:304. Sections 3.8 and 4.8 of this report provide lists of designated vista observation points in GSMNP, along with their locations with respect to the proposed route of Section 8B.

The EPA VISCREEN model (EPA 1988b) was used to simulate effects of the proposed Section 8B on visibility at the nearest integral vista observation point (Mt. Cammerer), which is about 5 km (3 miles) from the nearest points along the proposed parkway route. Because the VISCREEN model assumes a point source, it was first necessary to determine an equivalent point source that would simulate the contaminant emissions that might affect the visibility of distant objects viewed from Mt. Cammerer. The location of the equivalent point source was taken as the center of the smallest rectangle that could be drawn around the proposed parkway route (see Fig. 1A, 1B, and 52). This point is near the middle of the proposed route, about 10 km (6.2 miles) west of Mt. Cammerer. All emissions along the proposed Section 8B [about 23 km (14 miles) long] during maximum hourly traffic conditions were assumed to originate at the point source. Maximum visibility impairment from such a source-observer configuration would occur via forward scattering when the sun is to the west; actually, the sun would still be 12 degrees south of west on June 21. Background visibilities of up to 97 km (60 miles) were assumed in this analysis to account for values that can occur on a clear day. The VISCREEN model is very sensitive to changes in background visibility; the use of larger distances is more conservative. However, at those larger distances, the plume from U.S. 321 would be well mixed with the plume from the proposed Section 8B, so credit was taken for the reduction in traffic along U.S. 321 projected to result from the proposed action. Because O_3 concentrations in GSMNP are greater than the default value (0.04 ppm) in the VISCREEN model, the O_3 parameter was increased to 0.12 ppm for all simulations. This change made no difference in the results.

Results indicate no exceedances of any VISCREEN default visibility criteria except in a case where the observer would be looking almost directly into the sun. In that case, the background visibility would be much less than that assumed in the model and there would no perceptible visibility impairment due to the proposed action. Therefore, more refined modeling was not required, and it is concluded that the visibility of distant objects viewed from Mt. Cammerer would not be noticeably impaired as a result of operation of the proposed Section 8B. Because all other integral vistas in the GSMNP are located farther from the proposed route than is Mt. Cammerer, it is concluded that the proposed Section 8B would not affect visibility at any integral vista observation site in GSMNP.

4.5.5 Cumulative Impacts

Because most of the parkway route (particularly where the most fugitive dust from construction would be expected) is currently isolated, little change in existing conditions is expected before the proposed construction would begin. In Sect. 4.5.1, current background values of fine PM-10 are added to the estimated increase from the proposed construction to produce a cumulative impact for comparison with the NAAQS; details are discussed in that section. In summary, some temporary exceedances of the NAAQS for PM-10 are expected in the immediate vicinity of the construction sites, but these effects are not likely to expose any sensitive members of the general public (e.g., persons with appreciable respiratory problems) to ambient-air concentrations in excess of the NAAQS. Visibility effects of any particular action will be reduced if existing background visibility (in the absence of that action) is already low; conversely, a dust plume is more likely to be noticeable and annoying on very clear days when the visibility is otherwise high. On very clear days, construction effects could produce a visible plume that may be somewhat annoying. The latter situation is likely during October, when many visitors are in GSMNP to view the fall colors, and clear conditions favoring high background visibility are likely.

Decisions regarding the seasonal allocation of intense construction activities could involve cumulative effects of different pollutants. Background visibility is generally lowest in summer, so that construction activities would be less likely to impair visibility. However, summer is also the season of highest ozone values, and nitrogen oxides emitted from heavy construction equipment, while minor in comparison to other sources in the area, could lead to a very small increase in ozone when (a) ozone is at its maximum level, (b) plant leaves may be particularly sensitive to ozone and (c) large numbers of visitors are likely in the park. While both the ozone and visibility effects referred to are considered minor, the interplay of cumulative effects of different pollutants provides an interesting example of environmental complexities and tradeoffs that can increase the difficulty of decision making.

4.5.6 Summary of Air Quality and Visibility Conclusions

4.5.6.1 Construction

The pollutant of most concern for construction activities is fine particulate matter (particles less than 10 μm in diameter) originating as fugitive dust. According to EPA (1996) about 92% of the fine particulate matter emitted in the United States during 1995 was fugitive dust, which includes dust from excavation, agricultural tilling, and other activities involving earth movement or disturbance, as well as road dust from vehicle passage and other human activities. For such activities, temporary exceedances of standards may occur in the immediate vicinity of the disturbed area, but are not likely to occur where the most sensitive members of the general public would be spending appreciable amounts of time. With route dust-suppression measures (e.g., sprinkling with water twice per day, if needed) employed, exceedances of NAAQS would not be expected beyond about 200–300 meters from any part of a disturbed area during the proposed construction of Section 8B. This conclusion applies to heavy construction under unfavorable meteorological conditions; in most cases, expected impacts would be even less.

Smoke from fires burning removed woody plants would be another source of fugitive dust. Permits issued for open burning typically specify procedures, as well as weather conditions for which burning is allowed, so as to minimize environmental degradation and the risk of a fire getting out of control. Such potentially harmful effects would be eliminated by removing woody materials from the construction site and using them elsewhere, or chipping them (on-site or off-site) for use as mulch.

Heavy construction activity or burning of removed woody plants along the proposed route could produce a noticeable dust plume that might interfere with visibility of some distant terrain features viewed from Mt. Cammerer, the nearest integral vista observation site to the proposed route of Section 8B. Such visibility impairments would be temporary, and would depend on the weather conditions and background visibility, both of which tend to very from season to season. Other factors involved include intensity of construction activity and distance to the construction from observers at high elevation locations from which distant scenic features are visible.

4.5.6.2 Operation

4.5.6.2.1 Pollutant Concentrations

Pollutants of principal concern in this analysis were CO, O_3, NO_2, and PM-10. The greatest CO concentrations that might be associated with the operation of proposed Section 8B would not be associated with the proposed action, which includes an intersection with SR 416, but with the proposed option that instead has the intersection with U.S. 321. Modeling this option resulted in a highest estimated 8-hour average CO concentrations of about 55% of the corresponding NAAQS at a distance of 2 meters (6.6 ft) from the edge of the pavement—a location where a member of the general public is not likely to spend up to eight hours. All other estimated CO concentrations expected to result near an interchange with U.S. 321, including the possibility of workers spending up to 8-hours at a location 20 m (66 ft) from the hypothetical intersection, were much less than 50% of their corresponding NAAQS. The above analysis included reasonable estimates of existing background values, and it provides an upper-bound value for the proposed action as well as for any of the associated options.

The NAAQS for ozone was exceeded twice at one station in Blount County during 1995. An exceedance was also recorded for GSMNP, although that exceedance was within measurement error. One exceedance of the standard per year, averaged over a 3-year period, is allowed for purposes of determining attainment status (40 CFR 50.9). However, if background values of O_3 increase by even a few percent by 2006 or 2026, then GSMNP could become part of a nonattainment area for O_3. It is also possible that the NAAQS for O_3 could be lowered (61 *Fed. Reg.* 241:65716). If the region including the proposed Section 8B is not in attainment of whatever

O_3 exists at the time, then any additional O_3 contribution, however minuscule, would further contribute to the exceedance. Additional traffic associated with the opening of proposed Section 8B would be expected to contribute, at most, about 0.7 $\mu g/m^3$, or about 0.35% of the highest current values. Because of the regional distribution of sources of O_3 precursors (NO_x and VOCs), mitigation must be largely the responsibility of the community outside the boundaries of GSMNP.

The highest annual average NO_2 concentration estimated to result from the proposed action in year 2026, applicable to an individual residing 100 m (328 ft) from the edge of the parkway along a straight-line extension of the straight stretch of road 250 m (820 ft) long, was 7 $\mu g/m^3$. When added to the highest measured value in the area during the last five years (34 $\mu g/m^3$, in Sullivan County) the cumulative concentration is 41 $\mu g/m^3$, which is less than 50% of the corresponding NAAQS.

Appreciable increases in NO_2 concentration would not be expected as a result of constructing an intersection along U.S. 321. Results from MOBILE5b indicate that NO_x emissions from slower-moving vehicles, expected near an intersection, are less than those from faster-moving vehicles, which is the opposite of the case for CO emissions. However, additional NO_x emissions at an intersection would be provided by idling vehicles. The net effect was estimated to be a slight decrease in NO_x emissions and, by inference, in NO_2 concentrations.

Estimates of annual and 24-hr concentrations of fine particulate matter estimated to result from the operation of proposed Section 8B were well within NAAQS (Table 58). Increases in road dust might occur at intersections that might be constructed, due to increased wear on brake linings in deceleration zones, and on tires and pavement in acceleration zones. These dust inputs would be increased if the intersection were signalized. However, these increases in particulate inputs are small compared to other sources of road dust.

General increases in traffic along U.S. 321 and the appearance of convenience stores at any intersection that might be constructed, particularly if the intersection is signalized, are considered reasonably foreseeable. These actions would generate some additional fugitive dust, but it is not possible to accurately specify or quantify the resulting emissions increases. However, measurements of PM-10 at signalized intersections in non-urban areas indicate that PM-10 concentrations are typically well within NAAQS. Therefore, the proposed option involving an intersection of Section 8B with U.S. 321 is not likely to result in any member of the general public being exposed to an exceedance of NAAQS for PM-10.

Standards for the prevention of significant deterioration (PSD) of air quality exist, but these standards generally apply only to stationary sources, and not to vehicle traffic. However, a PSD assessment was presented here to provide an additional measure of potential impacts of the proposed action. The Class II (usual case) PSD standards for 24-hour average concentration of fine particulate matter could conceivably be exceeded at a very few locations up to 200 m from the edge of the pavement, under rare meteorological conditions. Such exceedances are not unusual close to ground-level sources such as roadways. The proposed action would not be expected to result in any exceedances of the more stringent PSD standards for Class I areas, of which GSMNP is the closest, at or within the park boundary.

4.5.6.2.2 Visibility

Visibility of distant objects viewed from the nearest integral vista site (Mt. Cammerer) would not be noticeably impaired as a result of operation of proposed Section 8B. Because all other integral vistas in the GSMNP are located farther from the proposed route than is Mt. Cammerer, it is concluded that proposed Section 8B would not affect visibility at any integral vista observation site in GSMNP.

4.5.6.2.3 Conservatism of the Analysis

Analyses in this section assumed worst-case possibilities, or a worst-case combination of possibilities, for the proposed action and any of the associated options. Existing conditions, or reasonably foreseeable future background conditions, were incorporated into these analyses. Therefore the results can be taken as upper-bound estimates of the effects of the proposed action.

4.6 SOCIOECONOMICS

Traffic—especially tourism-related traffic—is expected to be the major "driver" of impacts in the study area, with or without construction of Section 8B. An influx of visitors has the potential to stimulate commercial development and create a demand for additional tourist accommodations and dwellings for new year-round residents. As a result, local land use patterns and communities' established social and economic structures could be affected.

Even without construction of Section 8B, traffic flow in the impact area is expected to increase substantially between now and 2005, the year in which Section 8B would open if the project were built according to the proposed schedule. Projections for 2006, the closest year for which data are available, indicate that—compared with traffic counts made in 1994—approximately 1,100 additional vehicles would come to or through Cosby daily (from all directions), and close to 2,800 more vehicles would visit the Pittman Center area each day (for more details see Sect. 4.7). Over the following 20 years, the amount of traffic in the impact area is expected to continue to grow, with growth in the number of daily trips to Cosby and Pittman Center between 2006 and 2026 being expected to roughly equal the number of additional daily trips projected to occur between 1994 and 2006. The growth in traffic (especially trips by tourists) is expected to stimulate commercial growth adjacent to U.S. 321, perhaps creating pressure for more intensive development than many Pittman Center residents would like. In addition, many tourists traveling on U.S. 321 are likely to visit the arts and crafts community along Buckhorn Road, and this exposure to the Pittman Center area could increase the demand for seasonal and year-round accommodations.

Should Section 8B be built and opened to traffic, it is expected to divert hundreds of tourists' vehicles daily from U.S. 321, but it would *induce* very few trips. Thus, the primary effect of Section 8B on area traffic would be to provide a scenic alternative route for tourists who would otherwise have used local roads to reach the same destination. Travelers using the Foothills Parkway would follow a route that lies north of U.S. 321 and traverses terrain that is sparsely populated, rugged, and heavily vegetated. In the vicinity of Pittman Center, Section 8B would run immediately adjacent to the existing town hall and elementary school, but much of the community