Vol. 1 of 6

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OAK RIDGE
NATIONAL
LABORATORY

LOCKHEED MARTIN

# Foothills Parkway Section 8B
# Final Environmental Report

**Volume 1**

July 1999

Prepared for

The National Park Service
Denver Service Center and
The Great Smoky Mountains National Park

MANAGED AND OPERATED BY
LOCKHEED MARTIN ENERGY RESEARCH CORPORATION
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DEPARTMENT OF ENERGY

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# VOLUME 1 SUMMARY

In 1994, Oak Ridge National Laboratory (ORNL) was tasked by the National Park Service (NPS) to prepare an Environmental Report (ER) for Section 8B of the Foothills Parkway in the Great Smoky Mountains National Park (GSMNP). Section 8B represents 27.7 km (14.2 miles) of a total of 115 km (72 miles) of the planned Foothills Parkway and would connect the Cosby community on the east to the incorporated town of Pittman Center to the west. The major deliverables for the project are listed below.

| | |
|---|---|
| Study Plan | August 1994 |
| First Field/Progress Report | October 1994 |
| Second Progress Report | February 1995 |
| Third Progress Report | June 1995 |
| Draft Environmental Report | April 1997 |
| Final Environmental Report | July 1999 |

From August 1995 through October 1996, NPS, GSMNP, and ORNL staff interacted with Federal Highway Administration (FHWA) staff to develop a conceptual design plan for Section 8B with the intent of protecting critical resources identified during the ER process to the extent possible. In addition, ORNL arranged for bioengineering experts to discuss techniques that might be employed on Section 8B with NPS, GSMNP, and ORNL staff during September 1996.

For the purposes of this ER, there are two basic alternatives under consideration: (1) a build alternative and (2) a no-build alternative. Within the build alternative are a number of options including constructing Section 8B with no interchanges, constructing Section 8B with an interchange at SR 416 or U.S. 321, constructing Section 8B with a spur road on Webb Mountain, and considering operation of Section 8B both before and after the operation of Section 8C. The no-build alternative is considered the no-action alternative and is not to construct Section 8B.

The following summary sections provide information for each resource area concerning the data collected, the timing of such data collection, and the results of the impact assessment.

## GEOLOGY AND SOILS

During 1994 and 1995, existing information on geology and soils along the proposed right-of-way (ROW) was compiled and evaluated, and supplemental information was collected to characterize the existing environment in order to evaluate potential environmental impacts of the proposed project. The geology and soils investigation was presented in the April 1997 and in this final ER. As part of the investigation, detailed soil mapping of the entire ROW was completed by a soil mapping expert. The details of this mapping effort are included in Volume 2, Appendix B of the ER (October 1995). A detailed discussion of the geologic impacts is provided in Volume 2,

Appendix A of the ER (October 1995). Specific completed objectives of the geology and soils assessment are as follows:

- verified and augmented published geological and structural data along the proposed route;
- mapped soils within the ROW using National Cooperative Soil Survey Standards and mapped bodies of colluvium and alluvium along the ROW to identify potential problem areas related to slope stability and hydrologically important areas and wetlands;
- collected data on fracture systems present in the bedrock and commented on particular ROW segments that might be affected by combinations of surface dip due to fractures, bedding/cleavage, and rock type; and
- provided impact assessment of engineering properties of the different bedrock types, brittle faults that might cause problems, potential construction hazards in karst areas and relationships to groundwater systems, and pyritic zones which could contribute to stream acidification.

The results of the ER analysis included

- the recommendation to employ all necessary engineering practices (including bioengineering techniques) to all build options to maintain slope stability, control pyritic material, accommodate deeply weathered rock, and to avoid brittle fault zones.

## WATER RESOURCES

Thirty stations located on 21 streams were selected for water quality sampling at intervals ranging from monthly to twice during the period from July 1994 to June 1995. This baseline information was used to evaluate the potential for major deterioration of water quality in some areas (particularly surface water acidification as a result of exposure of pyritic materials). A 1-year study (1994–95) of water quality in the area of the Section 8B ROW was conducted to characterize existing, baseline conditions. For streams that cross the ROW but originate outside of it, sampling stations were located at sites upstream and downstream of the ROW (primarily streams in the Pittman Center and Rocky Flats areas). For streams that originate within the ROW, a downstream station was selected (e.g., streams draining Webb Mountain and Big Ridge).

Early results from the monthly sampling showed somewhat higher sulfate levels in the three streams draining the central portion of Webb Mountain than in the other streams sampled. Therefore, a one-time survey sampling of streams draining Webb Mountain was conducted on March 20, 1995 (some stations were collected again in June 1995). In addition to the routine water quality sampling, several instances of storm flow were sampled to evaluate short-term water quality changes resulting from stormflow in selected streams (changes that would not be detected in results from the monthly sampling).

Water quality parameters measured included water temperature, electrical conductance, pH, alkalinity, dissolved oxygen, total suspended sediments, major cations and anions, ammonium, nitrite plus nitrate, soluble reactive phosphorus, trace metals, and mercury. The trace metals and mercury measurements were made quarterly at each station (September, December, March, June) and for one or two storms at each storm sampling station. The water quality measurements were

designed to allow inferences regarding (1) conditions for fish and other aquatic biota, (2) current effects of agriculture and other human activities in the catchments of these streams, (3) the likelihood of the presence of pyritic materials in the ROW, and (4) potential effects of parkway construction and operation on the surface waters. Details of field and laboratory water quality analysis procedures, data, and quality assurance/quality control considerations are included in Volume 2, Appendix C dated August 1995. Impacts from the construction and operation of the Foothills Parkway Section 8B were assessed in the April 1997 and this final ER.

Several recommendations resulted from the ER analysis:

- Erosion control, including bioengineering techniques, for all options is necessary in the Webb Mt. and Rocky Flats areas to mitigate impacts to Webb Creek, Matthew Creek, Dunn Creek, Carson Branch, and to a lesser extent, the Little Pigeon River.
- Bridging is needed over Dunn Creek in the Rocky Flats area.
- Inspection of excavations in the Webb Mt. area are needed to identify sulfide-bearing materials. If identified, these materials should be sealed.
- A septic system not be used in the facilities on Webb Mt. If the Webb Mt. option is employed, restroom facilities should be self-contained and waste transported out. A water quality study (over at least 1 full year) should be conducted just before construction to establish pre-construction, baseline conditions with which to compare conditions during or after construction for determining construction effects.

## AQUATIC ECOLOGY

Stream biological surveys were completed at 31 stream sites during the Fall of 1994 to identify aquatic ecological resources along Section 8B. The sampling strategy for both invertebrates and fish was to survey the different taxa from all available habitats. For benthic invertebrates, a standardized qualitative manual collection technique was employed for all 31 stations. For fish, all streams of sufficient water were sampled using various methods of electroshocking.

Two listed species were identified during the surveys: the Allegheny snaketail dragonfly (formerly a C2 federal candidate species found at six of the stream survey sites) and the tangerine darter (a Tennessee state special concern species found at two of the stream survey sites).

Detailed listings of the stream biological data collected are included in Volume 3, Appendix D dated August 1995. Impacts from the construction and operation of the Foothills Parkway Section 8B were assessed in the April 1997 and this final ER.

Recommendations included the following:

- All mitigation measures identified to protect water resources should be instituted.
- Delays in paving road surfaces should be minimized to reduce soil erosion, and turbidity and sedimentation in the streams.

- Culverts or other structures should be constructed in such a way as to ensure that fish movements are not blocked, especially for Copeland Creek, Lindsey Creek, Mill Dam Branch, Warden Branch, Butler Branch, Matthew Creek, Carson Branch, Chavis Creek, and Sandy Hollow Creek.

## TERRESTRIAL ECOLOGY

Field surveys for vegetation and wildlife were conducted to determine the presence of federal and state listed, federal candidate, park-rare, and non-native (exotic) species; sensitive habitats; and general characterization of the biota of the ROW. Specific field surveys were done for vascular plants, small mammals, salamanders, reptiles, birds, and bryophytes.

Of the 14 species with federal or state endangered, threatened, previous candidate, or special concern status (including park rare plants, bryophytes, lichens, small mammals and one bird), the populations of the state threatened ovate catchfly and ash-leaved bush-pea are of greatest concern because of their potential global rarity. Although not currently protected, the globally rare population of hornwort is also of concern. Of the sensitive habitats identified or found on the ROW, those of greatest concern are the floodplains of the Little Pigeon River and Cosby Creek; Webb Mountain, including drainages and slopes; wetlands and streams in the Rocky Flat area; and some upper drainages on Big Ridge.

The detailed findings of the wildlife and vegetation surveys can be found in Volume 4 which includes Appendix E—Floral Resources (January 1995), Appendix F—Bird Survey Report (August 1995), Appendix G—Survey Report for Listed Wildlife (February 1995), Appendix H—Bryophyte and Lichen Survey (May 1995), and Appendix I—Wetlands Survey Field Notes (August 1995). Impacts from the construction and operation of the Foothills Parkway Section 8B were assessed in the April 1997 and this final ER.

Results are listed below.

- Forest clearing should be limited as much as possible.
- Disturbed areas should be replanted with native trees.
- Drainages should be bridged rather than leveled with cut and fill.
- For areas of steep slopes and potential erosion, bioengineering techniques should be implemented.
- The Webb Mt. spur road is not recommended. If the spur road is built, no grass shoulders should be used (to minimize forest fragmentation impacts).
- Transplanting of protected plants should be done when possible.
- Construction in wetland areas should be avoided, and erosion and sedimentation mitigation measures discussed under water resources and aquatic ecology should be implemented.

## AIR QUALITY

Historic meteorological data and air quality data from various sources in the vicinity of the Foothills Parkway ROW were obtained. These data were then used in a number of models, as appropriate.

The models were employed to help predict potential impacts to air quality as a result of the construction and operation of Section 8B. Models included the Industrial Source Complex Short-term (ISCST3) air dispersion model, EPA VISCREEN visibility model, MOBILE5b, and the CAL3QHC computer model. Results from the models were discussed as part of the impact assessment of the construction and operation of Section 8B in the April 1997 and this final ER.

The air quality assessment identified potential impacts of the proposed project:

- Visibility impacts due to construction would be most apparent during summer months and October.
- Construction activities could result in exceedences of 24-hour PM-10 standards.
- If the tunnel option is chosen, and an accident that blocked traffic occurred, high carbon monoxide concentrations could result in the tunnel.

Mitigation measures were developed to address the potential impacts:

- Construction activities should be minimized during the summer months and October.
- Dust suppression techniques should be employed to limit fugitive dust (including paving parking areas).
- If the tunnel option is chosen, signs should be posted to alert motorists to turn off their engines in case of a stoppage of traffic lasting more than a few minutes.

## SOCIOECONOMICS

The impact region of interest for the assessment was defined as Sevier and Cocke counties. Pittman Center and Cosby were identified to be the primary focus of potential environmental impacts as the parkway would affect travel most in those communities. Data concerning population, housing, public services, land use, taxes, economic structure, and social structure were gathered from 1995 to 1997 from various sources and used in the impact assessment of the construction and operation of the Foothills Parkway Section 8B in the April 1997 and this final ER.

The results of the assessment indicate that there would be no significant impacts from additional workforce, traffic, housing, or public utilities or to the existing social structure. If the SR 416 exit option is chosen, traffic, population growth, and housing development of the Pittman Center area could increase at a slightly faster rate than with the other interchange options (i.e., U.S. 321 or no interchange), particularly if 8B is opened prior to 8C.

## TRAFFIC

An initial effort in the traffic study was the collection of data that could be used to establish existing traffic conditions and historical traffic trends in the study area. Traffic volume and turning movement counts were collected at key locations in the study area during the summer and fall peak seasons in 1994. Also, traffic volume and turning movement data collected by ORNL in 1991 for the Section 8B traffic study were compiled. In addition to these data, traffic volume counts were acquired from the NPS, the Tennessee Department of Transportation, and a traffic study conducted by Wilbur Smith Associates (*Sevier Transportation Network Evaluation: Phase I*). Also, historical GSMNP visitation data were obtained from the NPS.

ORNL originally performed a study that projected the potential traffic impacts from the addition of Section 8B only. However, in 1995, the NPS requested that ORNL undertake a regional transportation study to provide a larger contextual analysis of the entire Foothills Parkway from which Section 8B impacts could be assessed. ORNL completed this study in 1996 with direct guidance and input from NPS. The regional traffic study was conducted using standard traffic assignment and capacity analysis methodologies used in the traffic engineering community.

Unacceptable levels of service will occur on numerous roads within and outside of the park increasingly in the future based upon current and future regional growth. However, the results of the traffic assessment indicated that there would be no significant or cumulative impact from the addition of Section 8B or the completion of the Foothills Parkway as a whole within the study area by 2026.

The assessment of potential traffic impacts was presented in the April 1997 and this final ER. Additional data and details collected and used in the ER are presented in Volume 5, which includes Appendix J—Roadway Traffic Volume and Level-of-Service Results for the Five Build Options (August 1995) and Appendix K—Intersection Traffic Volume Results for the Five Build Options (August 1995).

## NOISE

In June and July of 1994, ORNL measured existing noise levels at 41 key receptor sites in areas that may be affected by traffic noise along Section 8B as well as other roads in the study area. Key receptor sites included residences, rental properties, churches, schools, and other locations in and around Pittman Center, Cobbly Nob, Rocky Grove, and Cosby.

ORNL used existing traffic and noise measurements, along with the traffic projections generated from this study, to project future traffic noise levels and their impact on ambient noise levels. These noise level projections were calculated using the simple version of the FHWA's Highway Traffic Noise Prediction Model. The results of the noise analysis indicate that impacts would be quite similar for each of the build options and that none of these options should increase noise levels above FHWA standards for residential areas. Therefore, no mitigation measures are recommended for traffic noise.

Because site construction and haul road plans were not available for the Parkway and its intersections with other roads, no analysis of noise related to parkway construction activities was performed. To reduce the impacts of construction noise, a four-step plan was recommended:

1. Community relations—Early communication with the public is vital. The public should be informed of any potential construction noise impacts as well as procedures planned to mitigate them. Also, a responsive complaint mechanism should be established and publicized for the duration of the project.
2. Design considerations—To the extent possible, construction operations should be located and sequenced to minimize noise impacts near sensitive receptors. Permanent noise barriers planned for the site can be erected early in the construction process to minimize noise, and quieter construction alternatives (e.g., rubber-tired equipment rather than tracked equipment; cast-in piles rather than driven piles) should be used where feasible.
3. Source control—Using newer, quieter equipment or equipment with mufflers will often lessen noise impacts.
4. Site control—Modifying the time, place, or method of operation for particular noise sources can reduce noise impacts. This usually entails limiting the hours of operation near sensitive receptors.

The assessment of potential noise impacts is presented in this final ER. Additional data and details used collected and used in the ER are in Volume 5, Appendix L—Noise Data (August 1995).

## AESTHETIC RESOURCES

The aesthetic resources affected by the proposed Foothills Parkway Section 8B involve viewing opportunities of the GSMNP, specific local viewsheds, scenery to the north, and interpretive opportunities. Factors such as season, time of day, vegetation condition, and traffic affect the value of the potential viewing experience.

An initial approach of evaluating all potential views in detail was taken and provided in the April 1997 ER. Thirty-eight potential views of varying quality and focus were inventoried along the proposed Section 8B alignment. These were evaluated and ranked according to a number of factors including aesthetic value and suitability for development. Thirteen were eliminated from consideration as being too insignificant to develop. Fourteen exhibited some viewing opportunities for passive viewing without significant development. The remaining eleven sites showed the best development potential. Two of these sites contain opportunities for quiet trail development, nature interpretation, or viewing. Three or four contain resources for human settlement interpretation. Five sites offer special opportunities for pull-over parking and scenic views. These eleven sites were treated in detail in the impact assessment of the construction and operation of the Foothills Parkway Section 8B in this final ER.

Several recommendations regarding potential impacts to aesthetic resources were suggested:

- The western exit ramp across the Little Pigeon River should be used.
- The tunnel option east of SR 416 should be selected.
- The SR 416 option rather than the U.S. 321 option should be chosen.

- A ramp should be used at Webb Creek Road if the U.S. 321 option is chosen.
- Both the Webb Mountain lower parking lot and the Webb Mountain loop access road should be built.

Additional details on aesthetic resources methods are included in Volume 5—Appendix M of this final ER.

## CULTURAL RESOURCES

A cultural resources assessment for the entire Section 8B ROW was completed in May 1995 to document the architectural, historical, and cultural resources located within the project area. The assessment included evaluation of the potential for cultural (i.e., rural historic) landscapes in the area of the ROW. The cultural resources assessment report is included as Volume 6—Appendix N of the April 1997 and final ERs.

As a result of the assessment, seven properties appear to meet *National Register* criteria. For six of these seven sites, no audible or visual effects were predicted to result from the construction and operation of the build alternatives of Section 8B. Three areas were evaluated to determine if they could be considered rural historic landscapes: the Cosby Valley, Pittman Center, and Rocky Flats. None of these landscapes met *National Register* criteria for rural historic landscapes.

The ER impact analysis resulted in the following recommendations:

- Consideration should be given to screening the parkway in such a way that the Tyson McCarter Place is not visually impacted from the parkway construction or operation.
- The parkway should be placed on the eastern side of Big Ridge to avoid visual effects to the Lunsford Barn.
- Sutton Cemetery should be protected and public access to it should be provided.

# FOOTHILLS PARKWAY SECTION 8B
# FINAL ENVIRONMENTAL REPORT


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## ACRONYMS

| | |
|---|---|
| AADT | annual average daily traffic |
| Alcoa | Aluminum Company of America |
| BBS | Breeding Bird Survey |
| CALINE | California Line Source |
| CO | carbon monoxide |
| CDOT | California Department of Transportation |
| DOM | domestic |
| EA | environmental assessment |
| EIS | environmental impact statement |
| EPA | U.S. Environmental Protection Agency |
| ER | environmental report |
| FHWA | Federal Highway Administration |
| FISH | fish and aquatic life |
| GSMNP | Great Smoky Mountains National Park |
| HF | hydrogen fluoride |
| I-40 | Interstate 40 |
| IND | industrial |
| IRR | irrigation |
| ISC3 | Industrial Source Complex |
| ISCST | Industrial Source Complex Short-Term |
| LOS | level of service |
| LW&W | livestock watering and wildlife |
| MGD | million gallons per day |
| NAAQS | National Ambient Air Quality Standards |
| NO | nitric oxide |
| $NO_2$ | nitrogen dioxide |
| $NO_x$ | oxides of nitrogen |
| NPS | National Park Service |
| NWI | National Wetlands Inventory |
| O | oxygen atom |
| $O_2$ | oxygen molecule |
| $O_3$ | ozone |
| OEPA | Ohio Environmental Protection Agency |
| ONRWs | Outstanding National Resource Waters |
| ORNL | Oak Ridge National Laboratory |
| OSHA | Occupational Safety and Health Act of 1970 |
| PM-10 | particulate matter |
| PSD | prevention of significant deterioration |
| REC | recreation |
| ROW | right-of-way |
| RPM | reactive plume model |
| RTDM | Rough Terrain Dispersion Model |
| $SO_2$ | sulfur dioxide |
| SR | State Route |
| TDOT | Tennessee Department of Transportation |
| TOS | Tennessee Ornithological Society |
| TSP | total suspended particulate matter |

| | |
|---|---|
| TSS | total suspended solids |
| $UF_6$ | uranium hexafluoride |
| USGS | U.S. Geological Survey |
| VISCREEN | visibility screening |

# 1. INTRODUCTION

Oak Ridge National Laboratory (ORNL) is preparing an environmental report for the National Park Service (NPS) on the proposed construction and operation of Section 8B of the Foothills Parkway between Cosby and Pittman Center in East Tennessee. The NPS will use the information in the environmental report (ER) and from other sources to prepare an environmental impact statement (EIS) that evaluates the potential environmental impacts of the proposed project. The Federal Highway Administration (FHWA) is designing this and other sections of the parkway with NPS input.

The first deliverable for this project (August 1994) presented a detailed study plan to the NPS. In October 1994 the First Field/Progress Report was submitted to NPS. The Second Progress Report was submitted to NPS in February 1995 and the Third Progress Report in June 1995. This Environmental Report contains data gathered on various tasks through November 1996 and an assessment of environmental impacts from the proposed Foothills Parkway, Final Conceptual Plans for Environmental Review, December 27, 1996. The text of this report is similar to a NEPA document with detailed technical data in appendices.

## 1.1 PURPOSE AND NEED

The purpose of developing the Foothills Parkway along the Tennessee side of the Great Smoky Mountains National Park (GSMNP) is to provide a scenic roadway from which visitors may view the Smoky Mountains from a sufficient distance and from a sufficiently high perspective to permit full perception of their grandeur, extent, and height. The Foothills Parkway was planned as a scenic parkway, 115 km (72 miles) long, traversing the western and northern perimeters of GSMNP. When completed, the Foothills Parkway would extend from Chilhowee on the west to the intersection with Interstate 40 (I-40) east of Cosby. The road is to be a two-lane, 6.1-m (20-ft)-wide, asphalt paved parkway, with a design speed of 48 km (30 miles) per hour or less.

The right-of-way (ROW) of the parkway section currently under study, which is called Section 8B, is approximately 305 m (1000 ft) wide and extends from Cosby on the east to Pittman Center on the west. Section 8B of the Foothills Parkway would connect Section 8A, which is already built and in use, and Section 8C, which would run from Pittman Center to the Gatlinburg Spur (U.S. 441) (Figs. 1A and 1B). Section 8C will be evaluated in the future after proposals to construct this section are developed. A draft EIS on Section 8D was published and distributed for public review in January 1995.

## 1.2 SCOPE AND APPROACH OF THE ENVIRONMENTAL REPORT

This report describes the existing environmental resources that could be affected by construction and subsequent use of Section 8B and presents an analysis of potential environmental impacts of the proposed project. Existing information is summarized and new resource data is described including information on geology, soils, water, aquatic ecology, terrestrial ecology, meteorology and air quality, socioeconomics, aesthetics, and archaeologic and historic resources. In addition,

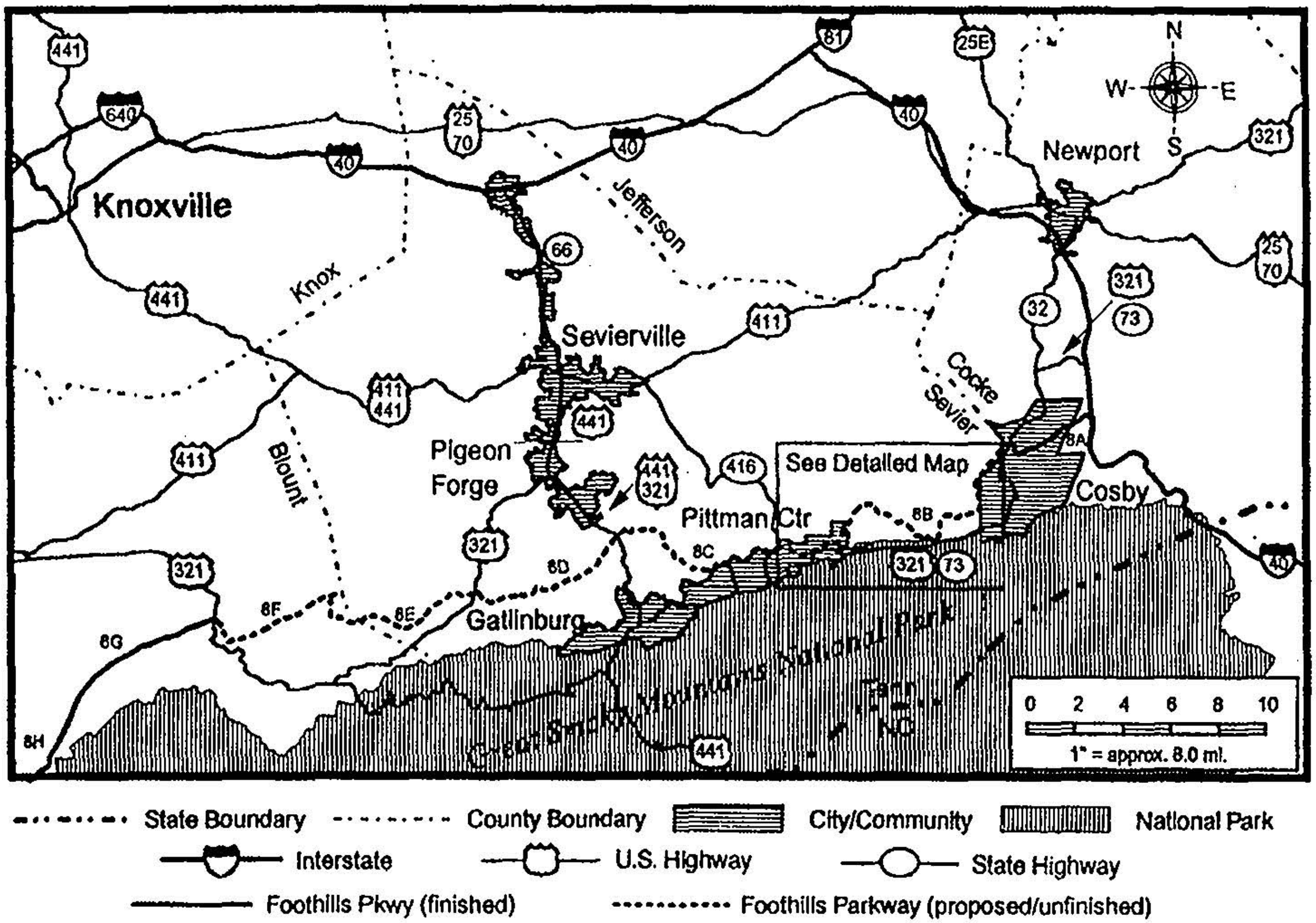


Fig. 1A. General location map for the area of the Foothills Parkway.

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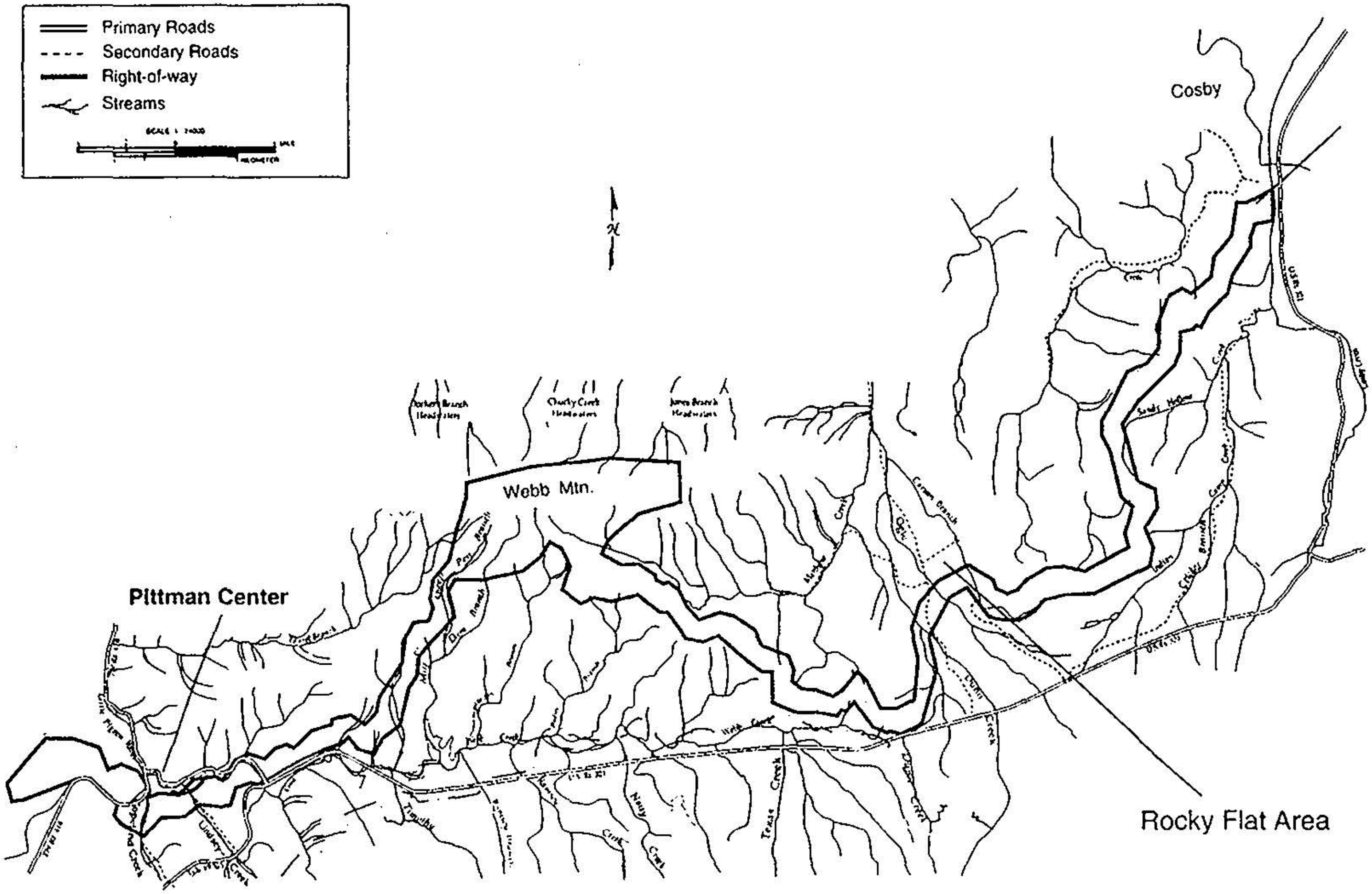


**Fig. 1B. General map of Foothills Parkway Section 8B.**

existing traffic patterns and noise are evaluated. Issues for which environmental impacts are evaluated are listed in Sect. 1.4.

Preparation of this environmental report has been conducted in phases. Phase one consisted of data gathering and the preparation of the "affected environment" section for the environmental report. Phase two involved a meeting with NPS and FHWA staff to present and discuss results of the field studies as input to the FHWA to initiate conceptual project design and identification of mitigation measures for environmental impacts. Phase three, which started when the FHWA conceptual design was completed, involved assessing environmental impacts and assembling the complete environmental report. Upon its completion, NPS staff will use the environmental report to prepare a draft EIS for public review and comment.

## 1.3 BACKGROUND

### 1.3.1 History

The NPS has been committed to construction of the Foothills Parkway since 1944, when Congress passed Public Law 232. That law authorized construction of the Foothills Parkway to provide scenic views of the GSMNP and allowed the Secretary of the Interior to accept land donated by the state of Tennessee for construction of a scenic parkway, with the stipulation that such lands would become part of the GSMNP.

In 1945 the Tennessee legislature passed a bill authorizing the state to acquire a corridor for the Foothills Parkway by gift, purchase, or condemnation. The legislature passed a second bill in 1947 authorizing the state to transfer the corridor lands to the NPS for inclusion in the GSMNP.

To date, approximately 38 km (24 miles) of the parkway have been completed and opened to traffic. The completed portions extend from Chilhowee to Walland and from Cosby to I-40 (Sections 8A, 8G, and 8H). Another portion about 24 km (15 miles) long between Walland and Wear Valley is almost complete (Sections 8E and 8F) except for a 2.2 km (1.4-miles) portion that will connect two sections of that stretch. A draft environmental assessment (EA) on this "missing link" portion was released to the public in January 1994. The revised EA was released in December 1996 and a decision by the NPS is pending.

### 1.3.2 Planning Background

*The General Management Plan for the GSMNP* (NPS 1982) designates management zones to carry out broad management strategies for the various lands and waters of the GSMNP. These management zones indicate the types of uses, activities, and management actions that are appropriate. The existing Foothills Parkway is considered under the development zone as part of the transportation subzone. As sections of the parkway are completed, they will be given this classification as public road corridors.

Management objectives within the development zones include the following (NPS 1982):

1. to ensure that all developments ... are the minimum necessary for safe, efficient park administration and essential visitor services, consistent with other park objectives and NPS policies; and to bring each to an attractive, safe, sound condition; and
2. to prevent, to the extent possible, deterioration of facilities to the point of unsightliness, unsafe conditions, or resource degradation, or deterioration beyond efficient repair.

## 1.4 ISSUES IDENTIFIED IN SCOPING

Construction of Section 8B was the subject of two scoping meetings at Pittman Center and Gatlinburg held by the NPS on November 19–20, 1993. The principal issues of concern identified during the scoping process are discussed in this section.

**Water quality.** Construction activities could affect the quality of water in streams that cross or are adjacent to the ROW in two ways. Erosion from steep slopes could increase sediment in the streams. In addition, there is a potential for exposing pyritic soils, which are high in sulfates and may contribute acidic materials to adjacent waters when exposed to air and water. These acidic materials may affect water quality and the plant and animal species living in the aquatic systems.

Other issues of concern include floodplain effects, flooding, and streamflow changes; impacts on local water supplies (quality and quantity) and groundwater quality; and impacts on stream ecology of increased temperatures that would result from forest canopy removal.

**Slope stability.** Slope stability is a major concern, given the steep slopes on which the parkway may be constructed and stability problems experienced in construction of previous sections.

**Local economy and land use.** Construction of Section 8B of the Foothills Parkway might cause additional commercial and residential development in adjacent areas, affecting the economy and social structure of the area and changing current land use.

**Visual experience.** The purpose of the parkway is to provide scenic views of the GSMNP from a high vantage point. However, there is concern about the visual changes that construction of the road might make to the view of the mountains from outside the park for visitors and local residents.

**Air quality.** Further completion of the Foothills Parkway might increase traffic within the area. Increased traffic could adversely affect air quality and might contribute to limiting the range of views now available. Impaired air quality might affect the unusual diversity of plant and animal life that is present in the park. Fugitive dust from construction of the parkway might also adversely affect the short-term air quality by increasing suspended particulates.

**Ecological resources.** Construction and operation of the Foothills Parkway might adversely affect species within the ROW that are listed, or candidates for listing, as threatened or endangered by the state or the federal government. Other ecological resources that could be affected include stream biota, wetlands, and existing terrestrial plant and animal communities. The potential adverse

effects to these resources include impacts from disturbance, introduction of non-native species, impacts of physical alteration and fragmentation of habitats, and impacts on biodiversity and sustainability of existing habitats.

**Cultural resources.** Construction of the Foothills Parkway might have an impact on archeological and historic resources, including cultural landscapes, that are listed on or are eligible for listing on the *National Register* of Historic Places. Ethnographic resources associated with the native populations of the region may also be affected by construction of the parkway.

**Traffic (motor vehicle and bicycle) and noise.** Potentially adverse effects include changes in vehicle traffic patterns and levels, impacts of increased traffic noise on people and wildlife, and potential impacts from and to bicycle traffic.

# 2. OVERVIEW OF ALTERNATIVES CONSIDERED

The corridor for Section 8B transferred to NPS is approximately 305 m (1000 ft) wide, with a considerably wider section on Webb Mountain. The NPS proposes to construct and subsequently operate Section 8B of the Foothills Parkway in the GSMNP. Section 8B would extend from the existing interchange of the Foothills Parkway (Section 8A) and U.S. 321 at Cosby, Tennessee, approximately 22.7 km (14.2 miles) to Pittman Center, Tennessee (Figs. 1A and 1B). Gatlinburg is the next community to the west of Pittman Center; Newport is north and east of Cosby. Approximately midway between Cosby and Pittman Center the ROW crosses the small community of Rocky Flats. The topography of Section 8B is rugged and includes a large portion of Webb Mountain. Section 8B traverses many large and small streams including Cosby Creek at the east end and the Little Pigeon River at the west end.

The following discussion of no build and build alternatives is a very general description of those that will be considered. The build alternative options are based upon the conceptual design plans provided from FHWA in January of 1997. Since these are conceptual plans, it is probable that the alternative options may change in refinement of detail, but would be re-evaluated if changes were substantial. However, for the purposes of this ER, they are considered in order to assess the potential impacts that could be expected if they were implemented. There are two basic alternatives: (1) a build alternative and (2) a no-build alternative. Within the build alternative are a number of options including constructing Section 8B with no interchanges, constructing Section 8B with an interchange at SR 416 or U.S. 321, constructing Section 8B with a spur road on Webb Mountain, and considering operation of Section 8B both before and after the operation of Section 8C. The no-build alternative is considered the no-action alternative and is not to construct Section 8B.

## 2.1 BUILD ALTERNATIVE

Potential impacts for the construction of most of the ROW will be very similar among all build options and would be the result of clearing, cutting, filling, paving, and operating Section 8B. If the build alternative is ultimately chosen, it may become a combination of options discussed in Sects. 2.1.1–2.1.4.

### 2.1.1 Construct Section 8B with no Interchanges Option

No interchanges would be designed for the western end of Section 8B at Pittman Center under this build option. Sections 8B and 8C would be one single continuous section of the Foothills Parkway from Cosby to U.S. 441 (on the Pigeon Forge to Gatlinburg Spur). No interchanges in the Pittman Center area would be provided. This option would result in a total of about 39 km (24 miles) without an interchange. Emergency roads and access gates would be provided at selected interim locations.

Included in the assessment of impacts for this option are the two variations of construction in the Rocky Flats area and the tunnel option near SR 416 (Fig. 1B). In the Rocky Flats area, one option is to have the road constructed into the ridge above the valley drainage. This would require

extensive cutting into the hillside but would require little fill in the drainage area. The other option is to take the roadway through the valley on fill material. Large amounts of fill would be necessary, but the large cuts into the hillside could be avoided.

Just east of SR 416 in Pittman Center, two possible options for construction are being considered. One would involve extensive cuts into the ridge that lies east and overlooks SR 416. An option is to place a tunnel in this same location, to limit the amount of cutting into the ridge. The tunnel would significantly decrease the amount of cutting that would be required and would limit the visual impacts to the area.

### 2.1.2 Western Terminus Options

The no-interchange option (Sect. 2.1.1) will be assessed and the options for interchanges at either SR 416 or U.S. 321 will be added. Interchange options (north and south) for SR 416 at Pittman Center along with the options for U.S. 321 (interchange directly to U.S. 321 and interchange indirectly to Webb Creek Road) will be considered as part of the build alternative.

The SR 416 north interchange option at Pittman Center would be a ramp that exits to the northeast and crosses the flood plain of the Little Pigeon River and the Little Pigeon River itself. Construction would require a bridge large enough to accommodate flooding over the Little Pigeon River, the purchase of a small amount of land to complete the ramp at SR 416, and the reconstruction of the SR 416 bridge over Webb Creek. The ramp would then connect to SR 416 directly opposite Webb Creek Road. Large amounts of fill material would be required for the roadbed of the ramp. The SR 416 south option would entail a longer ramp that would meander to the southwest. This option would also require large amounts of fill and a bridge over the Little Pigeon River. It also would require that the NPS either acquire land areas easement in the field opposite the ramp entrance along SR 416 to maintain adequate parkway character.

Another interchange is being considered for U.S. 321. Two exit ramp options are being evaluated. One ramp would exit the parkway to the south and connect directly to U.S. 321 just east of Webb Creek Road. This option would require massive cuts into the hillside above U.S. 321 and would require acquisition of additional land. The second option would be to construct a ramp just west of Webb Creek Road which would exit to the south and then east, connecting to Webb Creek Road. This ramp would travel over part of the flood plain of Webb Creek and would therefore require large amounts of fill material. A bridge over Webb Creek would be part of the connection at Webb Creek Road.

### 2.1.3 Webb Mountain Options

All the elements of the previously discussed alternative options (Sects. 2.1.1 and 2.1.2) will be assessed as well as the two options for Webb Mountain. These options include a parking area along the edge of the parkway ROW at the foot of Webb Mountain (this option would include a trail system up to and around Webb Mountain) or a spur road leading to an overlook facility and associated parking area on top of Webb Mountain.

The main parkway option would provide a parking area north of the main parkway and south of the Matthew Creek drainage. Some cutting into the hillside would be necessary. The upper

overlook facility option would be much more extensive. A spur road would wind to the top of Webb Mountain. This road would start to the northeast and then would circle to the south and then to the west. A loop road would be constructed on top of Webb Mountain, along with a comfort station and a parking area. The loop road would cross two areas of the Matthew Creek drainage as well as a tributary of Jones Creek to the north. Large amounts of cuts and fills would be used for the construction of the spur road and the overlook loop and facilities. Large retaining walls would be required in two different areas along the south side of the access road.

### 2.1.4 Operational Timing Options

All the considerations of the previously discussed options (Sects. 2.1.1–2.1.3) for the build alternative will be assessed along with a consideration of the timing of the initiation of operation of Section 8B. The options to be assessed here are (1) Section 8B to be constructed as described but not to be operational until Section 8C is completed or (2) Section 8B to be constructed and put into operation before the completion of Section 8C. Possibilities under this option would also include constructing the roadway but not paving it, or finishing all construction (including pavement) but securing the section so it could not be used until Section 8C was completed.

Under the first operational timing option, the constructed parkway might be used in the same way as other sections (8E and 8F) that are not fully completed. These sections are opened to the public for 2 weekends in the fall and spring to experience the fall colors, wildflowers, and the mountain and valley views. If Section 8B were constructed and operational before Section 8C (i.e., option 2), this section of the parkway would have two exits. One would be at Cosby (at the connection to Section 8A) and one would be at Pittman Center (either at SR 416 or U.S. 321).

## 2.2 NO-ACTION ALTERNATIVE (NO-BUILD)

Under this alternative, Section 8B of the Foothills Parkway would not be constructed. It is assumed that the missing link between Sections E and F will be completed, Section 8D probably would be completed, and Section 8C would not be built. Thus, the final Foothills Parkway would consist of Sections A, B, E, F, G, and H. Under this alternative, it is uncertain what the future land use of Sections 8B and 8C would be. Any change of use (i.e., use other than a parkway) would require a change in legislation.

# 3. AFFECTED ENVIRONMENT

This section describes the existing natural resources and environmental conditions within the ROW and immediately adjacent to Section 8B of the Foothills Parkway. The information and data presented in this section provide a baseline description of the environment against which changes to the environment, both positive and negative, resulting from the alternatives described in Sect. 2 are evaluated in Sect. 4.

## 3.1 GEOLOGY AND SOILS

### 3.1.1 Regional Geology and Soil Characteristics

The rocks that underlie the Great Smoky Mountains and vicinity comprise part of the western Blue Ridge geologic province in the southern Appalachians (Fig. 2). The geology of the Western Blue Ridge contrasts with that of the adjacent provinces, which include the unmetamorphosed Paleozoic carbonates (limestone, dolomite) and clastic (shale, sandstone, conglomerate) rocks in the Valley and Ridge Province to the west, and the Proterozoic to early Paleozoic high-grade metasedimentary and metaigneous intrusive rocks in the eastern Blue Ridge. The slightly to highly metamorphosed western Blue Ridge rocks of this latitude are divided (based on rock type and geologic age) into three major divisions: the Chilhowee Group, Ocoee Supergroup, and crystalline basement rocks. All are represented in the GSMNP and vicinity (Fig. 2). Rocks of the lower Paleozoic Chilhowee Group comprise an alternating sequence of quartzite and shale that underlies Chilhowee Mountain (Parkway Section 8F), and English, Stone, and other mountains north and east of Parkway Section 8A. Southeast of the mountain front, the foothills and higher peaks of the Great Smoky Mountains are underlain by a thick homogeneous succession of coarse- and fine-grained clastic sedimentary and subordinate carbonate rocks belonging to the late Proterozoic Ocoee Supergroup. These sedimentary rocks overlie crystalline basement rocks composed of Middle Proterozoic gneisses and deformed granitic rocks.

The Great Smoky Mountains are part of the southern Appalachians that formed some 250 million years ago when Africa and North America collided during the final stages of formation of the supercontinent Pangaea (Hatcher 1987). Products of that collision are particularly evident in the vicinity of Wear, Tuckaleechee, and Cades coves which, in geologic terms, are windows (erosional holes in nearly horizontal faults) that expose unmetamorphosed Valley and Ridge carbonate and clastic rocks beneath the cleaved and metamorphosed clastic (and minor carbonate) rocks of the Blue Ridge-Piedmont (Great Smoky) thrust sheet (Fig. 2) (Rodgers 1953; King et al. 1958; Hatcher 1987; Hatcher et al. 1989; Hatcher, Larson, and Neuman 1989). They provide direct evidence of several tens of kilometers of westward transport on the great Blue Ridge-Piedmont thrust sheet (the Great Smoky and Miller Cove thrust blocks) thus formed some 350 km to the southeast; and the rocks southeast of the Miller Cove fault were folded, cleaved, and slightly metamorphosed (some 430–480 million years ago) before being transported westward as part of the Blue Ridge-Piedmont thrust sheet. Subsequent erosion during the past 5 to 20 million years has produced the modern landscape that remains strongly influenced by the composition and structure formed millions of years before (Hack 1982). In particular, the location and size of streams is a

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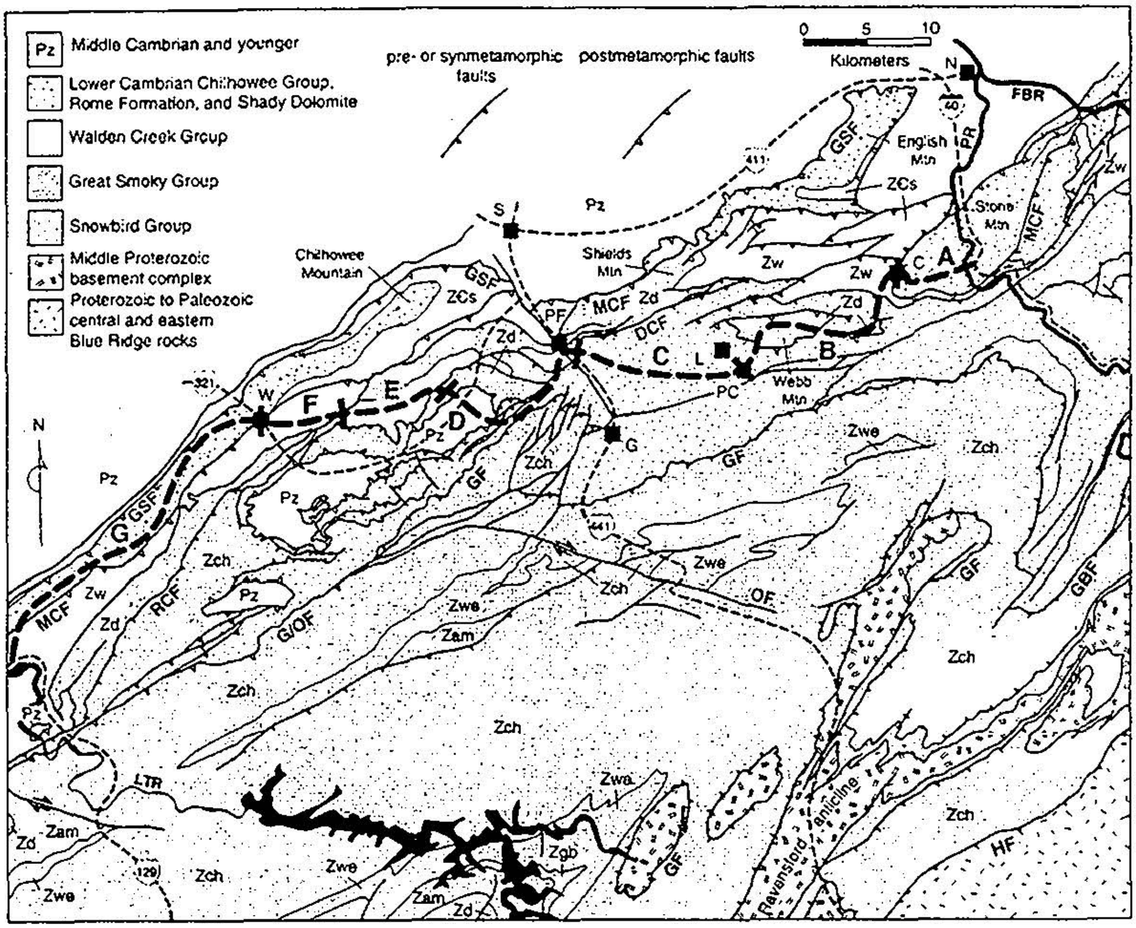


**Fig. 2. Regional geologic map of the western Blue Ridge in the vicinity of the Great Smoky Mountains of Tennessee and western North Carolina showing distribution of rock units between the Great Smoky and Hayesville faults.** Foothills Parkway indicated by heavy dashed line; bold capital letters indicate segments. Abbreviations of stratigraphic units: ZCs—Sandsuck Formation; Zam—Ammons Formation; Zch—Copperhill Formation; Zd—Dean Formation; Zgb—Grassy Branch Formation; Zw—Wilhite Formation; Zwe—Wehutty Formation. Fault abbreviations: DCF—Dunn Creek fault; GF—Greenbrier fault; G/OF—Greenbrier/Oconaluftee fault; GSF—Great Smoky fault; HF—Hayesville fault; MCF—Miller Cove fault; OF—Oconaluftee fault; RCF—Rabbit Creek fault. Geographic abbreviations: C—Cosby; FBR—French Broad River; G—Gatlinburg; L—Laurel; LTR—Little Tennessee River; N—Newport; PC—Pittman Center; PF—Pittman Center; PR—Pigeon River; W—Walland. Map modified from King, Neuman, and Hadley (1968), Madley and Neslon (1971), and Connelly (1993).

product of rock composition and structural features (e.g., faults and fracture zones) and the accumulation of colluvial deposits that provide the groundwater reservoirs that sustain streamflow.

King et al. (1958) subdivided the Ocoee Supergroup in the GSMNP and vicinity into three major rock units (groups), subdivided each group into formations, and carefully mapped their areal extent throughout the GSMNP region. The Ocoee Supergroup was divided into (1) Snowbird Group rocks (of which the Pigeon Siltstone constitutes the uppermost formation), which lie stratigraphically above crystalline basement rocks; (2) Great Smoky Group rocks, which overlie Snowbird Group rocks along the Greenbrier fault; and (3) Walden Creek Group rocks, which underlie Chilhowee Group rocks south of Chilhowee, English, and Stone Mountains, Tennessee. The Snowbird Group consists of clean to unclean sandstone (feldspathic sandstone to graywacke), shale, and siltstone; the Great Smoky Group consists of medium to massive beds of unclean sandstone and conglomerate (mostly graywacke) and dark shale (appreciably pyritic); and the Walden Creek Group consists of siltstone, sandstone, conglomerate, and limestone.

More subtle features of the modern landscape were formed by erosion and deposition processes working on somewhat shorter time scales. Rocks and sediments that have been moved from higher-elevation slopes to lower slopes by gravity (e.g., landslides, slumping, or creep) form colluvial deposits. These deposits are like the talus slopes seen at the base of many western mountains, but in this region they are generally covered by forest and have often themselves been highly dissected by streams. Colluvial deposits are very common on the lower slopes of this region. Many of them probably formed during periods of colder and/or wetter climate thousands of years ago. Deposits of sediments left by water are called alluvial deposits and are common as floodplains in the valleys and as bank deposits along many lower-slope streams. A notable example of a combined colluvial and alluvial deposit is the Rocky Flats area near the middle of the Section 8B ROW (Fig. 1B). The present Rocky Flats landscape is the result of a series of large, late Pleistocene mudflows originating from Greenbrier Pinnacle to the south.

Soils that developed on each of the geologic features of the region have characteristics that reflect the underlying bedrock or surficial deposits and that can be used to interpret opportunities for or constraints on the use of that land. Residual soils formed in place from underlying bedrock. Colluvial soils were formed in gravity-transported materials that have moved from upslope; they reflect presently inactive colluvial or mass-movement processes. Alluvial soils were formed in water-transported alluvial deposits and may reflect both ancient or continuing erosional and depositional processes.

### 3.1.2 Objectives and Data Collection

Existing information on geology and soils along the proposed ROW was compiled and evaluated and supplemental information was collected to characterize the existing environment in order to evaluate potential environmental impacts of the proposed project. Specific objectives of the geology and soils investigations were as follows:

1. to verify and augment published geological and structural data along the proposed route;
2. to map the soils within the ROW using National Cooperative Soil Survey Standards;
3. to comment on engineering properties of the different bedrock types and on constraints associated with soils mapped on the ROW;

4. to locate and study in detail any brittle faults that might cause problems;
5. to collect data on fracture systems present in the bedrock and comment on particular ROW segments that might be affected by combinations of dip of fractures, bedding/cleavage, and rock type;
6. to identify potential construction hazards in karst areas and relationships to groundwater systems;
7. to map bodies of colluvium and alluvium along the ROW to identify potential problem areas related to slope stability and hydrologically important areas and wetlands; and
8. to locate pyritic zones in slates which might impact long-term stability of construction materials and cuts or contribute to stream acidification.

Detailed geologic and soil surveys of the ROW were conducted to verify and augment the existing published data for the area (e.g., King et al. 1958; Hamilton 1961; King 1964; Neuman and Nelson 1965) and the outdated soil survey map for Sevier County (SCS 1956). The geology and soils surveys were conducted using observations during numerous site visits, published U.S. Geological Survey (USGS) maps, and aerial photographs. The information obtained was correlated to USGS topographic quadrangle maps enlarged to 1:12,000 scale and to FHWA maps of the ROW produced at a scale of 1:2000. Detailed findings of the geology and soils investigations are reported in Appendices A (Geology) and B (Soils). The first-order, medium resolution soil map (1:2000 scale) is provided separately. A summary of the geology and soils investigations, including the general 1:12,000-scale soil and parent materials map, is provided in the following sections. Not all soil features can be depicted on the general soil maps (1:12,000), but they are shown on the first-order, medium resolution (1:2000 scale) maps.

### 3.1.3 Local Geology Along Proposed Section 8B

The Foothills Parkway Section 8B ROW is underlain by four rock units: (1) Pigeon Siltstone, consisting mostly of greenish-gray laminated to thinly banded (<3 cm), locally calcareous, metasiltstone, very fine-grained sandstone, and minor coarse sandstone; (2) a clay slate unit, stratigraphically above rocks of the Pigeon Siltstone, consisting of an interbedded medium gray laminated metaslate to thinly (≤3 cm) banded metasiltstone and fine- to medium-grained feldspathic (i.e., contains feldspar) metasandstone; (3) Great Smoky Group sandstone, a massive unit that underlies Webb Mountain and Big Ridge and consists dominantly of thicker (≤2 m) beds of medium- to coarse-grained feldspathic metasandstone and subordinate granule metaconglomerate; and (4) the Yellow Breeches Member of the Wilhite Formation (Walden Creek Group), consisting dominantly of medium to dark gray calcitic and micaceous slate and metasiltstone, with subordinate interbeds (≤3 m) of medium- to coarse-grained argillaceous (i.e., clay or clay-sized particles) and feldspathic metasandstone (Hamilton 1961) (Fig. 3). Several faults cross the ROW, including the Dunn Creek fault, Webb Mountain fault, a portion of the Gatlinburg fault zone, and several unnamed low-angle and high-angle thrust faults (Fig. 3).

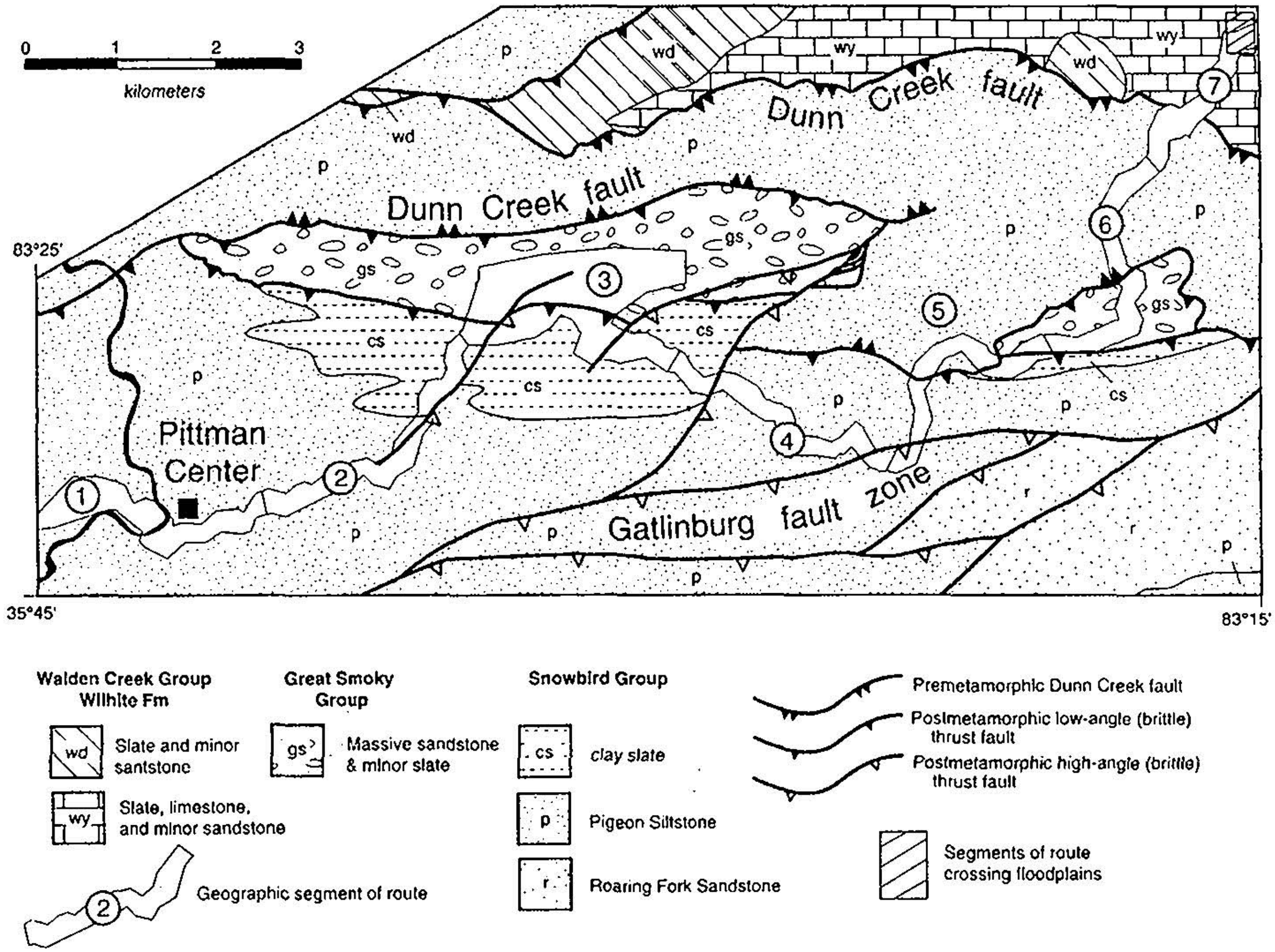


**Fig. 3. Simplified geologic map of the Webb Mountain area.** Segmented 8B right-of-way is lightly shaded. Numbers indicate geographic segments.

The structural data collected along the ROW include bedding*, slaty cleavage**, joint, fault, and quartz vein orientations; they are presented in Appendix A. A diagram of the rock units of the Foothills Parkway, including other sections in addition to Section 8B, and their engineering and other properties that would affect environmental impacts is provided in Fig. 4. Bedding, cleavage, and joint orientations define rock surfaces that may be problematic to stabilize during road construction. In general, orientation of bedding and slaty cleavage in the vicinity of the Section 8B ROW is very consistent, with bedding having a generally E–W strike with shallow to steep N and S dips, and cleavage having a northeast strike and shallow to moderate southeast dip. Further work is needed to characterize the geotechnical engineering properties of these rock surfaces to fully understand their significance with respect to engineering considerations (e.g., measurements of tensile strength, unconfined compressive strength, shear strength, and characterization of friction angles). Numerous outcrop-scale brittle thrust and strike-slip faults have been encountered during the geologic survey, and many more are expected to be uncovered as development proceeds. A more complete analysis of areas of geologic concern and potential impacts is presented in Appendix A.

### 3.1.4 Description of Geology and Soils by Segment

The entire Foothills Parkway Section 8B ROW has been subdivided into 7 segments from west to east for the geology and general soils maps (scale of 1:12,000) and descriptions (Fig. 5). Soil mapping units and parent materials are shown in Table 1. Each segment is considered separately in this section.

#### 3.1.4.1 Little Pigeon River Terraces (segment 1)

In segment 1, the ROW traverses the floodplain and terraces of the Little Pigeon River and slopes of the low hills southwest of Webb Mountain. These hills are underlain by Pigeon Siltstone. Bedding generally strikes E–W, with shallow to steep N dips, and cleavage strikes NE–SW and dips moderately SE. The ROW crosses approximately 500 m of Little Pigeon River alluvium of unknown thickness about 0.3 km southwest of Pittman Center. Additionally, the ROW crosses a fault as recognized by Hamilton (1961) about 300 m east of its western terminus. The fault is interpreted to have duplicated Pigeon Siltstone rocks in this area, but tangible surface evidence for it is lacking. The ROW also crosses three streams, Copeland Creek, Lindsey Creek, and Webb Creek in this segment. Copeland Creek has downcut through the Little Pigeon terraces and is now entrenched (Fig. 6).

Alluvial and colluvial soils dominate this segment. Alluvial soils in the Little Pigeon River floodplain and terraces consist of modern floodplain alluvium with high cobble and boulder content and stratified silts and clays that cover older sands and gravels on terraces. Slopes in much of the ROW in this segment are gentle, although there are a few areas of moderately steep slope near the eastern end of the segment (Fig. 7).

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*Bedding-planar surfaces that separate original layers in sedimentary rocks.

**Slaty cleavage-planar structure produced by compressional deformation that mostly results from recrystallization of fine-grained minerals (commonly clays) in a rock. Slate contains slatty cleavage.

| AGE | | | ROCK UNIT/TYPE | PARKWAY SECTION | ESTIMATED ROCK MASS RATING CATEGORIES | OTHER GEOLOGIC ENVIRONMENTAL IMPACTS |
|---|---|---|---|---|---|---|
| Quat. | Stream and slope deposits | | Alluvium & colluvium: Unconsolidated sand, gravel, boulders, clay in various degrees of sorting | All | Mostly I, some II | unstable slopes excessive sediment to streams |
| Paleoz. | Valley and Ridge units | | *Shale and limestone* | *8D & E1* | sh (F) II–III<br>sh (W) III–IV<br>ls (F) I–II<br>ls (W) II–IV | karst and fracture-controlled cave and ground-water systems |
| CAMBRIAN AND PRECAMBRIAN (?) | Chilhowee Group | | Alternating massive sandstone (+ conglomerate) and brown to gray nonpyritic shale | 8G (?) | ss, cgl (F) I–II<br>ss, cgl (W) III–IV<br>sh, sltst (F) II–III<br>sh, sltst (W) III–IV<br>ls (F) I–II<br>ls (W) II–IV | unstable dip slopes |
| CAMBRIAN AND PRECAMBRIAN (?) | Ocoee Supergroup — Walden Creek Group | | Sandsuck Formation (shale, siltstone, sandstone) | 8G (?) & 8F | | shale yields excessive sediment to streams |
| LATE PROTEROZOIC | Ocoee Supergroup — Walden Creek Group | Wilhite Formation | Yellow Breeches Member (banded siltstone, slate, impure limestone) | 8B & F | | minor karst |
| LATE PROTEROZOIC | Ocoee Supergroup — Walden Creek Group | Wilhite Formation | Dixon Mountain Member (banded siltstone, slate) | 8B & F | | slates yield excessive sediment to streams |
| LATE PROTEROZOIC | Ocoee Supergroup — Walden Creek Group | | Shields Formation (conglomerate, sandstone, shale—some pyritic) | 8B & F | | Intense fracturing & *clay fill in fault zone* |
| | | | Dunn Creek fault | | | |
| LATE PROTEROZOIC | Ocoee Supergroup — Great Smoky Group | | Rocks of Webb Mountain and Big Ridge, Thunderhead Sandstone, Dean Formation<br>Massive graywacke, minor shale (gray to black and pyritic) | 8B, C, & D | ss, cgl (F) I–II<br>ss, cgl (W) III–IV<br>sh (F) II–III<br>sh (W) IV | pyritic slate<br>slate yields excessive sediment to streams |
| | | | Greenbrier or Dunn Creek fault | | | |
| LATE PROTEROZOIC | Ocoee Supergroup — Snowbird Group | | Metcalf Phyllite (W) (phyllite, siltstone, sandstone)<br>Clay slate<br>Pigeon Siltstone (E) (siltstone, phyllite, sandstone) | 8B, C, & D | clay sl (F) II–III<br>clay sl (W) IV<br>sltst (F) II–III<br>sltst (W) III–IV<br>ss (F) I–II<br>ss (W) III–IV | pyrite unit near and minor disseminated pyrite in clay shale<br>slate & phyllite yield excessive sediment to streams |

$RMR = \Sigma (qu + RQD + Js + Jr + Jw + Jo)$, where: qu = unconfined compressive strength, $RQD = \frac{\sum \text{Length core pieces} > 10\text{ cm}}{\text{Total core run length}} \cdot 100$

*RMR = Rock mass rating (I – IV)*  J = Joint parameters, spacing (Js), roughness (Jr), water content (Jw), and orientation (Jo) (Bieniawski, 1989)

**Fig. 4. Rock units of the Foothills Parkway and their engineering and other properties that would affect environmental impacts.**

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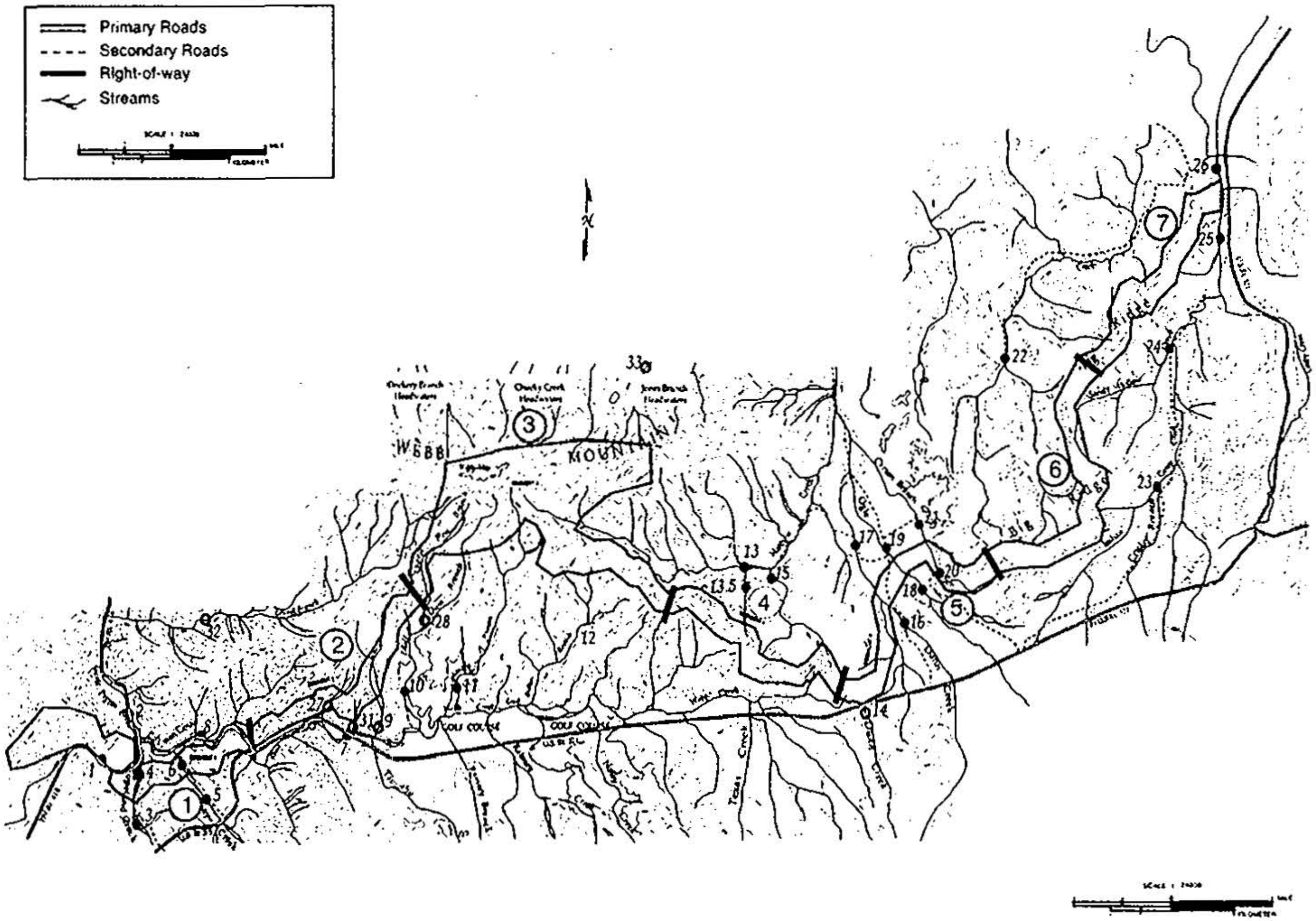


**Fig. 5. Map of right-of-way showing the seven segments into which it was divided for presentation of geology and soils characterization.**

**Table 1. Soil mapping units and parent materials**

| Number[a] | Soil series name (parent material) |
|---|---|
| 1E, 1F, 1G | Cataska-Citico, siltstone phase, rock outcrop complex (Pigeon siltstone residuum |
| 3D, 3E, 3F | Ranger (pigeon siltstone residuum) |
| 4B | Monongahela (Cosby Creek terrace alluvium) |
| 5A | Combs-like (Cosby Creek floodplain alluvium) |
| 6D, 6E, 6F, 6G | Sylco-Citico slaty phase complex (Webb Mountain slate residuum) |
| 7C, 7D, 7E | Junaluska (Pigeon siltstone residuum) |
| 10C, 10D, 10E | Shelocta (Pigeon siltstone colluvium) |
| 20B, 20C, 20D | Braddock (Cosby Creek high terrace alluvium) |
| 21A, 21B, 21C | Craigsville (local floodplain stony alluvium) |
| 22C, 22D, 22E, 22F | Maymead (Great Smoky Group sandstone colluvium) |
| 23A | wetlands Fluvaruents (alluvium) |
| 24D, 24E | Nantahala (Webb Mountain slate residuum) |
| 26D | Keener, non-pyritic phase (Webb Mountain slate colluvium) |
| 27A, 27B, 27C, 27D | State (low terrace alluvium) |
| 28B, 28C, 28D | Lost Cove (very stony mudflow alluvium) |
| 33D, 33E | Unicoi-rock outcrop complex (Great Smokies Group sandstone residuum) |
| 36C, 36D, 36E | Brasstown (Great Smoky Group sandstone residuum) |
| 37D, 37E, 37F, 37G | Soco (Great Smoky Group sandstone residuum) |
| 38C | State, high terrace phase (Little Pigeon River terrace alluvium) |
| 39B | Toccoa (Little Pigeon River 2nd bottom alluvium) |
| Cut and fill | Orthents |

[a]Slope class legend:

| | | |
|---|---|---|
| A | 0 to 2% | |
| B | 2 to 6% | |
| C | 6 to 12% | |
| D | 12 to 25% | |
| E | 25 to 45% | (approximate upper limit for argillic horizons due to slope stability) |
| F | 45 to 65% | |
| G | >65% | (creep processes become very serious) |

Note: Not all of these soils can be shown on the 1:12,000 scale soils map.

### 3.1.4.2 Webb Creek Ridge (segment 2)

In segment 2, the ROW ascends the southwestern footslope ridges of Webb Mountain. Most of this segment is underlain by Pigeon Siltstone. Bedding generally strikes E–W and dips steeply N, and cleavage strikes NE–SW and dips SE as in segment 1. In the northeastern portion of this segment, west of Mill Dam Branch, the ROW centerline approximately parallels a SE-dipping brittle fault zone (<15 m wide) characterized by anastomosing outcrop-scale brittle faults and crosses the structure in the vicinity of the stratigraphic contact between the Pigeon Siltstone and the lower clay unit (near the northeastern end of the segment between boundary monuments 84 and 152) (Fig. 8).

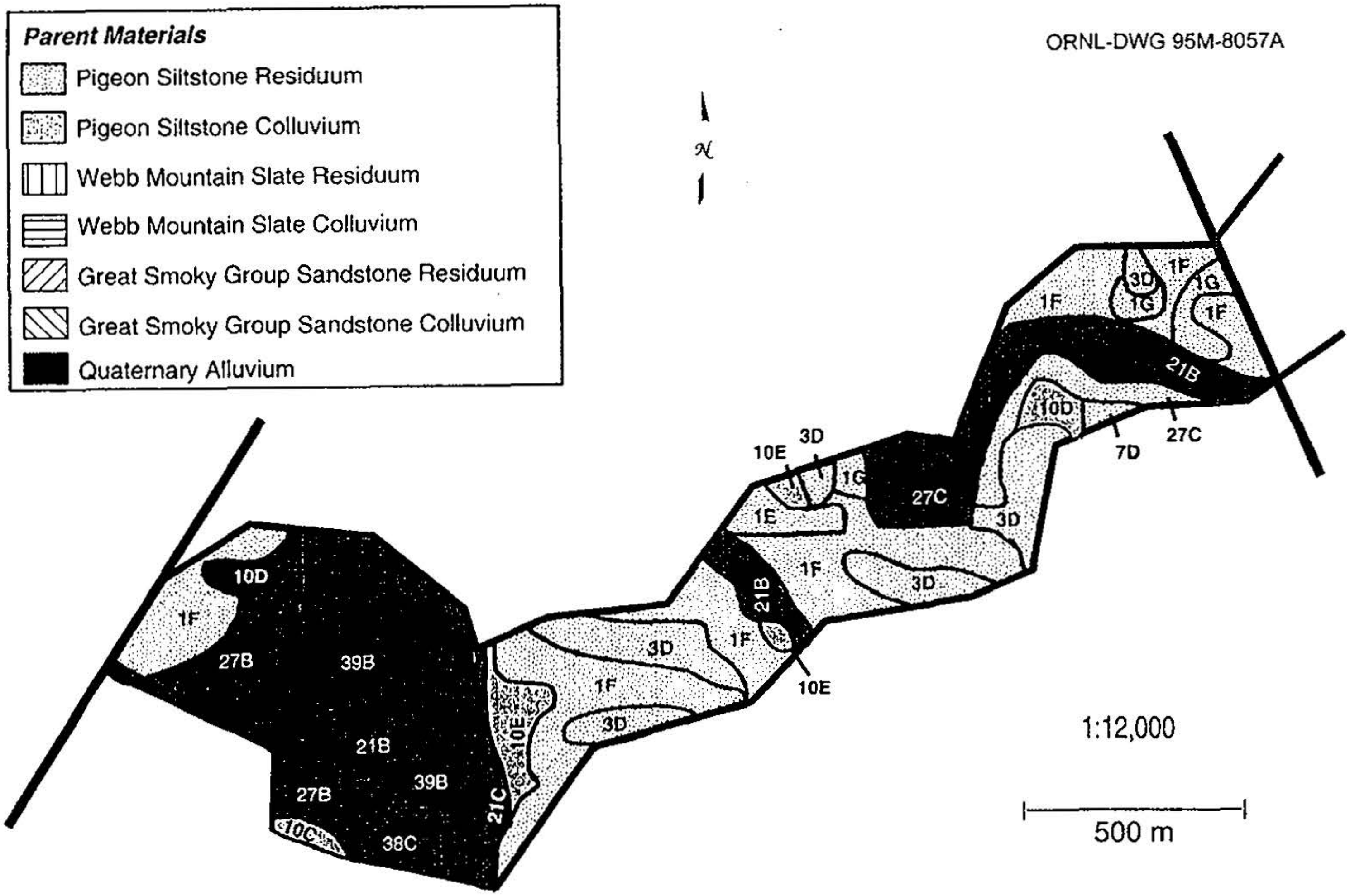


Fig. 6. Parent materials of Segment 1 (Little Pigeon River Terraces).

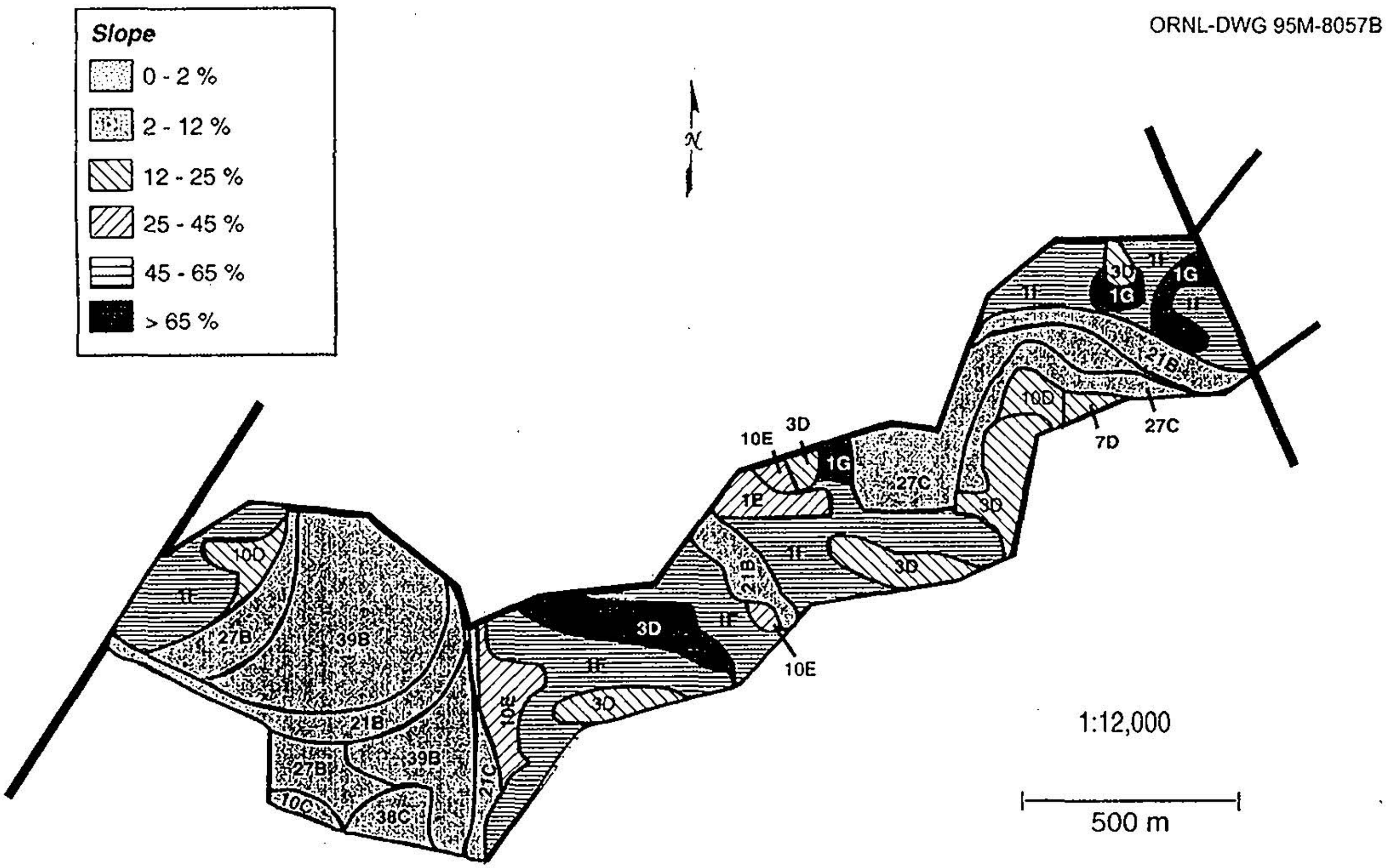


Fig. 7. Slopes of Segment 1 (Little Pigeon River Terraces).

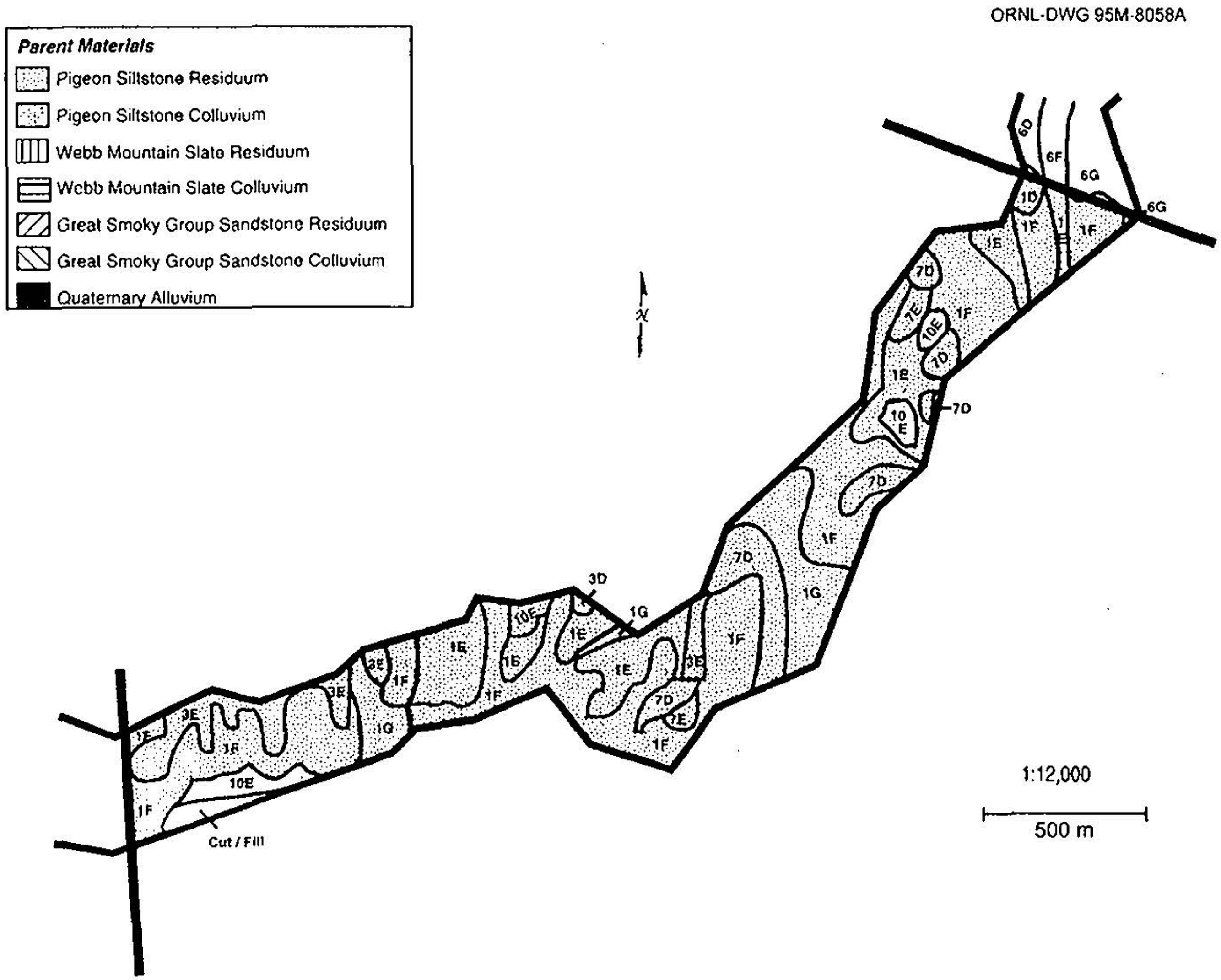


Fig. 8. Parent materials of Segment 2 (Webb Creek Ridge).

Residual soils formed in the Pigeon siltstone dominate this segment. Relatively steep slopes are common, with much of the area having slopes >25%. This segment of the ROW also includes low terraces of Webb Creek along its southwestern edge (Fig. 9).

### 3.1.4.3 Webb Mountain (segment 3)

In segment 3, the ROW traverses the slopes and ridges of Webb Mountain. The ROW centerline and to the south is wholly underlain by rocks of the clay slate unit (which the soil survey refers to as the Webb Mountain slate). North of the centerline, the ROW on Webb Mountain is underlain by coarser-grained rocks of the Great Smoky Group. The Great Smoky Group rocks underlying Webb Mountain generally do not appear to contain significant pyritic materials. However, the lower slate unit (Webb Mountain slate) contains some finely divided pyrite. Although the pyrite content appears to be low, it may be sufficient to produce significant amounts of acid sulfate as the pyritic material weathers. The presence of the Webb Mountain clay slate unit with its low pyrite content is the most likely reason for the elevated sulfate levels observed in streams draining the south side of Webb Mountain, particularly Warden Branch and its headwater tributaries (see Sect. 3.2.3.2). In particular, a recently constructed road in the upper end of Cobbly Knob area near the southern border of the ROW has probably resulted in fresh exposure of pyritic materials and increased sulfate in streams. Bedding and cleavage orientations are the same as in segment 2 to the west (Fig. 10).

Soils of segment 3 of the ROW are primarily residual soils of the Great Smoky Group in the upper portion (above the centerline) and residual soils of the Webb Mountain slate in the lower portion. Slopes are quite steep in this segment, with many areas exceeding 45% (Fig. 11). Numerous colluvial fields of limited extent (<1 ha) and unknown thickness are located on the midslopes. These are too small, however, to be shown on the general soil maps (see Appendix B and the accompanying first-order soil map for details).

### 3.1.4.4 Matthew Branch Ridge (segment 4)

In segment 4, the ROW descends the southeastern footslope ridges of Webb Mountain and is underlain by the non-pyritic Pigeon Siltstone (the stratigraphic contact between the Webb Mountain slate and Pigeon Siltstone is approximately at the border between ROW segments 3 and 4). Bedding strikes NW-SE and dips moderately SW in segment 4, whereas cleavage orientations are the same as in the previous segments (Fig. 12).

Soils of segment 4 are primarily residual soils formed from the Pigeon siltstone, although some areas of colluvium were found. Slopes are also relatively steep, although somewhat less steep than in segment 3 (Fig. 13).

### 3.1.4.5 Rocky Flats (segment 5)

The western one-third of segment 5 consists of the slopes and low hills flanking the southeast side of Webb Mountain and is underlain by rocks of the Pigeon Siltstone (Fig. 14). Bedding strikes E–W and dips steeply N, whereas cleavage orientations are again similar to the previous segments (NE–SW strikes with moderate SE dips). Soils are primarily residual, except for extensive colluvial areas along the eastern edge of the ROW to the west of Rocky Flats. One area of very

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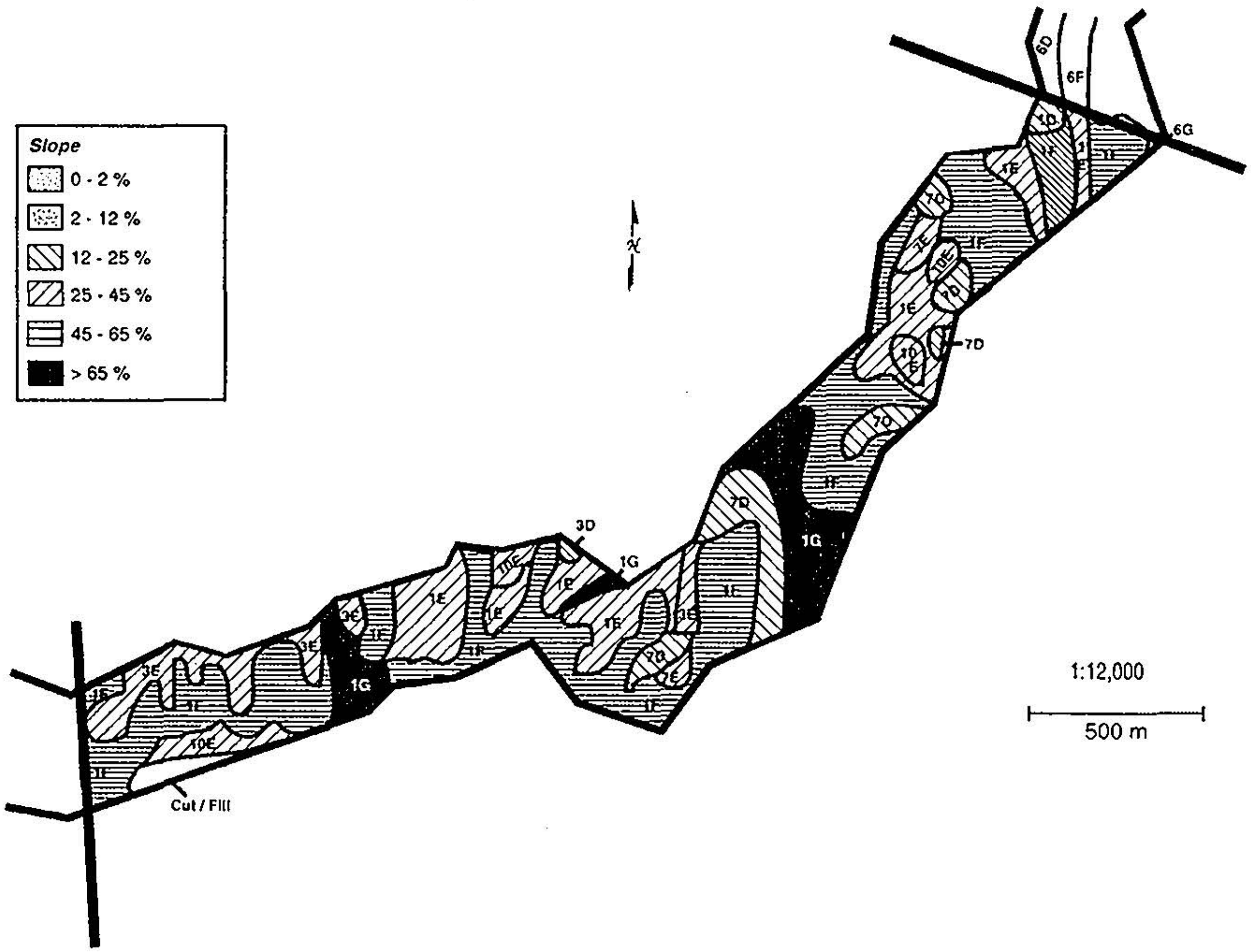


Fig. 9. Slopes of Segment 2 (Webb Creek Ridge).

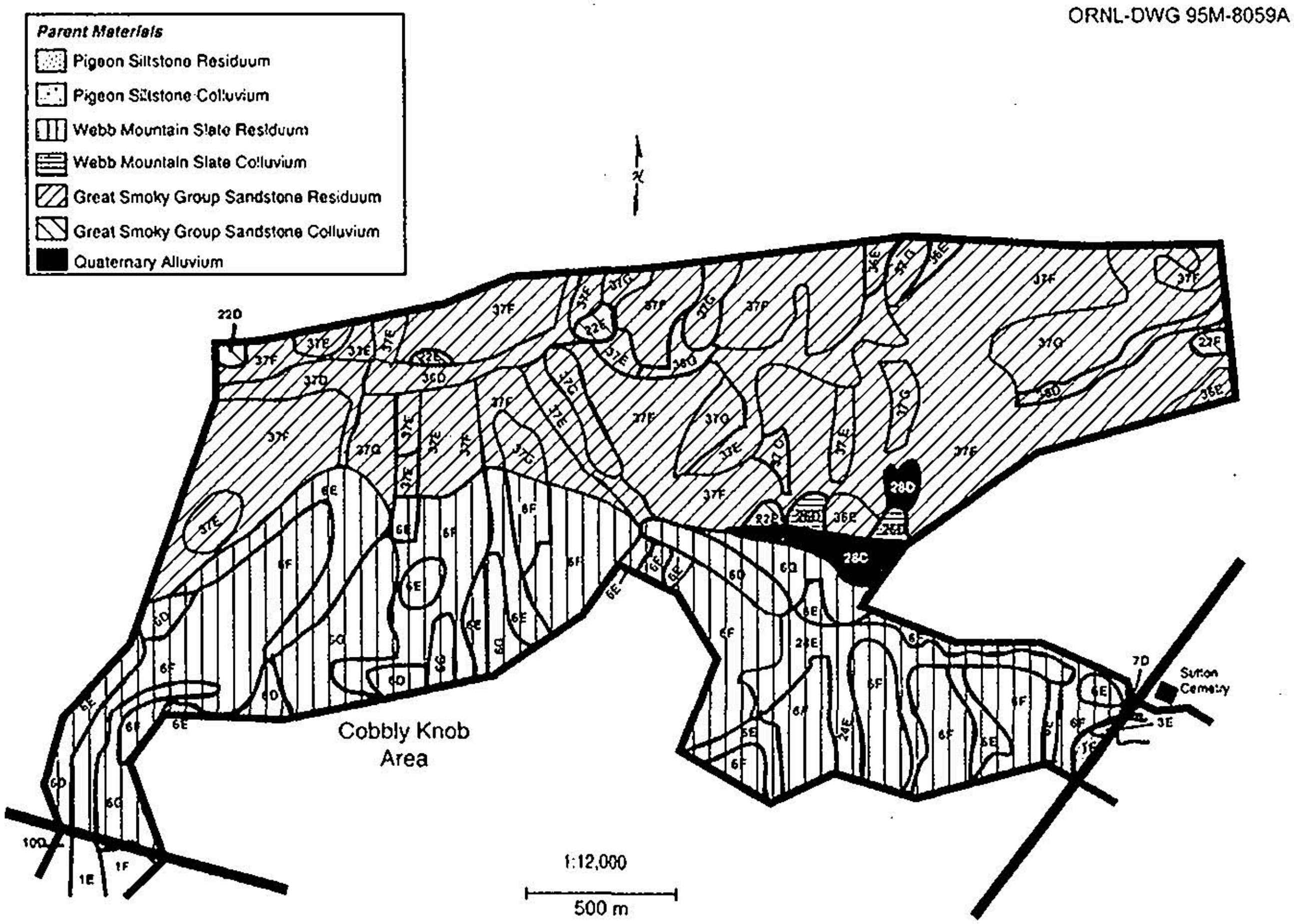


Fig. 10. Parent materials of Segment 3 (Webb Mountain).

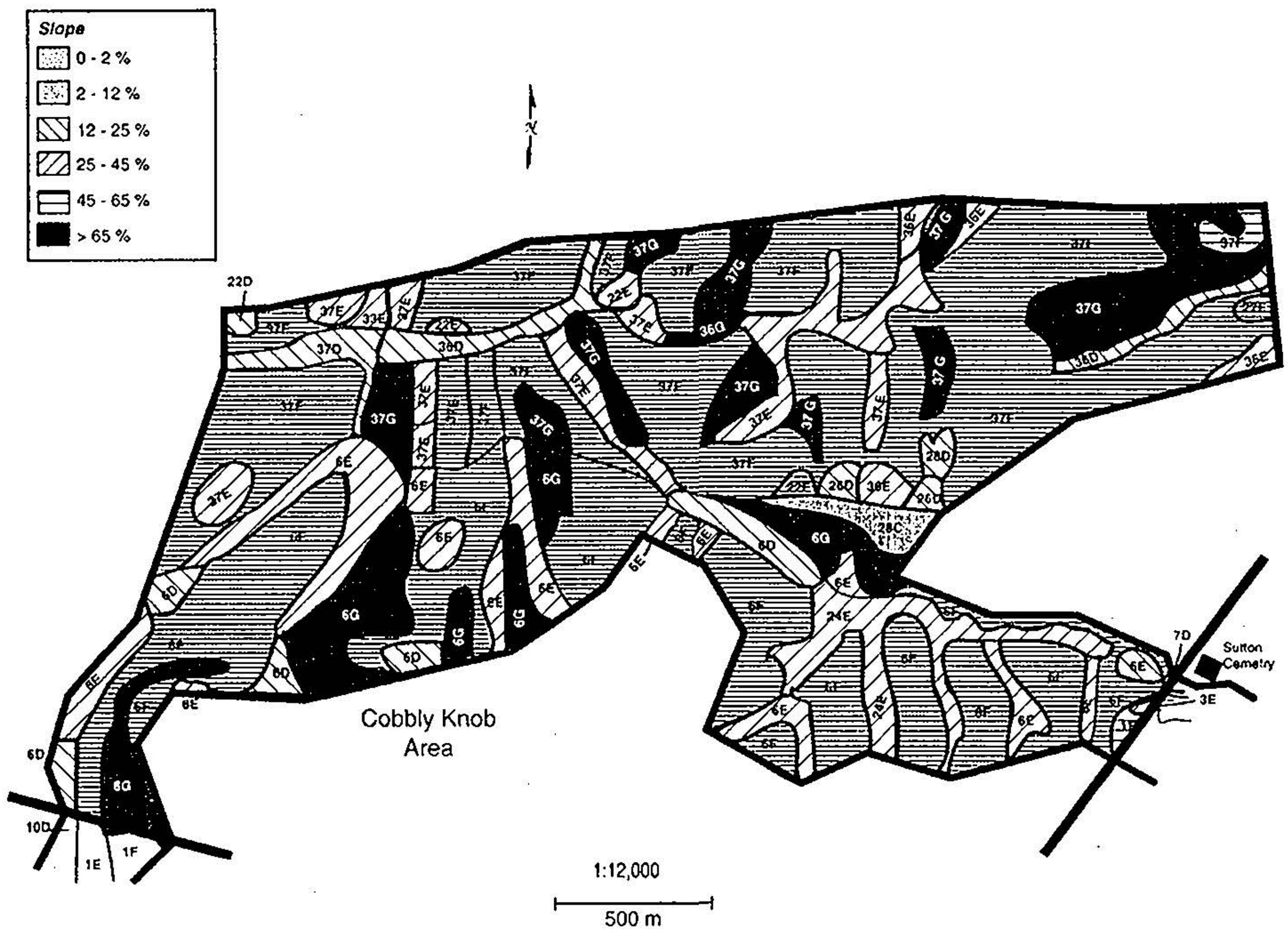


**Fig. 11. Slopes of Segment 3 (Webb Mountain).**

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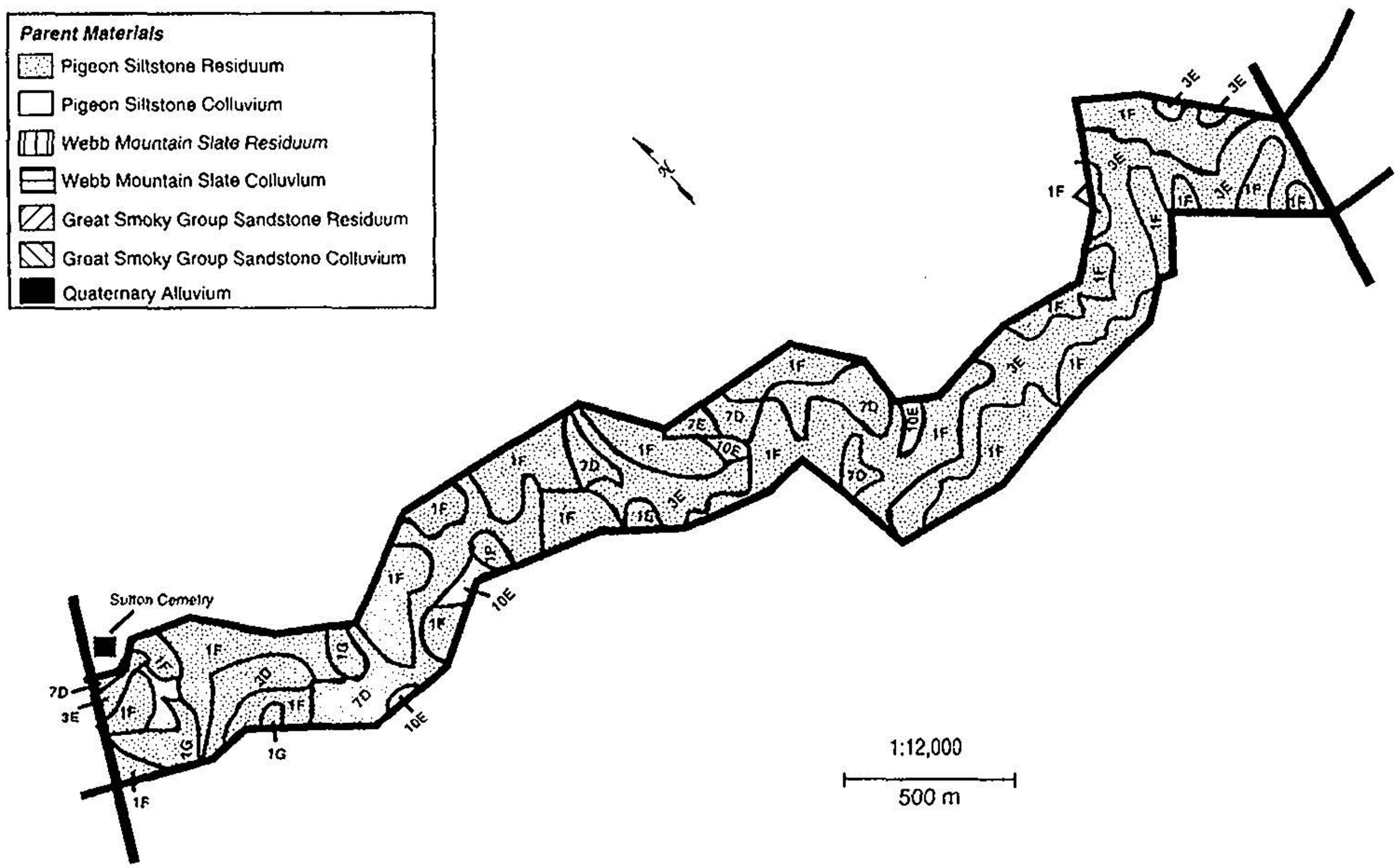


**Fig. 12. Parent materials of Segment 4 (Matthew Branch Ridge).**

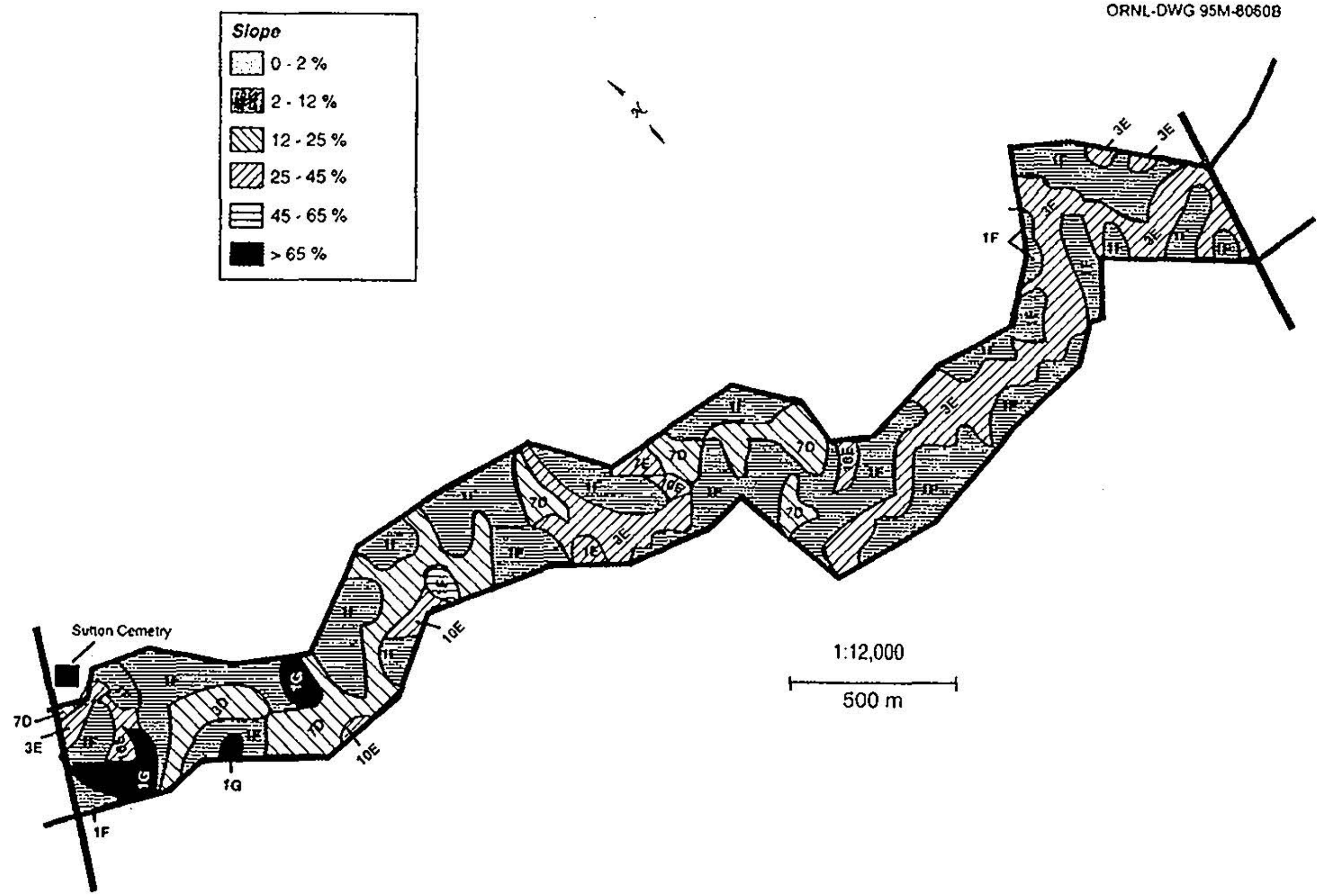


Fig. 13. Slopes of Segment 4 (Matthew Branch Ridge).

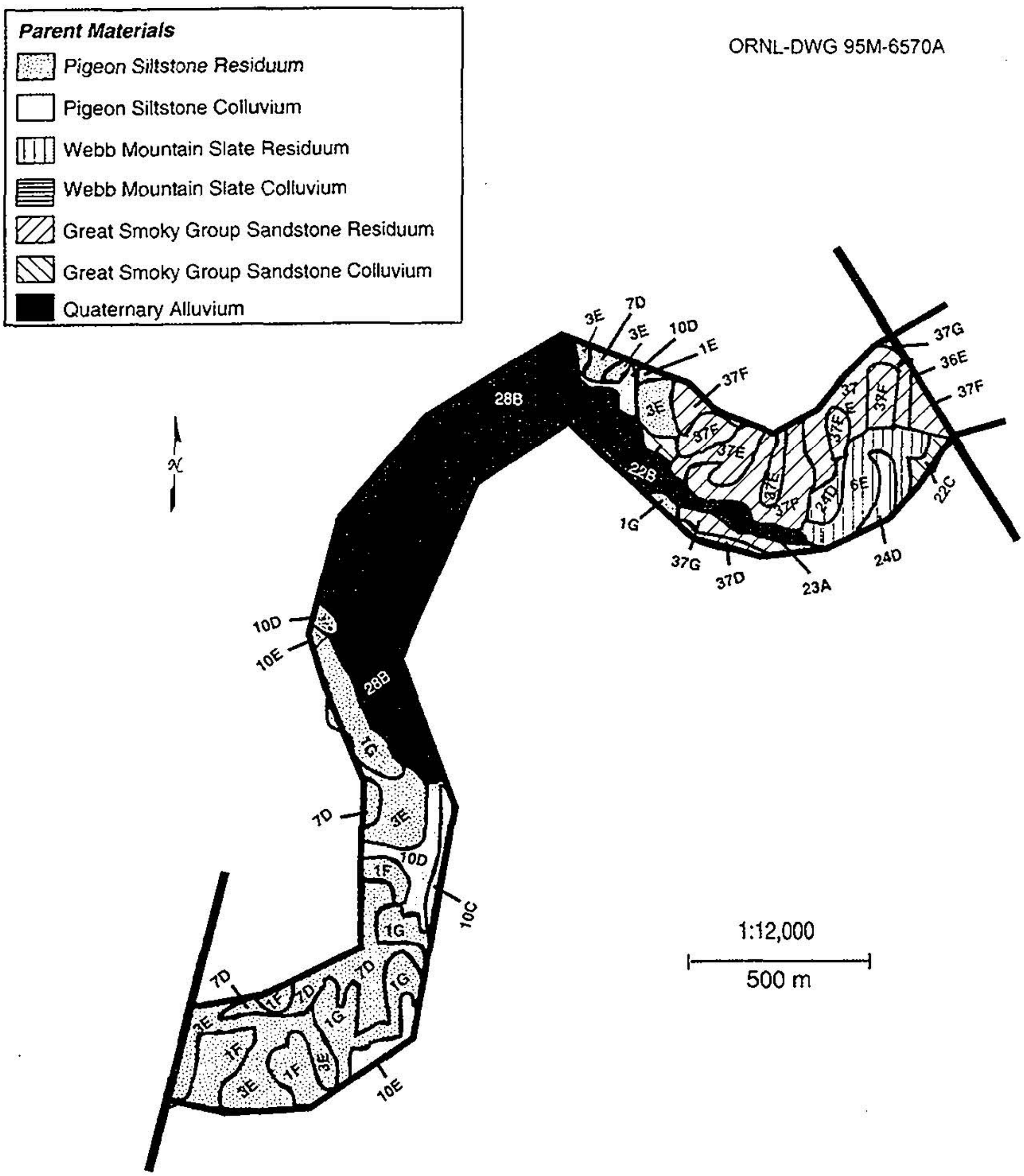


**Fig. 14. Parent materials of Segment 5 (Rocky Flats).**

steep slope (>65%) borders the lowland Rocky Flats area at the eastern end of this portion of segment 5 (Fig. 15; see 1st order soils map and Appendix B for greater detail).

The middle third of segment 5 consists of the Rocky Flats lowland area, which is the toe of a vast colluvial field of unknown thickness composed of blocks ($\leq 3$ $m^3$) of Thunderhead Sandstone (Great Smoky Group) shed from Greenbrier Pinnacle to the south. This area has since been modified extensively by alluvial deposition, stream cuts, and recent agricultural activity. The soils of this area are mapped as alluvium and slopes are gentle, except for a small area of moderately steep residual and colluvial soils formed in Pigeon siltstone to the northeast of Rocky Flats.

The eastern one-third of segment 5 consists of the southwestern slopes of Big Ridge and is mostly underlain by coarse-grained rocks of the Great Smoky Group southeast of the Webb Mountain fault (Fig. 14). To the north of the fault is the Pigeon Siltstone. Hamilton mapped the location of the Webb Mountain fault in this area on the basis of different footwall (Pigeon)/hanging wall (Great Smoky Group) rocks, but surface evidence for a fault is lacking. The soil survey also indicated a stratigraphic contact between the Great Smoky Group rocks and the Webb Mountain slate in the lower eastern portion of segment 5. As described for segment 3, the Webb Mountain slate contains pyritic materials that may produce acid sulfates when exposed and weathered, although streams draining this area do not indicate elevated sulfate levels (see Sect. 3.2.3.2). Bedding and cleavage orientations remain constant from segment 4 across both the fault and the surficial deposits of Rocky Flats (bedding strikes E–W and dips N, cleavage strikes NE–SW and dips SE).

#### 3.1.4.6 Big Ridge (segment 6)

The southern half of segment 6 of the ROW is located close to the top of Big Ridge and is underlain by coarse-grained rocks of the Great Smoky Group (Fig. 16). Bedding and cleavage orientations are similar to those for previous segments (bedding strikes E–W and steep N dips, cleavage strikes NE–SW with moderate SE dips). The coarser sandstone rocks of the Great Smoky Group do not appear to contain pyrite, although thin slate strata within it show some evidence of past pyrite oxidation. Soils are residual and relatively steep (Fig. 17).

The Webb Mountain fault crosses the ROW again near the middle of this segment between boundary monuments 20 and 215/216 (also see Fig. 3), forming the stratigraphic contact between the Great Smoky Group rocks to the south and the Pigeon Siltstone to the north. This fault defines a sharp break in soils and vegetation. To the north are primarily Pigeon siltstone residual soils that, based upon the vegetation differences (white pine and hemlock to the north, virginia pine to the south) may contain higher levels of calcium than the Great Smoky Group soils to the south. In the Pigeon siltstone to the north of the fault, bedding orientations remain constant (E–W strikes with moderate N dips), but cleavage in this area strikes E–W to NW–SE with shallow to moderately steep dips to the S and SW.

#### 3.1.4.7 Cosby Creek Terraces (segment 7)

The southwestern portion of segment 7 of the ROW traverses the upper sideslopes and ridgetop of Big Ridge and is underlain by Pigeon Siltstone (Fig. 18). Soils are formed in siltstone residuum and slopes are moderately steep (Fig. 19). The ROW crosses the Dunn Creek fault on the northeast

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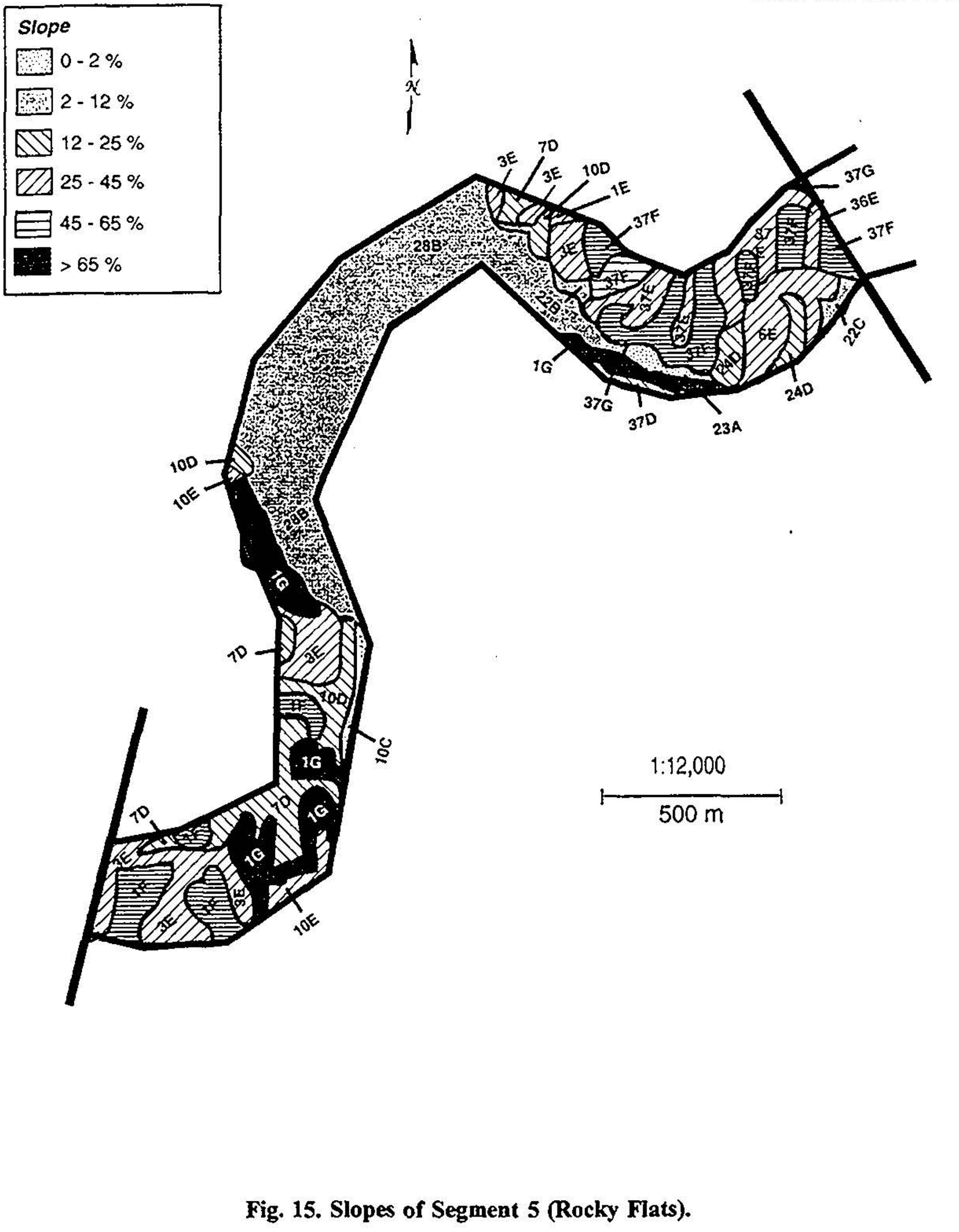


Fig. 15. Slopes of Segment 5 (Rocky Flats).

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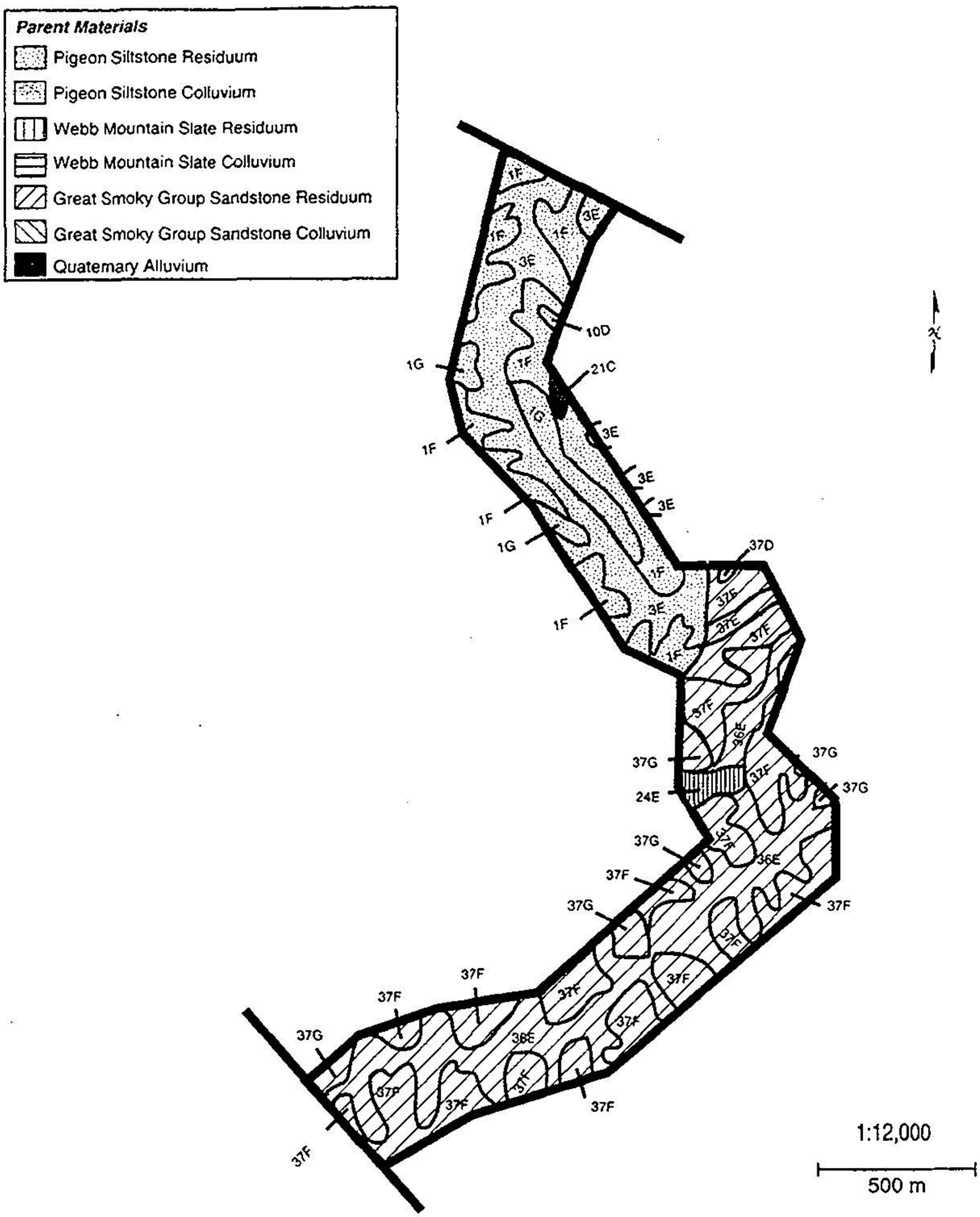


Fig. 16. Parent materials of Segment 6 (Big Ridge).

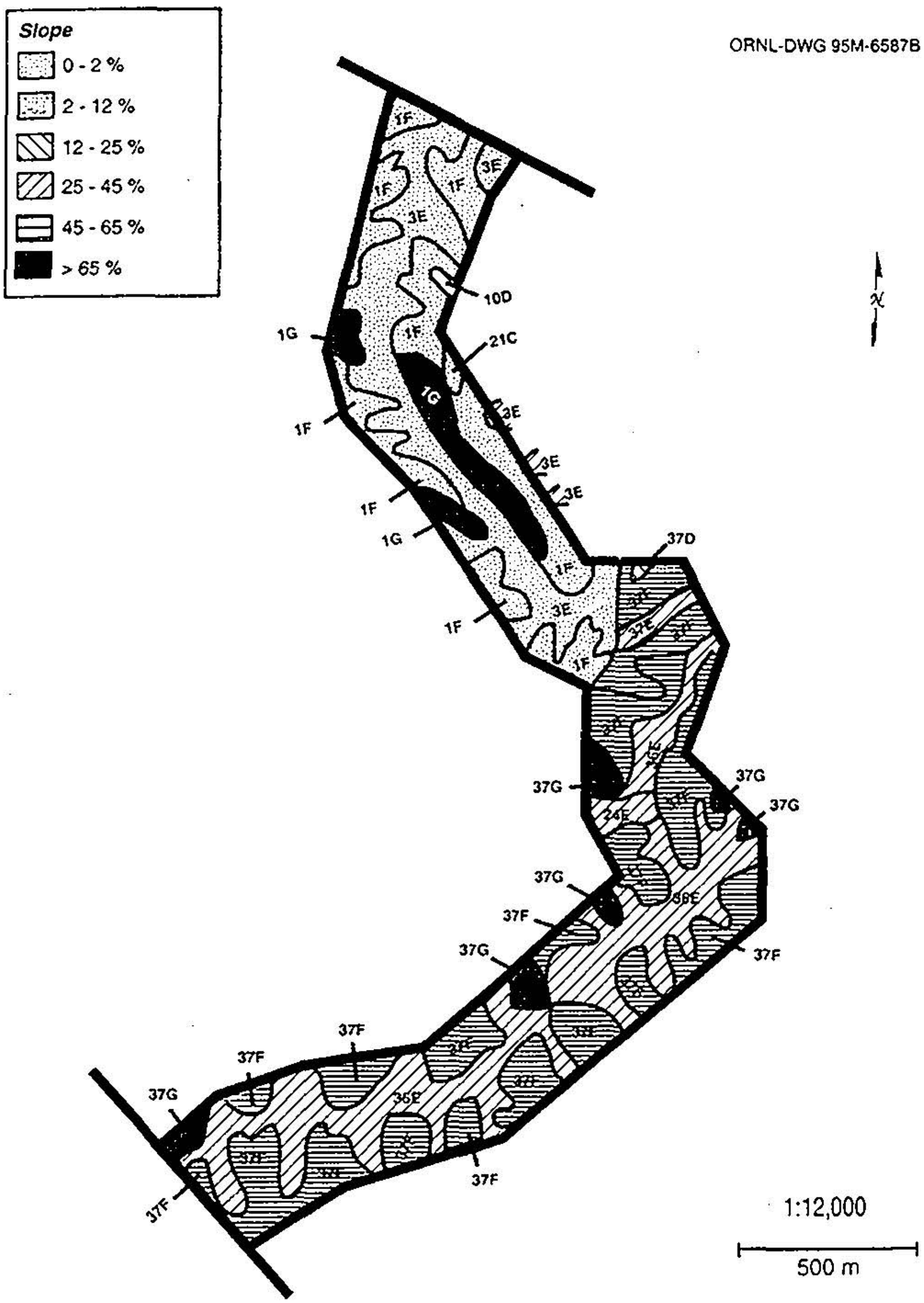


**Fig. 17. Slopes of Segment 6 (Big Ridge).**

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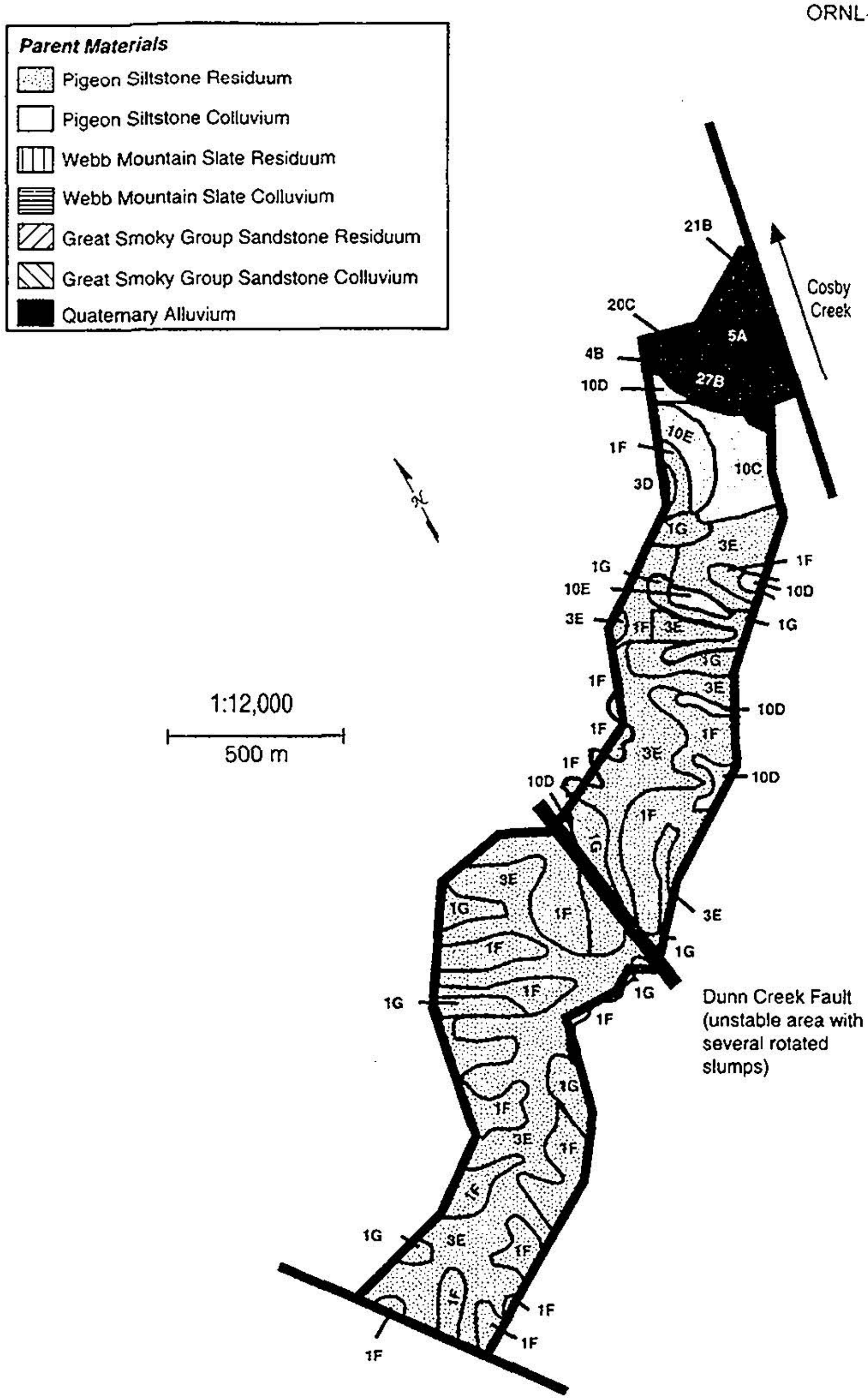


**Fig. 18. Parent materials of Segment 7 (Cosby Creek Terraces).**

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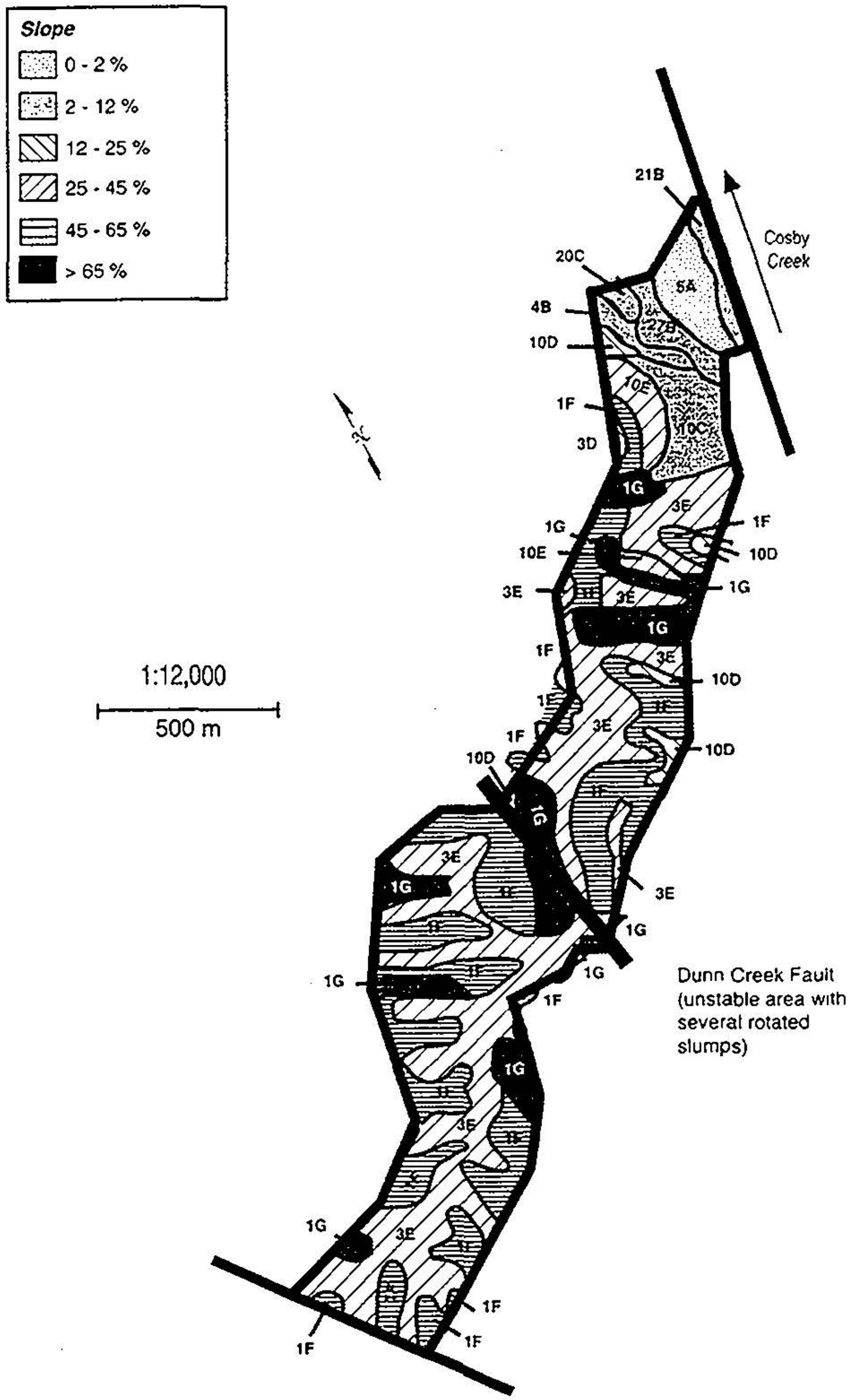


**Fig. 19. Slopes of Segment 7 (Cosby Creek Terraces).**

end of Big Ridge (between boundary monuments 9 and 227). Here the fault forms the stratigraphic contact between the Pigeon Siltstone to the southwest and rocks of the Yellow Breeches Member of the Wilhite Formation to the northeast. The soils and underlying saprolite on either side of the fault do not have many evident differences, although the Yellow Breeches Member contains more calcium carbonate. The same siltstone-derived residual soils were mapped on both sides of the fault. Soils on the northeast side of the fault were severely eroded, probably by past agricultural activity.

The Dunn Creek fault may present stability problems. The rock on either side of the fault has been extensively fractured and shattered, resulting in very deep weathering. The slopes in this area are steep and there is field evidence of slumps and other geomorphic instabilities near this fault. In the northeastern portion of segment 7, the ROW traverses alluvial deposits of unknown thickness forming the terraces of Cosby Creek.

## 3.2 WATER RESOURCES

### 3.2.1 General Description of Surface Waters

The ROW for the proposed parkway extension Section 8B crosses about 30 perennial streams (Fig. 20). The streams in the western end of Section 8B, including those draining the south side of Webb Mountain, either discharge directly to the Little Pigeon River or are tributaries to Webb Creek, which discharges to the Little Pigeon River at Pittman Center. To the east of Webb Mountain, several streams cross the ROW in the low-lying Rocky Flats area. These streams generally flow northward, and some have their headwaters in the GSMNP (e.g., Dunn Creek). Several small wetland areas are found close to streams in the Rocky Flats area (e.g., Carson Branch). To the east of Rocky Flats, streams draining Big Ridge to the north, south, and east discharge to Cosby Creek, a segment of which is crossed by the ROW at the eastern terminus of Section 8B.

Many of the streams studied appear to be affected by human activities, at least in terms of the physical condition of their channels and floodplains. Copeland Creek (near Pittman Center) and Sandy Hollow Creek (draining Big Ridge in the eastern section of the ROW) flow through pasture at the sampling stations, and use of the stream by cattle appears to have resulted in unstable stream banks and siltation of the streambed. Streambed siltation is also evident at the sampling stations on Lindsey Creek in Pittman Center (probably due to residential development adjacent to the stream); Ogle Spring Branch and the lower Carson Branch station in the Rocky Flats area; and Chavis Creek, which drains the north side of Big Ridge (probably as a result of clearing for homes and unpaved roads near the stream channel). Considerable residential development has also occurred in the Webb Mountain area drained by Sheep Pen Branch, Mill Dam Branch, Warden Branch, and Butler Branch (e.g., Cobbly Knob). The roads in this area are mostly paved and many of the homes are on a central sewer system; however, continued home construction in the very steep terrain and runoff from a few new, unpaved roads and cleared residential areas appear to have resulted in minor to moderate siltation impacts in the vicinity of the sampling stations on all of these streams. Webb Creek, which drains much of the south side of Webb Mountain via the streams named earlier, as well as areas to the south of U.S. 321 and Pittman Center, is heavily developed along its length. This development includes a golf course in the Cobbly Knob area, the

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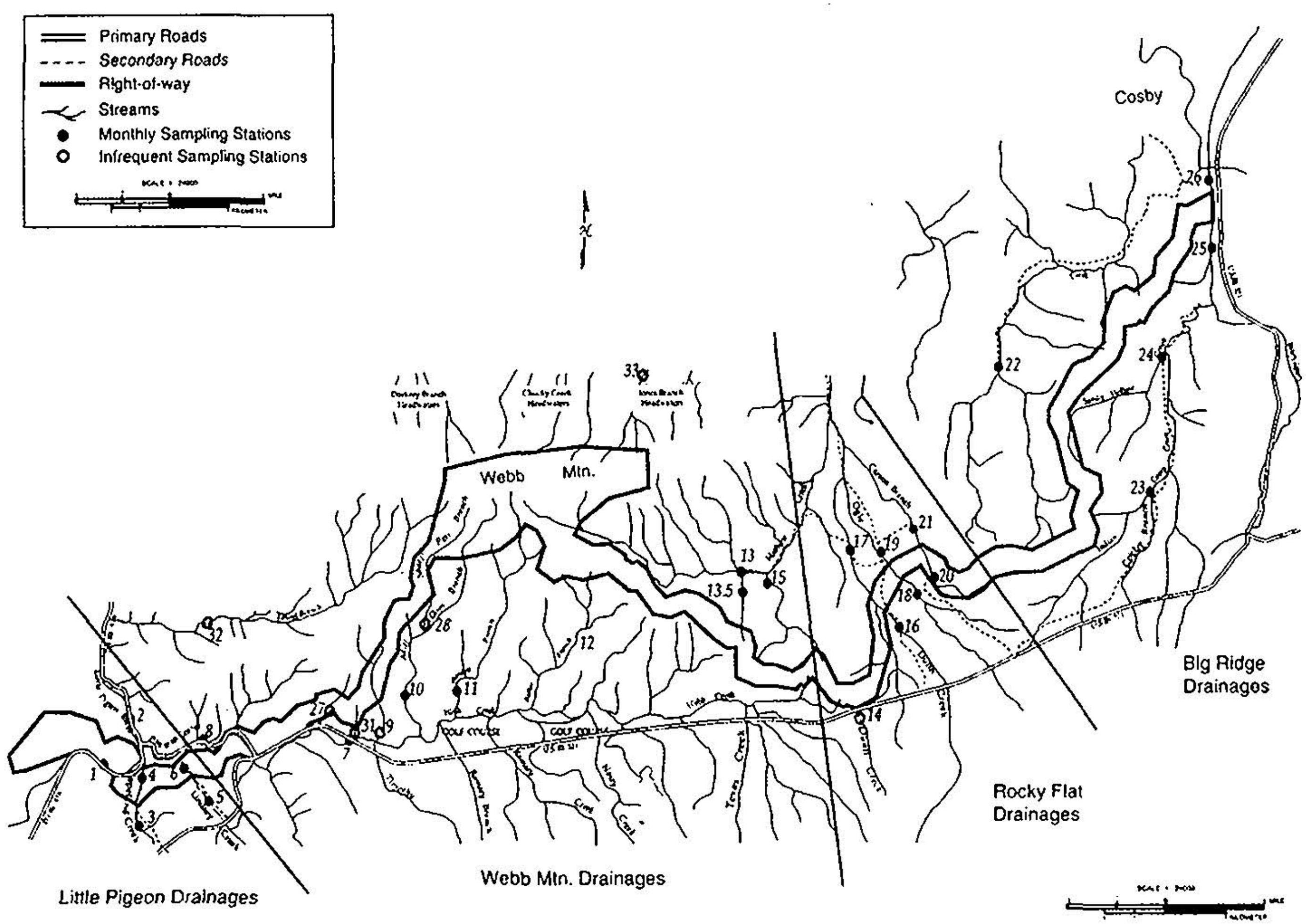


**Fig. 20. Map showing the location of all perennial streams and the stream sampling stations for the water quality and aquatic biota studies for Section 8B.**

outfall for the sewage treatment plant serving the Cobbly Knob residential area on the south side of Webb Mountain, residential development along U.S. 321 and secondary access roads, and the Pittman Center residential/commercial area. This development has resulted in streambank instability and streambed siltation in some reaches of Webb Creek. The two major rivers receiving drainage from the ROW, the Little Pigeon River to the west and Cosby Creek to the east, have their headwaters in the GSMNP but appear to be affected to a minor degree by residential development in the vicinity of and upstream from the sampling stations in this study.

A few streams draining or crossing the Section 8B ROW appear to be only minimally influenced by human activities, at least in terms of development in their catchments or channel characteristics. Matthew Creek, draining the southeastern portion of Webb Mountain, and the upper portion of Carson Branch, which drains the southwestern portion of Big Ridge, including some wetland areas, appear to have very little current human development in their catchments. Dunn Creek and Indian Camp Creek arise in the GSMNP and appear to have limited residential development upstream of the sampling stations used in this study.

A more extensive presentation of observations of human impacts on channel and near-channel conditions in the vicinity of the sampling stations is provided in Appendix C. Included are photographs of each sampling station.

### 3.2.2 Tennessee Stream Use Classification

Stream use classifications established by the Tennessee Department of Environment and Conservation have been determined for each stream being sampled. All streams are classified as suitable for fish and aquatic life (FISH), recreation (REC), irrigation (IRR), and livestock watering and wildlife (LW&W). In addition, the Little Pigeon River and Dunn Creek are classified as suitable for domestic (DOM) and industrial (IND) water supply. Each use classification has a set of water quality criteria, with the DOM and FISH classifications generally being the most stringent (Table 2). Seven streams (Little Pigeon River, Copeland Creek, Webb Creek, Dunn Creek, Matthew Creek, Indian Camp Creek, and Cosby Creek) have also been classified as trout waters and have more stringent water temperature (≤20°C) and dissolved oxygen (≥6 mg/L) criteria.

In addition to the parameter-specific water quality criteria, the state of Tennessee has recently added an antidegradation statement to the Tennessee standards (Chapter 1200-4-3-.06) to fully protect existing uses of all surface waters. This antidegradation statement specifies that certain surface waters can be designated as Outstanding National Resource Waters (ONRWs) by the Tennessee Department of Environment and Conservation because (1) they have important habitat for ecologically significant populations (including rare, threatened and endangered species), (2) they offer specialized recreational opportunities, (3) they have outstanding scenic or geologic values, or (4) they have very high existing water quality. If waters are designated as ONRWs, no new or expanded discharges would be allowed unless it is demonstrated that such activity would not degrade existing water quality. Conversations with Tennessee Division of Water Pollution Control personnel indicated that many of the streams in the vicinity of the ROW, particularly in the Pittman Center and Rocky Flats areas, may be considered for designation as ONRWs in the future; and new activities that have a potential to degrade streams would be closely scrutinized (G. Denton, Tennessee Division of Water Pollution Control, personal communication with P. Mulholland, ORNL, December 20, 1994).

**Table 2. Tennessee water quality criteria for domestic water supply (DOM) and fish and aquatic wildlife (FISH) use classifications**

| | Use classification | |
|---|---|---|
| Parameter | Domestic | Fish and aquatic life |
| Dissolved oxygen | NI[a] | ≥5.0 mg/L[b] |
| pH | 6.0 to 9.0 | 6.5 to 8.5 |
| Hardness | NI | — |
| Total dissolved hardness | 500 mg/L | — |
| Solids, floating material | NI | NI |
| Turbidity | NI | NI |
| Temperature | 30.5°C | 30.5°C[c] |
| Coliform bacteria | 1000/100 mL | — |
| Taste or odor | NI | NI |
| Toxic inorganics:[d] | | |
| Antimony | 6 μg/L | — |
| Arsenic, total | 50 μg/L | — |
| Arsenic (III) | — | 360 μg/L (max), 190 μg/L (cont) |
| Barium | 2 mg/L | — |
| Beryllium | 4 μg/L | — |
| Cadmium, dissolved | 5 μg/L | 1.8 μg/L (max), 0.7 μg/L (cont) |
| Chlorine (TRC) | — | 19 μg/L (max), 11 μg/L (cont) |
| Chromium, total | 100 μg/L | — (max), 100 μg/L (cont) |
| Chromium, IV | — | 16 μg/L (max), 11 μg/L (cont) |
| Copper, dissolved | — | 9.2 μg/L (max), 6.5 μg/L (cont) |
| Cyanide | 200 μg/L | 22 μg/L (max), 5.2 μg/L (cont) |
| Lead, dissolved | 5 μg/L | 33.8 μg/L (max), 1.3 μg/L (cont) |
| Mercury | 2 μg/L | 2.4 μg/L (max), 0.012 μg/L (cont) |
| Nickel, dissolved | 100 μg/L | 789 μg/L (max), 87 μg/L (cont) |
| Selenium | 50 μg/L | 20 μg/L (max), 5 μg/L (cont) |
| Silver, dissolved | 50 μg/L | 1.23 μg/L (max), — (cont) |
| Thallium | 2 μg/L | — |
| Zinc, dissolved | — | 65 μg/L (max), 58.9 μg/L (cont) |
| Toxic organics[e] | | |

[a]NI indicates that the criterion is generally one of non-impairment of the usefulness of the water for the designated use.

[b]For streams designated as trout waters, the criterion is ≥6.0 mg/L.

[c]For streams designated as trout waters, the criterion is ≤20°C (68°F).

[d]Concentration criteria for toxic inorganics are given as maximum permissible concentrations. Two values are listed for the FISH classification, a one-hour maximum criterion (max) and a 24-hour average continuous criterion (cont). For dissolved cadmium, copper, lead, nickel, silver, and zinc, the FISH classification criteria vary with total hardness concentrations. The values listed here are for total hardness ≤50 mg/L, typical of most of the study streams. Criteria concentrations for hardness values >50 mg/L would be somewhat larger than these values.

[e]See reference for Toxic Organics criteria.

*Source:* Rules of the Department of Environment and Conservation, Division of Water Pollution Control, Chapter 1200-4-3 General Water Quality Criteria and Chapter 1200-4-4 Use Classifications for Surface Waters, revised November 1994.)

### 3.2.3 Water Quality

Water quality is a major issue in the planning for Section 8B of the parkway. Many of the streams in this area are of relatively high water quality, as classified by the state of Tennessee, although water quality degradation due to rapid residential and other development in the area is currently a concern. In addition, the recent construction of Sections 8E and 8F of the parkway, which resulted in major deterioration of water quality in some areas (particularly surface water acidification due to exposure of pyritic materials), has contributed to water quality concerns for Section 8B construction. To develop the information needed to evaluate this issue, a 1-year study of water quality in the area of the Section 8B ROW was conducted to establish existing, baseline conditions. This study establishes only the conditions present during the sampling period (1994–1995), and a follow-up study (over at least 1 full year) should be conducted just before construction to establish pre-construction, baseline conditions with which to compare conditions during and after construction for determining construction effects.

#### 3.2.3.1 Data Collection

Thirty stations (Table 3) located on 21 streams were selected for water quality sampling at intervals ranging from monthly to twice during the period from July 1994 to June 1995. For streams that cross the ROW but originate outside of it, sampling stations were chosen at stations upstream and downstream of the ROW (primarily streams in the Pittman Center and Rocky Flats areas). For streams that originate within the ROW, only a downstream station was selected (e.g., streams draining Webb Mountain and Big Ridge). These water quality sampling stations include most of the stations at which biological sampling was conducted.

Early results from the monthly sampling showed somewhat higher sulfate levels in the three streams draining the central portion of Webb Mountain (Mill Dam Branch, Warden Branch, and Butler Branch). Therefore, a one-time survey sampling of streams draining Webb Mountain was conducted on March 20, 1995. The sampling was designed to locate more specifically the source of the higher sulfate levels in these streams and determine whether they were associated with any known geologic source of sulfate (e.g., pyritic material) that may result in surface water acidification problems during parkway construction in this area. Samples were collected from 12 headwater tributaries of Mill Dam Branch, Warden Branch, Butler Branch, and Matthew Creek draining the south side of Webb Mountain, and from 3 stations in the headwaters of Jones Branch and Chucky Creek draining the north side of Webb Mountain (Fig. 21). A few of these stations were revisited and samples collected again in June 1995.

In addition to the routine water quality sampling described, sampling across the hydrographs of several storms was conducted at four stations (Webb Creek-station 8, Warden Branch-station 11, Matthew Creek-station 13, and Carson Branch-station 21). Samples were collected by automatic samplers triggered by a rise in water level monitored by a pressure transducer placed within a stilling pipe in the stream, and recorded by a datalogger. From 5 to 15 samples were collected across each of 2 or 3 storm hydrographs lasting from 1 to 3 days at each station. The storm sampling was performed to evaluate short-term water quality changes resulting from stormflow in selected streams—changes that would not be detected in results from the monthly sampling. The concentrations of many water quality constituents change markedly during stormflow as a result of changes in the dominant hydrologic flowpaths through soils and bedrock and increases in erosion

**Table 3. Water quality sampling stations and sampling frequency [generally listed from west to east** (see Fig. 20)**]**

| Site number | Stream name, relationship to ROW | Sampling frequency |
|---|---|---|
| | **Little Pigeon River/Copeland Creek/Lindsey Creek** | |
| 1-LP-A | Little Pigeon River, above ROW | monthly |
| 2-LP-B | Little Pigeon River, below ROW | monthly |
| 3-CP-A | Copeland Creek, above ROW | monthly |
| 4-CP-B | Copeland Creek, below ROW | monthly |
| 5-LN-A | Lindsey Creek, above ROW | monthly |
| 6-LN-B | Lindsey Creek, below ROW | monthly |
| | **Webb Mountain/Webb Creek Drainages** | |
| 32-LB-B | Laurel Branch, below ROW | semi-annual |
| 7-WB-A | Webb Creek, above ROW | monthly |
| 8-WB-B | Webb Creek, below ROW | monthly |
| 27-WBT1-B | Webb Creek Tributary 1, below ROW | quarterly |
| 31-WBT3-B | Webb Creek Tributary 3, below ROW | semi-annual |
| 9-WBT2-B | Webb Creek Tributary 2, below ROW | quarterly |
| 28-SP-B | Sheep Pen Branch, below ROW | quarterly |
| 10-MD-B | Mill Dam Branch, below ROW | monthly |
| 11-WR-B | Warden Branch, below ROW | monthly |
| 12-BT-B | Butler Branch, below ROW | monthly |
| 33-JB-B | Jones Branch, below ROW | semi-annual |
| 13-MA-B | Matthew Creek, below ROW | monthly |
| 15-MAT-B | Matthew Creek Tributary, below ROW | monthly |
| 13.5-MAT-B | Matthew Creek Tributary, below ROW | no water quality samples |
| | **Rocky Flat Drainages** | |
| 14-DNW-A | Dunn Creek West Branch, above ROW | semi-annual |
| 16-DN-A | Dunn Creek, above ROW | monthly |
| 17-DN-B | Dunn Creek, below ROW | monthly |
| 18-OG-A | Ogle Spring Branch, above ROW | monthly |
| 19-OG-B | Ogle Spring Branch, below ROW | monthly |
| 20-CR-A | Carson Branch, above ROW | monthly |
| 21-CR-B | Carson Branch, below ROW | monthly |
| | **Big Ridge/Cosby Creek Drainages** | |
| 22-CH-B | Chavis Creek, below ROW | monthly |
| 23-IC-B | Indian Camp Creek, below ROW | monthly |
| 24-SH-B | Sandy Hollow Creek, below ROW | monthly |
| 25-CB-A | Cosby Creek, above ROW | monthly |
| 26-CB-B | Cosby Creek, below ROW | monthly |

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**Webb Mountain Stream Survey Sites**

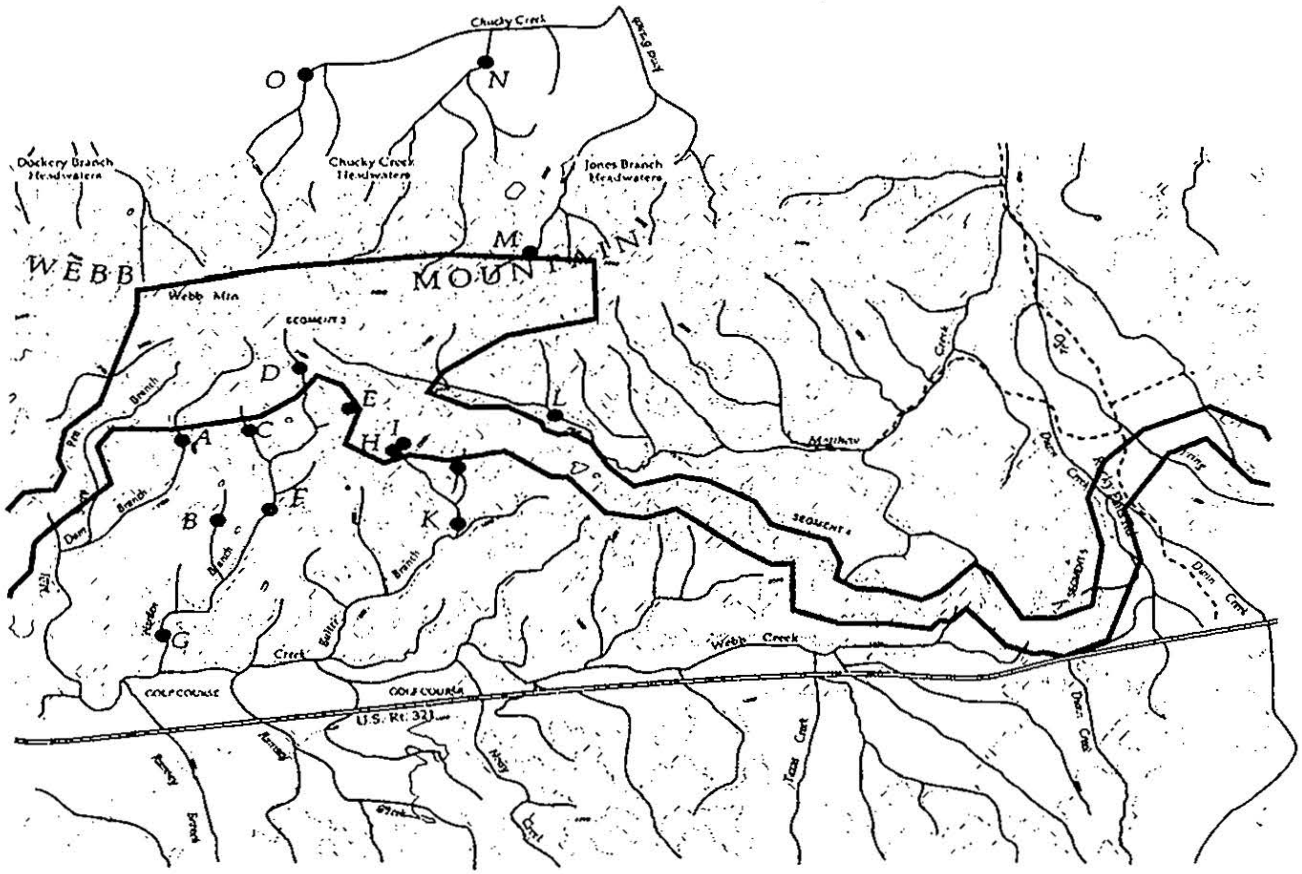


**Fig. 21. Map showing the location of stream sampling stations for the Webb Mountain water quality survey conducted on March 20, 1995.**

and transport of channel and near-channel sediments. The reasons for selecting these particular stations are as follows:

- Webb Creek, because of the extensive development along its corridor;
- Warden Branch, because of its higher sulfate levels (potential drainage of pyritic materials) and home development in its basin;
- Matthew Creek, because of its relatively undisturbed Webb Mountain catchment; and
- Carson Branch, because of the wetlands within its catchment.

Water quality parameters measured included water temperature, electrical conductance, pH, alkalinity, dissolved oxygen, total suspended sediments, major cations and anions, ammonium, nitrite plus nitrate [referred to as nitrate because very little nitrite is usually present at the high dissolved oxygen concentrations (>8.0 mg/L) found at all stations], soluble reactive phosphorus, trace metals, and mercury. The trace metals and mercury measurements were made only quarterly at each station (September, December, March, June) and only for one or two storms at each storm sampling station. For the Webb Mountain survey, trace metals and mercury were not measured. The water quality measurements were designed to allow inferences regarding conditions for fish and other aquatic biota, current effects of agriculture and other human activities in the catchments of these streams, the likelihood of the presence of pyritic materials in the ROW, and potential effects of parkway construction and operation on the surface waters. Field and laboratory water quality analysis procedures, data, and quality assurance/quality control considerations are presented in Appendix C.

### 3.2.3.2 Existing Surface Water Quality

**Monthly Sampling Results.** Water quality data are summarized (means, standard deviations, number of samples) in Tables 4, 5, and 6 for all stream stations sampled. In general, samples collected during the period July to November 1994 and May and June 1995 were during periods of relatively low flow; and samples collected during December 1994 to April 1995 were for somewhat higher flow, but were not representative of stormflow. Considering the physical and bulk chemical parameters (Table 4, Fig. 22), several streams stand out as having low alkalinity (<190 $\mu$Equiv/L) and electrical conductance (<37 $\mu$S/cm). The Little Pigeon River (stations 1 and 2), Dunn Creek (stations 14, 16, and 17), and Indian Camp Creek (station 23) have their headwaters in the GSMNP; and water quality at the study stations primarily reflects the dilute and poorly buffered character of most GSMNP streams. Laurel Branch (station 32), Mill Dam Branch (station 10), Sheep Pen Branch (station 28), unnamed Webb Creek tributary 3 (station 31), Jones Branch (station 33), and Matthew Branch (station 13), all of which drain Webb Mountain, also are dilute, poorly buffered streams. However, as noted above, Mill Dam Branch and Sheep Pen Branch have some evidence of siltation resulting from development in their catchments. Carson Branch (stations 20 and 21), which originates on the southwest flank of Big Ridge, also has low electrical conductance and alkalinity, although there is evidence of moderate siltation from development at the downstream station (21). All streams had relatively high dissolved oxygen concentrations (>9 mg/L).

Streams with the highest ionic strength and alkalinity are generally those with considerable human disturbance in their catchments (e.g., homes, roads, golf courses, agriculture and livestock). They include Copeland Creek (sites 3 and 4), Lindsey Creek (stations 5 and 6), Webb Creek (stations 7

**Table 4. Average physical and bulk chemical characteristics from July 1994 to June 1995**

| Site | Water temperature (C) | Dissolved oxygen (mg/L) | Conductance (μS/cm) | pH (units) | Alkalinity (μeg/L) | Dissolved organic carbon (mg/L) | Total suspended solids (mg/L) | Organic suspended solids (mg/L) |
|---|---|---|---|---|---|---|---|---|
| 1-LP-A | 9.8 (5.6) | 12.1 (3.1) | 19.2 (1.5) | 6.84 (0.5) | 65 (17.1) | 1.2 (0.8) | 0.9 (0.5) | 0.7 (ND) |
| 2-LP-B | 9.9 (5.6) | 11.6 (1.6) | 28.3 (2.9) | 6.98 (0.2) | 150 (30.3) | 1.2 (0.7) | 1.4 (0.6) | 0.8 (ND) |
| 3-CP-A | 10.5 (5.3) | 11.1 (1.5) | 38.5 (5.3) | 7.04 (0.2) | 282 (53.7) | 0.9 (0.6) | 2.6 (1.5) | 1.0 (ND) |
| 4-CP-B | 10.5 (5.6) | 11.3 (1.6) | 45.3 (5.9) | 7.16 (0.1) | 330 (67.1) | 1.0 (0.6) | 4.0 (2.2) | 1.2 (ND) |
| 5-LN-A | 12.7 (5.6) | 10.3 (1.5) | 65.6 (12.6) | 7.12 (0.1) | 441 (93.4) | 1.1 (0.6) | 6.8 (4.7) | 1.7 (1.3) |
| 6-LN-B | 12.3 (5.6) | 10.4 (1.5) | 65.3 (9.8) | 7.28 (0.1) | 461 (85.2) | 1.0 (0.4) | 7.6 (5.5) | 1.7 (1.4) |
| 7-WB-A | 10.9 (5.7) | 11.2 (1.5) | 46.9 (9.4) | 7.33 (0.1) | 298 (68.0) | 1.1 (0.6) | 3.4 (1.9) | 1.2 (ND) |
| 8-WB-B | 10.7 (5.8) | 11.3 (1.6) | 47.0 (8.0) | 7.31 (0.2) | 321 (79.0) | 1.2 (0.9) | 3.5 (2.5) | 1.1 (ND) |
| 32-LB-B | 9.9 (7.2) | 12.3 (0.8) | 30.3 (3.8) | 7.03 (0.1) | 186 (42.0) | 0.6 (0.2) | 6.7 (5.0) | 1.3 (0.7) |
| 27-WBT1-B | 12.2 (4.3) | 10.0 (1.2) | 52.7 (5.8) | 6.95 (0.1) | 382 (68.3) | 0.9 (0.3) | 4.5 (1.5) | 1.4 (ND) |
| 31-WBT3-B | 9.3 (N1) | 10.6 (N1) | 31.1 (N1) | 6.64 (N1) | 184 (N1) | 0.7 (N1) | 10.2 (N1) | 1.5 (N1) |
| 9-WBT2-B | 11.5 (5.5) | 10.7 (1.3) | 37.0 (5.6) | 7.17 (0.1) | 245 (55.4) | 0.8 (0.3) | 5.9 (3.3) | 2.2 (1.3) |
| 28-SP-B | 12.7 (4.5) | 10.1 (0.9) | 30.6 (5.6) | 6.91 (0.0) | 167 (51.1) | 0.8 (0.3) | 6.4 (5.8) | 2.1 (ND) |
| 10-MD-B | 10.6 (5.3) | 11.2 (1.6) | 33.6 (4.4) | 7.18 (0.2) | 192 (37.2) | 1.1 (0.5) | 2.4 (1.6) | 1.0 (ND) |
| 11-WR-B | 10.4 (5.6) | 11.1 (1.6) | 50.0 (6.2) | 7.18 (0.1) | 276 (50.5) | 0.9 (0.4) | 3.6 (2.3) | 1.2 (ND) |
| 12-BT-B | 11.5 (5.2) | 10.2 (1.4) | 56.7 (8.5) | 7.21 (0.1) | 379 (93.1) | 0.9 (0.5) | 6.0 (2.5) | 1.7 (1.1) |
| 33-JB-B | 14.2 (4.9) | 10.5 (N1) | 36.3 (12.4) | 7.04 (0.2) | 185 (89.1) | 0.4 (ND) | 2.2 (0.1) | 0.6 (ND) |
| 13-MA-B | 10.8 (5.4) | 10.9 (1.5) | 24.3 (2.3) | 7.11 (0.2) | 134 (20.8) | 1.0 (0.4) | 1.9 (1.0) | 0.9 (ND) |
| 15-MAT-B | 11.3 (5.2) | 10.8 (1.5) | 50.9 (7.6) | 7.30 (0.1) | 394 (71.8) | 0.8 (0.5) | 10.5 (5.6) | 2.2 (1.4) |

**Table 4. Continued**

| Site | Water temperature (C) | Dissolved oxygen (mg/L) | Conductance (μS/cm) | pH (units) | Alkalinity (μeg/L) | Dissolved organic carbon (mg/L) | Total suspended solids (mg/L) | Organic suspended solids (mg/L) |
|---|---|---|---|---|---|---|---|---|
| 14-DNW-A | 12.4 (4.9) | 10.8 (N1) | 16.7 (3.6) | 7.23 (0.4) | 118 (31.1) | 0.8 (ND) | 17.0 (17.2) | 3.3 (ND) |
| 16-DN-A | 10.4 (5.3) | 10.9 (1.4) | 20.9 (12.0) | 7.01 (0.2) | 70 (19.9) | 0.9 (0.5) | 2.1 (1.2) | 1.2 (ND) |
| 17-DN-B | 10.8 (5.2) | 11.0 (1.5) | 24.5 (3.0) | 7.09 (0.3) | 117 (31.3) | 0.9 (0.6) | 3.0 (2.2) | 1.3 (ND) |
| 18-OG-A | 11.7 (5.1) | 10.2 (1.7) | 56.5 (4.4) | 7.00 (0.1) | 281 (36.8) | 1.3 (0.4) | 10.3 (6.0) | 3.3 (1.8) |
| 19-OG-B | 11.7 (4.9) | 10.4 (1.3) | 50.9 (2.7) | 7.12 (0.1) | 267 (36.6) | 1.2 (0.4) | 6.3 (3.0) | 2.4 (1.4) |
| 20-CR-A | 11.2 (5.0) | 10.6 (1.6) | 22.8 (1.9) | 6.93 (0.1) | 133 (16.5) | 0.9 (0.6) | 4.1 (2.7) | 1.6 (ND) |
| 21-CR-B | 11.9 (5.0) | 10.3 (1.4) | 26.9 (2.8) | 6.88 (0.2) | 172 (25.1) | 1.2 (0.7) | 9.7 (5.5) | 2.1 (1.3) |
| 22-CH-B | 13.7 (5.2) | 9.9 (1.3) | 40.4 (6.0) | 7.06 (0.1) | 329 (67.2) | 1.0 (0.5) | 7.1 (4.1) | 1.2 (ND) |
| 23-IC-B | 10.8 (4.9) | 11.0 (1.6) | 31.6 (6.4) | 7.07 (0.1) | 185 (60.7) | 0.9 (0.5) | 1.7 (1.2) | 1.0 (ND) |
| 24-SH-B | 13.8 (5.4) | 9.7 (1.3) | 37.1 (4.5) | 7.13 (0.1) | 272 (48.7) | 1.3 (0.7) | 5.5 (2.8) | 1.4 (0.9) |
| 25-CB-A | 12.4 (5.2) | 10.6 (1.2) | 33.5 (4.7) | 7.11 (0.3) | 214 (58.1) | 1.1 (0.7) | 2.3 (1.1) | 1.0 (ND) |
| 26-CB-B | 12.9 (5.4) | 10.6 (1.2) | 37.2 (4.9) | 7.25 (0.2) | 234 (58.0) | 1.0 (0.4) | 2.3 (1.1) | 1.0 (ND) |

[a]Results less than the detection limit were set to 1/2 the detection limit to compute the average and standard deviation. The standard deviation is in parentheses following the average. The average is followed by (ND) if more than 50% of the results were below the detection limit. The average is followed by (N1) when only one measurement was made.

**Table 5. Average chemical concentrations from July 1994 to June 1995**

| Site | $PO_4$ (μg-P/L) | $NH_4$ (μg-N/L) | $NO_3$ (μ-N/L) | Cl (mg/L) | $SO_4$ (mg/L) | Na (mg/L) | K (mg/L) | Ca (mg/L) | Mg (mg/L) | Si (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1-LP-A | 3 (1.0) | 7 (2.1) | 323 (101.1) | 0.6 (0.1) | 2.6 (0.2) | 0.9 (0.1) | 0.8 (ND) | 1.6 (0.1) | 0.4 (0.0) | 2.6 (0.3) |
| 2-LP-B | 9 (1.5) | 7 (3.5) | 275 (84.4) | 0.9 (0.2) | 2.6 (0.2) | 1.4 (0.2) | 0.8 (ND) | 2.6 (0.3) | 0.6 (0.1) | 3.3 (0.3) |
| 3-CP-A | 27 (4.3) | 5 (1.9) | 27 (20.4) | 1.4 (0.2) | 1.5 (0.3) | 2.8 (0.3) | 0.7 (ND) | 3.0 (0.5) | 1.0 (0.2) | 6.5 (0.5) |
| 4-CP-B | 29 (8.2) | 7 (4.3) | 46 (14.6) | 2.0 (0.2) | 1.7 (0.4) | 3.0 (0.4) | 0.8 (ND) | 3.9 (0.5) | 1.1 (0.2) | 6.4 (0.5) |
| 5-LN-A | 29 (29.3) | 47 (128.0) | 97 (63.2) | 4.3 (0.9) | 1.9 (0.8) | 4.0 (0.7) | 0.8 (ND) | 5.8 (1.2) | 1.7 (0.4) | 6.7 (0.8) |
| 6-LN-B | 29 (22.8) | 34 (95.4) | 115 (55.1) | 3.8 (0.5) | 2.0 (0.8) | 3.9 (0.5) | 0.8 (ND) | 5.8 (0.9) | 1.7 (0.3) | 6.7 (0.7) |
| 7-WB-A | 38 (17.0) | 12 (16.3) | 349 (114.6) | 1.5 (0.3) | 2.7 (0.6) | 2.4 (0.4) | 0.9 (ND) | 4.8 (1.0) | 0.9 (0.2) | 4.7 (0.3) |
| 8-WB-B | 28 (8.5) | 6 (4.0) | 269 (136.7) | 1.4 (0.2) | 2.4 (0.2) | 2.4 (0.3) | 0.8 (ND) | 4.9 (1.1) | 1.0 (0.2) | 4.9 (0.3) |
| 32-LB-B | 10 (1.7) | 8 (10.6) | 46 (50.5) | 0.5 (0.1) | 3.5 (0.4) | 2.2 (0.3) | 1.2 (ND) | 1.9 (0.3) | 0.8 (0.1) | 6.1 (0.4) |
| 27-WBT1-B | 42 (9.5) | 7 (3.1) | 40 (9.1) | 0.7 (0.2) | 3.6 (0.5) | 4.2 (0.4) | 1.1 (ND) | 4.0 (0.5) | 1.3 (0.1) | 9.4 (0.6) |
| 31-WBT3-B | 28 (N1) | 2 (N1) | 13 (N1) | 0.7 (N1) | 3.7 (N1) | 3.1 (N1) | 1.0 (ND) | 1.6 (N1) | 0.8 (N1) | 8.1 (N1) |
| 9-WBT2-B | 40 (9.9) | 3 (2.3) | 40 (45.9) | 0.5 (0.0) | 3.6 (0.4) | 3.1 (0.4) | 1.1 (ND) | 2.4 (0.4) | 1.0 (0.1) | 7.7 (0.8) |
| 28-SP-B | 21 (12.7) | 5 (4.0) | 41 (39.4) | 0.5 (0.1) | 3.8 (0.5) | 2.5 (0.4) | 1.2 (ND) | 1.6 (0.3) | 0.8 (0.1) | 6.9 (1.0) |
| 10-MD-B | 25 (4.2) | 4 (1.8) | 33 (30.6) | 0.5 (0.0) | 3.8 (0.5) | 2.7 (0.3) | 0.9 (ND) | 2.0 (0.3) | 0.9 (0.1) | 6.8 (1.6) |
| 11-WR-B | 18 (3.3) | 3 (1.7) | 49 (31.2) | 1.0 (0.1) | 6.5 (0.7) | 3.1 (0.3) | 0.9 (ND) | 4.0 (0.6) | 1.2 (0.2) | 7.2 (0.6) |
| 12-BT-B | 12 (3.1) | 3 (1.3) | 172 (66.2) | 1.6 (0.3) | 4.2 (0.6) | 3.1 (0.3) | 0.9 (ND) | 5.4 (1.1) | 1.3 (0.2) | 6.8 (0.5) |
| 33-JB-B | 10 (3.1) | 3 (0.7) | 93 (93.4) | 0.5 (0.1) | 5.3 (0.9) | 1.4 (0.3) | 1.5 (ND) | 3.4 (1.3) | 0.8 (0.2) | 4.8 (0.7) |
| 13-MA-B | 12 (2.0) | 3 (1.4) | 29 (27.7) | 0.5 (0.1) | 3.0 (0.3) | 1.7 (0.2) | 0.9 (ND) | 1.3 (0.1) | 0.7 (0.1) | 5.8 (0.5) |
| 15-MAT-B | 28 (3.8) | 3 (1.5) | 125 (46.5) | 1.1 (0.2) | 2.2 (0.3) | 2.7 (0.3) | 0.8 (ND) | 5.3 (1.0) | 1.1 (0.1) | 6.6 (0.4) |
| 14-DNW-A | 17 (2.8) | 2 (0.6) | 41 (48.9) | 0.4 (0.0) | 1.0 (0.2) | 1.6 (0.1) | 1.5 (ND) | 0.9 (0.2) | 0.4 (0.1) | 5.0 (0.6) |
| 16-DN-A | 5 (1.5) | 3 (2.1) | 333 (98.8) | 0.5 (0.2) | 1.9 (0.2) | 0.9 (0.1) | 0.8 (ND) | 1.5 (0.2) | 0.3 (0.0) | 2.8 (0.2) |

**Table 5. Continued**

| Site | $PO_4$ (µg-P/L) | $NH_4$ (µg-N/L) | $NO_3$ (µ-N/L) | Cl (mg/L) | $SO_4$ (mg/L) | Na (mg/L) | K (mg/L) | Ca (mg/L) | Mg (mg/L) | Si (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| 17-DN-B | 8 (2.0) | 4 (1.8) | 297 (92.5) | 1.1 (0.2) | 1.9 (0.2) | 1.4 (0.2) | 0.8 (ND) | 2.1 (0.3) | 0.5 (0.1) | 3.4 (0.3) |
| 18-OG-A | 32 (8.1) | 16 (14.8) | 960 (201.4) | 4.1 (0.6) | 2.1 (0.2) | 3.7 (0.4) | 0.9 (ND) | 4.5 (0.2) | 1.3 (0.1) | 5.3 (0.4) |
| 19-OG-B | 31 (7.6) | 4 (2.0) | 726 (224.2) | 3.2 (0.4) | 2.1 (0.2) | 3.4 (0.3) | 0.9 (ND) | 4.1 (0.5) | 1.2 (0.1) | 5.5 (0.4) |
| 20-CR-A | 14 (3.2) | 3 (2.0) | 18 (17.0) | 0.4 (0.1) | 2.5 (0.2) | 1.8 (0.1) | 0.9 (ND) | 1.3 (0.1) | 0.6 (0.0) | 6.1 (0.4) |
| 21-CR-B | 17 (16.9) | 4 (2.1) | 50 (31.7) | 0.5 (0.1) | 2.3 (0.2) | 2.0 (0.2) | 1.0 (ND) | 1.8 (0.2) | 0.7 (0.1) | 6.2 (0.4) |
| 22-CH-B | 23 (3.6) | 6 (2.6) | 29 (18.4) | 0.4 (0.1) | 1.9 (0.3) | 3.2 (0.4) | 1.0 (ND) | 3.0 (0.5) | 1.1 (0.2) | 7.8 (0.7) |
| 23-IC-B | 20 (15.4) | 18 (8.7) | 368 (98.0) | 0.7 (0.1) | 2.1 (0.2) | 1.1 (0.1) | 0.9 (ND) | 3.5 (0.9) | 0.6 (0.1) | 3.2 (0.2) |
| 24-SH-B | 35 (9.4) | 11 (11.4) | 114 (201.3) | 0.6 (0.2) | 2.2 (0.5) | 3.0 (0.4) | 1.1 (ND) | 2.4 (0.3) | 0.9 (0.1) | 7.8 (0.8) |
| 25-CB-A | 13 (3.1) | 6 (2.3) | 281 (152.6) | 0.9 (0.2) | 2.2 (0.2) | 1.6 (0.1) | 0.9 (ND) | 3.4 (0.6) | 0.7 (0.1) | 3.7 (0.2) |
| 26-CB-B | 13 (2.9) | 6 (2.8) | 254 (95.6) | 0.9 (0.2) | 2.5 (0.1) | 1.6 (0.2) | 0.9 (ND) | 3.9 (0.6) | 0.8 (0.1) | 3.7 (0.2) |

*Results less than the detection limit were set to 1/2 the detection limit to compute the average and standard deviation. The standard deviation is in parentheses following the average. The average is followed by (ND) if more than 50% of the results were below the detection limit. The average is followed by (N1) when only one measurement was made.

**Table 6. Average trace metal concentrations (mg/L) from July 1994 to June 1995**

| Site | Aluminum | Arsenic | Cadmium | Chromium | Copper | Iron | Lead |
|---|---|---|---|---|---|---|---|
| 1-LP-A | 0.0188 (0.0049) | 0.0003 (ND) | 0.0001 (ND) | 0.0003 (ND) | 0.0005 (0.0005) | 0.0076 (ND) | 0.0001 (ND) |
| 2-LP-B | 0.0129 (0.0083) | 0.0002 (ND) | 0.0001 (ND) | 0.0003 (ND) | 0.0005 (0.0004) | 0.0076 (ND) | 0.0001 (ND) |
| 3-CP-A | 0.0128 (ND) | 0.0004 (ND) | 0.0001 (ND) | 0.0004 (ND) | 0.0003 (ND) | 0.0089 (ND) | 0.0001 (ND) |
| 4-CP-B | 0.0124 (ND) | 0.0002 (ND) | 0.0001 (ND) | 0.0006 (ND) | 0.0004 (ND) | 0.0219 (ND) | 0.0001 (ND) |
| 5-LN-A | 0.0107 (ND) | 0.0003 (ND) | 0.0001 (ND) | 0.0004 (ND) | 0.0005 (ND) | 0.0536 (ND) | 0.0001 (ND) |
| 6-LN-B | 0.0116 (ND) | 0.0002 (ND) | 0.0001 (ND) | 0.0011 (ND) | 0.0005 (ND) | 0.0403 (0.0462) | 0.0001 (ND) |
| 7-WB-A | 0.0110 (ND) | 0.0004 (ND) | 0.0001 (ND) | 0.0004 (ND) | 0.0007 (0.0005) | 0.0076 (ND) | 0.0001 (ND) |
| 8-WB-B | 0.0107 (0.0102) | 0.0002 (0.0002) | 0.0001 (0.0001) | 0.0009 (0.0010) | 0.0005 (0.0005) | 0.0076 (0.0118) | 0.0001 (0.0102) |
| 32-LB-B | 0.0121 (0.0061) | 0.0002 (ND) | 0.0001 (ND) | 0.0004 (0.0001) | 0.0001 (ND) | 0.0019 (ND) | 0.0000 (ND) |
| 27-WBT1-B | 0.0109 (ND) | 0.0002 (ND) | 0.0001 (ND) | 0.0006 (ND) | 0.0005 (0.0002) | 0.0295 (0.0433) | 0.0001 (ND) |
| 31-WBT3-B | 0.0300 (N1) | 0.0002 (N1) | 0.0001 (N1) | 0.0005 (N1) | 0.0001 (ND) | 0.0005 (N1) | 0.0002 (N1) |
| 9-WBT2-B | 0.0158 (ND) | 0.0003 (ND) | 0.0001 (ND) | 0.0004 (ND) | 0.0003 (ND) | 0.0076 (ND) | 0.0001 (ND) |
| 28-SP-B | 0.0166 (ND) | 0.0002 (ND) | 0.0001 (ND) | 0.0008 (0.0007) | 0.0004 (ND) | 0.0020 (ND) | 0.0001 (ND) |
| 10-MD-B | 0.0163 (ND) | 0.0002 (ND) | 0.0001 (ND) | 0.0004 (ND) | 0.0003 (ND) | 0.0076 (ND) | 0.0001 (ND) |
| 11-WR-B | 0.0145 (ND) | 0.0002 (ND) | 0.0001 (ND) | 0.0006 (ND) | 0.0003 (ND) | 0.0076 (ND) | 0.0002 (ND) |
| 12-BT-B | 0.0111 (ND) | 0.0002 (ND) | 0.0001 (ND) | 0.0006 (ND) | 0.0003 (ND) | 0.0141 (ND) | 0.0003 (ND) |
| 33-JB-B | 0.0028 (ND) | 0.0001 (ND) | 0.0000 (ND) | 0.0004 (ND) | 0.0001 (ND) | 0.0003 (ND) | 0.0000 (ND) |
| 13-MA-B | 0.0109 (ND) | 0.0002 (ND) | 0.0001 (ND) | 0.0003 (ND) | 0.0003 (ND) | 0.0096 (ND) | 0.0001 (ND) |
| 15-MAT-B | 0.0123 (ND) | 0.0002 (ND) | 0.0001 (ND) | 0.0005 (ND) | 0.0003 (ND) | 0.0076 (ND) | 0.0001 (ND) |
| 14-DNW-A | 0.0225 (0.0106) | 0.0002 (ND) | 0.0000 (ND) | 0.0004 (ND) | 0.0001 (ND) | 0.0003 (ND) | 0.0001 (ND) |
| 16-DN-A | 0.0140 (ND) | 0.0002 (ND) | 0.0001 (ND) | 0.0003 (ND) | 0.0003 (ND) | 0.0076 (ND) | 0.0001 (ND) |
| 17-DN-B | 0.0125 (ND) | 0.0002 (ND) | 0.0001 (ND) | 0.0003 (ND) | 0.0002 (ND) | 0.0076 (ND) | 0.0002 (ND) |
| 18-OG-A | 0.0126 (0.0086) | 0.0004 (ND) | 0.0001 (ND) | 0.0005 (ND) | 0.0005 (ND) | 0.0196 (ND) | 0.0001 (ND) |
| 19-OG-B | 0.0128 (ND) | 0.0002 (ND) | 0.0001 (ND) | 0.0007 (0.0005) | 0.0006 (ND) | 0.0096 (ND) | 0.0001 (ND) |

**Table 6. Continued**

| Site | Aluminum | Arsenic | Cadmium | Chromium | Copper | Iron | Lead |
|---|---|---|---|---|---|---|---|
| 20-CR-A | 0.0203 (ND) | 0.0002 (ND) | 0.0001 (ND) | 0.0033 (0.0052) | 0.0006 (0.0005) | 0.0141 (ND) | 0.0001 (ND) |
| 21-CR-B | 0.0198 (ND) | 0.0002 (ND) | 0.0001 (ND) | 0.0014 (ND) | 0.0004 (ND) | 0.0099 (ND) | 0.0010 (ND) |
| 22-CH-B | 0.0193 (ND) | 0.0002 (ND) | 0.0001 (ND) | 0.0005 (ND) | 0.0004 (ND) | 0.0380 (0.0477) | 0.0009 (ND) |
| 23-IC-B | 0.0124 (0.0087) | 0.0002 (0.0002) | 0.0001 (0.0001) | 0.0004 (0.0001) | 0.0003 (0.0002) | 0.0076 (0.0118) | 0.0001 (0.0087) |
| 24-SH-B | 0.0158 (ND) | 0.0002 (ND) | 0.0001 (ND) | 0.0005 (ND) | 0.0003 (ND) | 0.0276 (ND) | 0.0010 (ND) |
| 25-CB-A | 0.0129 (ND) | 0.0002 (ND) | 0.0001 (ND) | 0.0004 (ND) | 0.0010 (0.0010) | 0.0076 (ND) | 0.0001 (ND) |
| 26-CB-B | 0.0129 (ND) | 0.0002 (ND) | 0.0001 (ND) | 0.0012 (0.0015) | 0.0002 (ND) | 0.0076 (ND) | 0.0001 (ND) |

**Table 6. Continued**

| Site | Manganese | Mercury | Nickel | Selenium | Silver | Zinc |
|---|---|---|---|---|---|---|
| 1-LP-A | 0.0040 (0.0054) | 0.00007 (ND) | 0.00024 (ND) | 0.0003 (ND) | 0.00008 (ND) | 0.0074 (0.0041) |
| 2-LP-B | 0.0021 (0.0012) | 0.00008 (ND) | 0.00019 (ND) | 0.0003 (ND) | 0.00008 (ND) | 0.0068 (0.0037) |
| 3-CP-A | 0.0103 (0.0046) | 0.00004 (ND) | 0.00019 (ND) | 0.0004 (ND) | 0.00008 (ND) | 0.0035 (0.0024) |
| 4-CP-B | 0.0143 (0.0048) | 0.00004 (ND) | 0.00019 (ND) | 0.0004 (ND) | 0.00008 (ND) | 0.0022 (0.0009) |
| 5-LN-A | 0.0253 (0.0095) | 0.00004 (ND) | 0.00019 (ND) | 0.0011 (ND) | 0.00008 (ND) | 0.0036 (0.0012) |
| 6-LN-B | 0.0088 (0.0035) | 0.00005 (ND) | 0.00102 (ND) | 0.0003 (ND) | 0.00008 (ND) | 0.0021 (0.0019) |
| 7-WB-A | 0.0017 (0.0011) | 0.00005 (ND) | 0.00019 (ND) | 0.0008 (ND) | 0.00008 (ND) | 0.0017 (0.0019) |
| 8-WB-B | 0.0020 (0.0011) | 0.00003 (.00002) | 0.00049 (.00081) | 0.0003 (0.0002) | 0.00008 (0.0001) | 0.0017 (0.0013) |
| 32-LB-B | 0.0005 (0.0004) | 0.00003 (ND) | 0.00009 (ND) | 0.0008 (ND) | 0.00003 (ND) | 0.0005 (0.0004) |
| 27-WBT1-B | 0.0308 (0.0093) | 0.00005 (ND) | 0.00019 (ND) | 0.0003 (ND) | 0.00008 (ND) | 0.0016 (0.0018) |
| 31-WBT3-B | 0.0001 (N1) | 0.00003 (N1) | 0.00013 (N1) | 0.0009 (N1) | 0.00003 (N1) | 0.0021 (N1) |
| 9-WBT2-B | 0.0011 (0.0007) | 0.00008 (ND) | 0.00109 (ND) | 0.0003 (ND) | 0.00008 (ND) | 0.0015 (0.0013) |
| 28-SP-B | 0.0009 (0.0004) | 0.00005 (ND) | 0.00019 (ND) | 0.0003 (ND) | 0.00008 (ND) | 0.0026 (0.0018) |
| 10-MD-B | 0.0007 (0.0004) | 0.00004 (ND) | 0.00019 (ND) | 0.0003 (ND) | 0.00008 (ND) | 0.0024 (0.0018) |
| 11-WR-B | 0.0007 (0.0005) | 0.00005 (ND) | 0.00019 (ND) | 0.0003 (ND) | 0.00008 (ND) | 0.0022 (0.0016) |
| 12-BT-B | 0.0011 (0.0013) | 0.00004 (ND) | 0.00019 (ND) | 0.0003 (ND) | 0.00008 (ND) | 0.0027 (0.0014) |
| 33-JB-B | 0.0001 (0.0001) | 0.00003 (ND) | 0.00008 (ND) | 0.0003 (ND) | 0.00002 (ND) | 0.0005 (0.0004) |
| 13-MA-B | 0.0006 (0.0005) | 0.00004 (ND) | 0.00019 (ND) | 0.0003 (ND) | 0.00008 (ND) | 0.0031 (0.0016) |
| 15-MAT-B | 0.0010 (0.0007) | 0.00004 (ND) | 0.00019 (ND) | 0.0011 (ND) | 0.00008 (ND) | 0.0031 (0.0025) |
| 14-DNW-A | 0.0006 (0.0008) | 0.00003 (ND) | 0.00008 (ND) | 0.0003 (ND) | 0.00002 (ND) | 0.0008 (0.0009) |

| Site | Manganese | Mercury | Nickel | Selenium | Silver | Zinc |
|---|---|---|---|---|---|---|
| 16-DN-A | 0.0008 (0.0005) | 0.00005 (ND) | 0.00019 (ND) | 0.0003 (ND) | 0.00008 (ND) | 0.0034 (0.0027) |
| 17-DN-B | 0.0006 (0.0004) | 0.00006 (ND) | 0.00019 (ND) | 0.0003 (ND) | 0.00008 (ND) | 0.0030 (0.0022) |
| 18-OG-A | 0.0049 (0.0031) | 0.00010 (ND) | 0.00062 (ND) | 0.0006 (ND) | 0.00008 (ND) | 0.0025 (0.0019) |
| 19-OG-B | 0.0013 (0.0013) | 0.00010 (ND) | 0.00332 (ND) | 0.0003 (ND) | 0.00008 (ND) | 0.0043 (0.0052) |
| 20-CR-A | 0.0016 (0.0008) | 0.00004 (ND) | 0.00341 (ND) | 0.0003 (ND) | 0.00008 (ND) | 0.0021 (0.0022) |
| 21-CR-B | 0.0034 (0.0018) | 0.00006 (ND) | 0.00062 (ND) | 0.0003 (ND) | 0.00008 (ND) | 0.0027 (0.0028) |
| 22-CH-B | 0.0393 (0.0152) | 0.00006 (ND) | 0.00019 (ND) | 0.0003 (ND) | 0.00009 (ND) | 0.0029 (0.0022) |
| 23-IC-B | 0.0014 (0.0007) | 0.00006 (.00005) | 0.00019 (.00021) | 0.0003 (0.0002) | 0.00008 (0.0001) | 0.0031 (0.0031) |
| 24-SH-B | 0.0105 (0.0051) | 0.00006 (ND) | 0.00042 (ND) | 0.0003 (ND) | 0.00008 (ND) | 0.0020 (0.0012) |
| 25-CB-A | 0.0018 (0.0003) | 0.00005 (ND) | 0.00019 (ND) | 0.0003 (ND) | 0.00008 (ND) | 0.0020 (0.0018) |
| 26-CB-B | 0.0041 (0.0046) | 0.00006 (ND) | 0.00124 (ND) | 0.0003 (ND) | 0.00008 (ND) | 0.0016 (0.0017) |

**Table 6. Continued**

*Results less than the detection limit were set to 1/2 the detection limit to compute the average and standard deviation. The standard deviation is in parentheses following the average. The average is followed by (ND) if more than 50% of the results were below the detection limit. The average is followed by (N1) when only one measurement was made.

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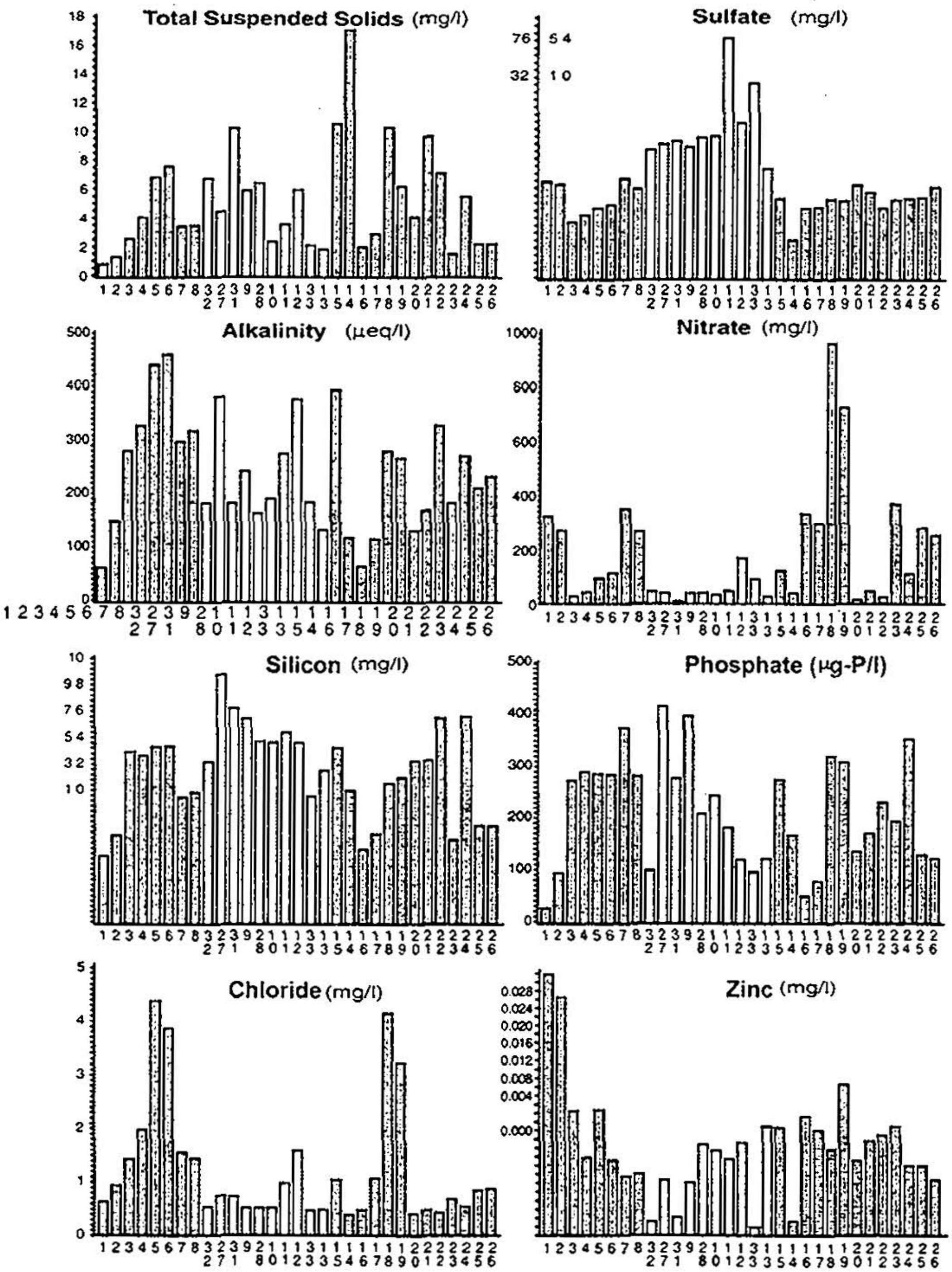


**Fig. 22. Variation in the concentrations of selected physical and chemical parameters across sampling stations in the water quality studies.** Open bars refer to streams draining Webb Mountain.

and 8) and unnamed Webb Creek tributary 1 (station 27), Warden Branch (station 11), Butler Branch (station 12), a tributary to Matthew Branch (station 15), Ogle Spring Branch (stations 18 and 19), Chavis Creek (station 22), and Sandy Hollow Creek (station 24). Five stations had relatively high total suspended solids (TSS) levels (>9 mg/L): unnamed tributaries to Webb Creek (station 31) and to Matthew Creek (station 15), the upstream station on Ogle Spring Branch (station 18), the downstream station on Carson Branch (station 21), and an upper station on Dunn Creek (station 14). The high TSS for the upper Dunn Creek station was the result of only one sample and is probably not representative of upper Dunn Creek. Each of the other four streams with high TSS is small and has some disturbed areas (gravel roads, cleared homesites) in close proximity to the sampling stations, which may account for the higher TSS values.

The data on nutrient and major ion concentrations (Table 5, Fig. 22) suggest that most streams have reasonably good water quality. Lindsey Creek (stations 5 and 6) and Ogle Spring Branch (stations 18 and 19) appear to be distinctly influenced by human activity, as indicated by relatively high levels of ammonium, nitrate, phosphate, and/or chloride compared with the other stations. Higher concentrations of nitrate, phosphate, and chloride in Webb Creek (stations 7 and 8) also reflect significant human effects, probably from runoff from the golf course and effluent from the sewage treatment plant (serving the Cobbly Knob area) upstream from the sampling stations. Moderately high phosphate concentrations ($\geq$20 $\mu$g/L, higher than the 0–10 $\mu$g/L typical of undisturbed streams in this region) in Copeland Creek (stations 3 and 4), unnamed Webb Creek tributaries 1, 2, and 3 (stations 9, 27, and 31), Mill Dam Branch (station 10), Sheep Pen Branch (station 28), unnamed Matthew Branch tributary (station 15), Chavis Creek (station 22), Indian Camp Creek (station 23), and Sandy Hollow Creek (station 24) also suggest some effects of human activity. The higher phosphate concentrations in Copeland Creek and Sandy Hollow Creek probably are a result of the extensive pasture in the riparian zone along these streams and access of cows to the streams. Streams that have extensive portions of their catchments in the GSMNP (Little Pigeon River, Dunn Creek, Indian Camp Creek, and Cosby Creek) also have somewhat higher concentrations of nitrate, probably as a result of higher rates of atmospheric nitrate deposition at higher elevations and lower nitrate retention efficiency of the older-aged forests in the GSMNP. Therefore, nitrate concentration alone is not a good indicator of local human impact on streams. Finally, the high sulfate concentrations in streams draining portions of Webb Mountain, particularly Warden Branch (station 11) and Jones Branch (station 33), deserve special note (Fig. 22). These probably reflect a geologic source of sulfate in this area. Although the pH and alkalinity levels in these streams were not particularly low and trace metals were not high, natural sources of alkalinity (e.g., calcium carbonate) or sources related to human disturbance could be obscuring a potential water quality problem associated with geologic sulfides in these catchments. The soil and geology surveys did indicate the presence of sulfide-bearing parent materials in the Webb Mountain area (Sect. 3.1.4.3).

Concentrations of metals (Table 6) were very low and at all times less than the Tennessee water quality criteria (Table 2). Of the metals, only manganese and zinc concentrations were consistently above detection limits (see Appendix C), and mean concentrations of both were relatively low (Mn <0.04 mg/L and Zn <0.004 mg/L). We found no metal values that exceeded Tennessee Water Quality Criteria (Table 3.2-1).

Concentrations of many chemical parameters in these streams showed distinct seasonality (Fig. 23). Concentrations of solutes produced primarily by weathering of parent materials (e.g.,

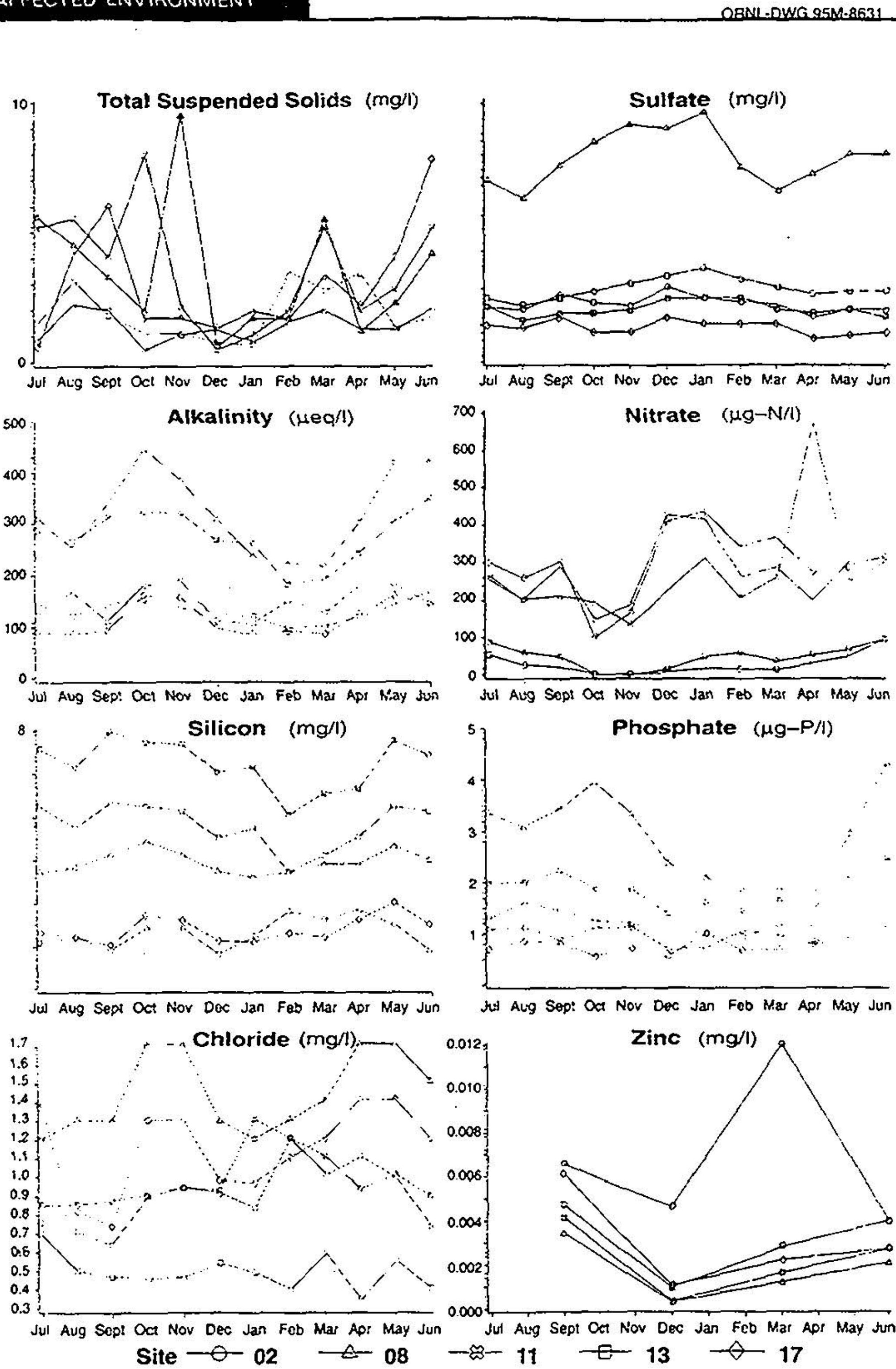


**Fig. 23. Seasonal variation in the concentrations of selected physical and chemical parameters for five streams.**

silicon, alkalinity) were higher during periods of lower flow in summer and fall, whereas concentrations of solutes primarily leached from surface soils by lateral flow (e.g., sulfate, nitrate) were higher during periods of higher stream flow during winter and early spring.

**Webb Mountain Survey Sampling Results.** Stream sulfate concentration is of interest as an indicator of the presence of sulfide-bearing parent materials in the catchments of the proposed ROW. Exposure of sulfide-bearing rock during construction of the parkway could allow rapid oxidation of sulfide minerals, which would produce sulfuric acid. Discharges of acidic water to streams could have harmful effects on fish and other aquatic biota.

Sulfate in stream water originates from the weathering of minerals, the degradation of organic material, and wet and dry atmospheric deposition. The concentrations in runoff also may be affected by sulfate adsorption by soils. If the primary source of sulfur input to the area is atmospheric deposition and the soils and parent materials are similar, then the streams draining the area should have similar concentrations of sulfate. The monthly sampling results indicated that many of the streams draining Webb Mountain had noticeably higher sulfate concentrations than other streams along the ROW (Fig. 22), with the highest concentrations found at Warden Branch (station 11) and Jones Branch (station 33).

The results from the Webb Mountain survey indicated that a geologic source of sulfur probably exists on Webb Mountain. Stations D and E in the headwaters of Warden Branch had sulfate concentrations of 6.3 and 16 mg/L, respectively, and stations F and G downstream in Warden Branch also had sulfate concentrations >5 mg/L (Fig. 24). These stations were considerably higher in sulfate than the other Webb Mountain stations (generally 3–4 mg/L, Fig. 24) or most other stations in the monthly sampling (generally <3 mg/L, Table 5 and Fig. 22). Despite the high sulfate concentrations at the Warden Branch headwater stations, the alkalinity of these streams is not low relative to the other streams surveyed (Fig. 24), and pH values were all >6.7 (see Appendix C for complete dataset). Apparently, the acid produced by oxidation of sulfide as it weathers from the parent materials has been neutralized by the weathering of other minerals and soil ion exchange processes. These stations are generally upstream of most residential development, so human activity probably is not responsible for the high sulfate concentrations. However, relatively high concentrations of phosphate in the stream showing the highest sulfate level (E) suggest there is some disturbance effect, although nitrate levels in this stream were very low (Fig. 24). Geologic surveys indicated that sulfate-bearing rock is not present in this area and cannot account for the higher streamwater sulfate concentrations.

Because of the potential for exposing sulfide minerals during construction on Webb Mountain, construction plans may need to include contingencies for mitigating the effects of the disturbance.

**Storm sampling results.** Changes in streamwater chemistry were monitored during several storms at four stations: Webb Creek downstream (#8), Warden Branch (#11), Matthew Creek (#13), and Carson Branch downstream (#21). Results are presented here for two storms at each of these stations, one storm during winter (January or February) and one storm during spring (May). Tables of the complete chemical analyses for these storms at all four stations, as well as one additional storm at Webb Creek and Warden Branch, are presented in Appendix C.

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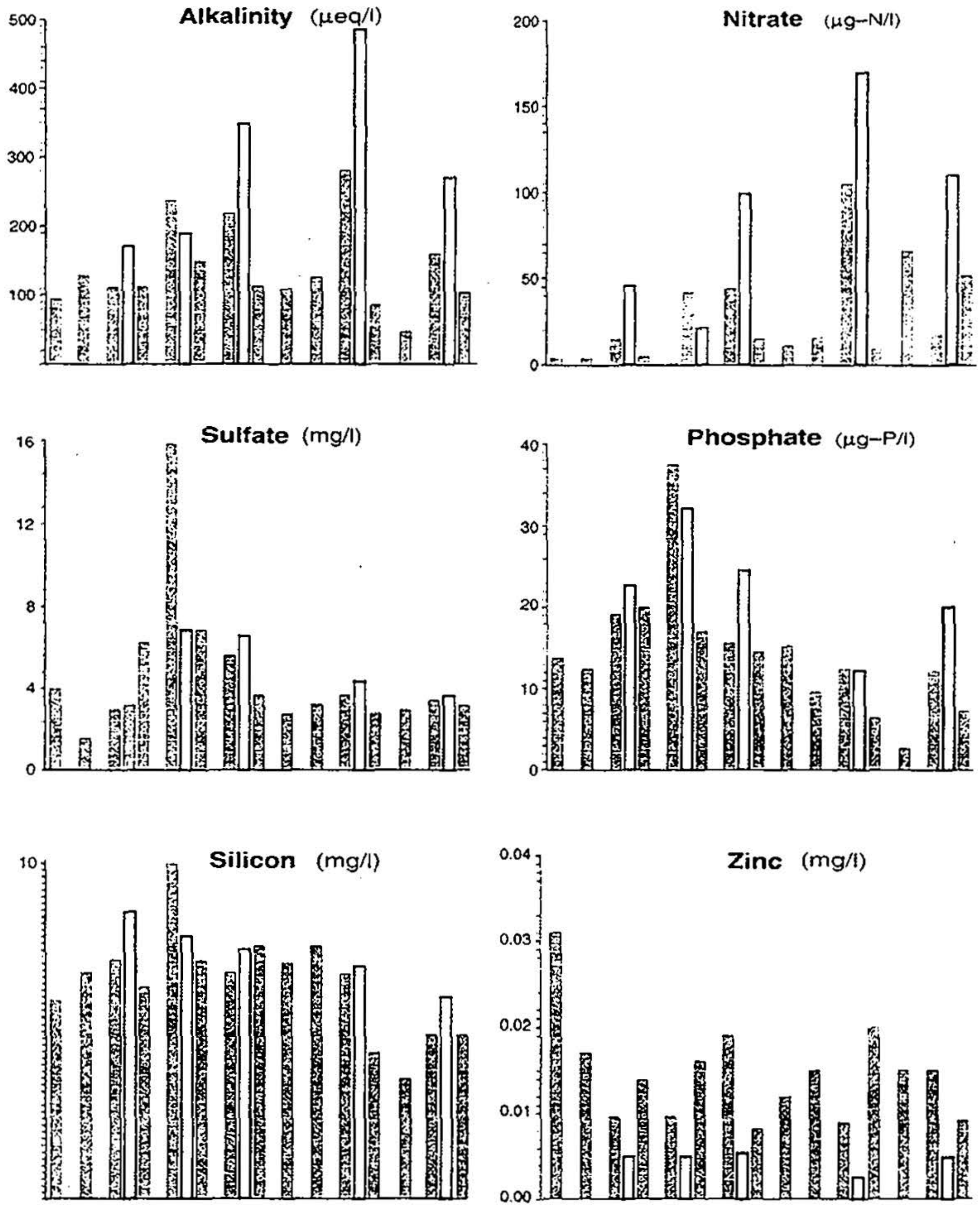


**Fig. 24. Variation in the concentrations of selected chemical parameters for streams sampled during the March Webb Mountain survey (open bars are results from a resurvey of a few streams on June 6, 1995).** Designations for streams A–O are shown in Fig. 21.

Stream chemistry was monitored at Webb Creek and Warden Branch during a relatively large storm event over a 3-day period on January 14–16, 1995 [rainfall of 50 mm (2 in.), primarily on January 14]. The stage height, which is a reasonably good surrogate for stream discharge, rose 51 cm (20 in.) over 24 hours peaking at 0800 hrs on January 15 at Webb Creek and rose 11 cm (4.3 in.) peaking about 1000 on January 15 at Warden Branch (Figs. 25 and 26). Total suspended solids increased sharply with increasing stage height and peaked prior to the peak in stage (discharge), as is typical in most streams. The peak concentrations of suspended solids were 192 mg/L at Webb Creek and 149 mg/L at Warden Branch. At both stations electrical conductance (not shown, see Appendix C for data), alkalinity, and silicon concentrations decreased with increasing stage height, indicative of a dilution effect of high flow. Values of pH (not shown, see Appendix C for data) also declined slightly in both streams at high flow, from 7.4 to 6.9 in Webb Creek and from 7.3 to 7.0 in Warden Branch. In contrast, nitrate in both streams and sulfate in Webb Creek increased with increasing stage height, indicating a flushing effect and additional sources of these solutes at high flow. Increases in nitrate concentration during stormflow are commonly observed in streams draining catchments influenced by human activities, as is the case with these streams. Increases in sulfate concentrations during storms are commonly observed in most catchments in the southeastern Appalachian region because of flushing of the relatively large sulfate levels in surface soils (due to previous wet and dry deposition) by the shallow water flowpaths that develop in soils during storms. Of particular note was the contrasting sulfate concentration pattern observed in Warden Branch, where sulfate concentration declined as stage increased (the opposite pattern to that observed in most other streams in this area). This stormflow sulfate concentration pattern suggests a dilution effect of a geologic source that masks the usually observed flushing effect from shallow soils. The minimum sulfate concentration during the storm in Warden Branch (5.2 mg/L) was considerably greater than the maximum sulfate concentration in Webb Creek (3.2 mg/L) during peak discharge, further supporting the geological source hypothesis. Thus, these storm sulfate patterns tend to support the Webb Mountain survey results suggesting a geologic source of sulfate in the Warden Branch catchment. Among the metals, only zinc and manganese were consistently above detection limits, and although zinc was somewhat higher at peak stage height than prior to the storm, concentrations were nonetheless low.

Stream chemistry was monitored over a 3-day stormflow period during February 15–17, 1995, in Matthew Creek (station 13) and Carson Branch (station 21) (Figs. 27 and 28). This event deposited 42.5 mm (1.7 in.) of rainfall. At the beginning of the storm, some patches of snow remained on the ground from about 127 mm (5 in.) of snowfall during the previous week. The stage height rose 31 cm (12 in.) over 48 hours peaking at 1100 hours on February 16 at Matthew Creek and rose 21 cm (8 in.) peaking at 1830 hours on February 16 at Carson Branch. The hydrograph at Matthew Creek had two distinct peaks compared with a more diffuse peak at Carson Branch. This may be related to the larger proportion of wetland area along the upper reaches of Carson Branch. Total suspended solids concentrations increased with increasing stage height in both streams, although the peak concentration at Carson Branch (312 mg/L) was considerably higher than the peak concentration in Matthew Creek (183 mg/L). This may be related to the residential development very near the sampling station on Carson Branch (station 21) used for storm sampling. Electrical conductance, alkalinity, and silicon concentrations declined with increasing stage height in Matthew Creek and Carson Branch, indicating dilution of geologic sources, as was observed in Webb Creek and Warden Branch. However, in contrast to the patterns observed in Webb and Warden, nitrate concentrations declined as stage height increased in Matthew and Carson, probably reflecting a minimum of human disturbance in these catchments. Sulfate

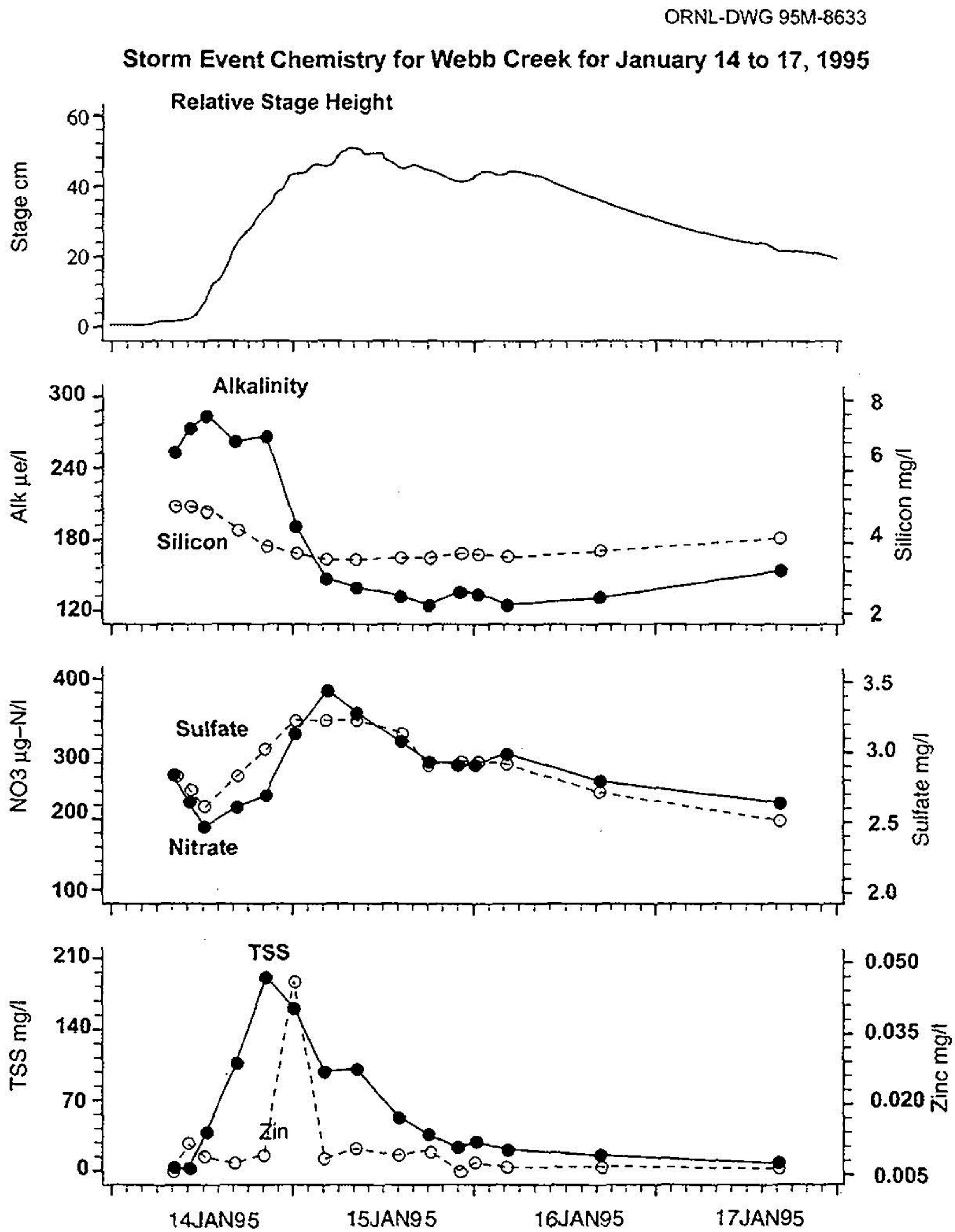


**Fig. 25. Concentrations of selected parameters during a storm in January 1995 in Webb Creek (station 8).**

ORNL-DWG 95M-8636

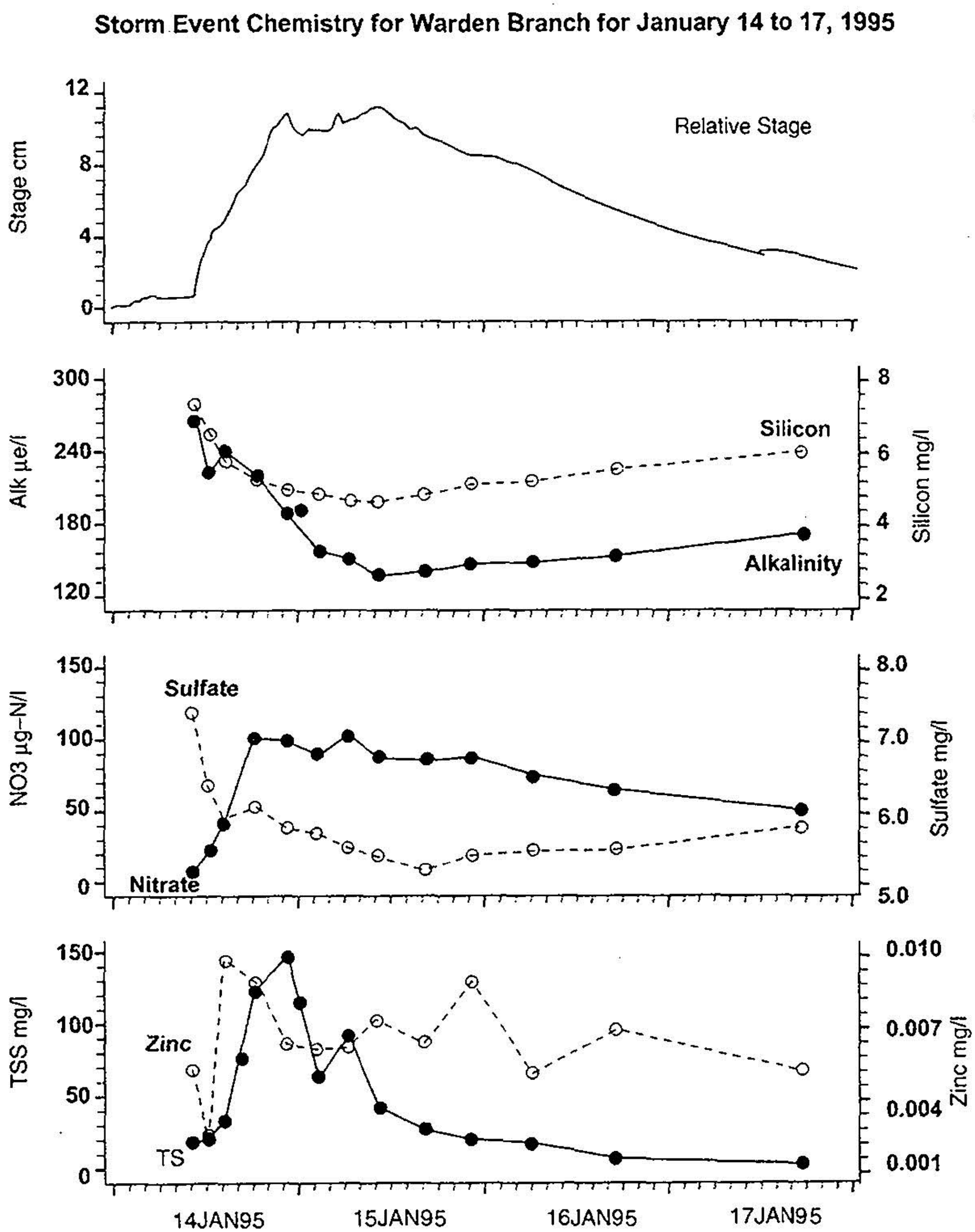


**Fig. 26. Concentrations of selected parameters during a storm in January 1995 in Warden Branch (station 11).**

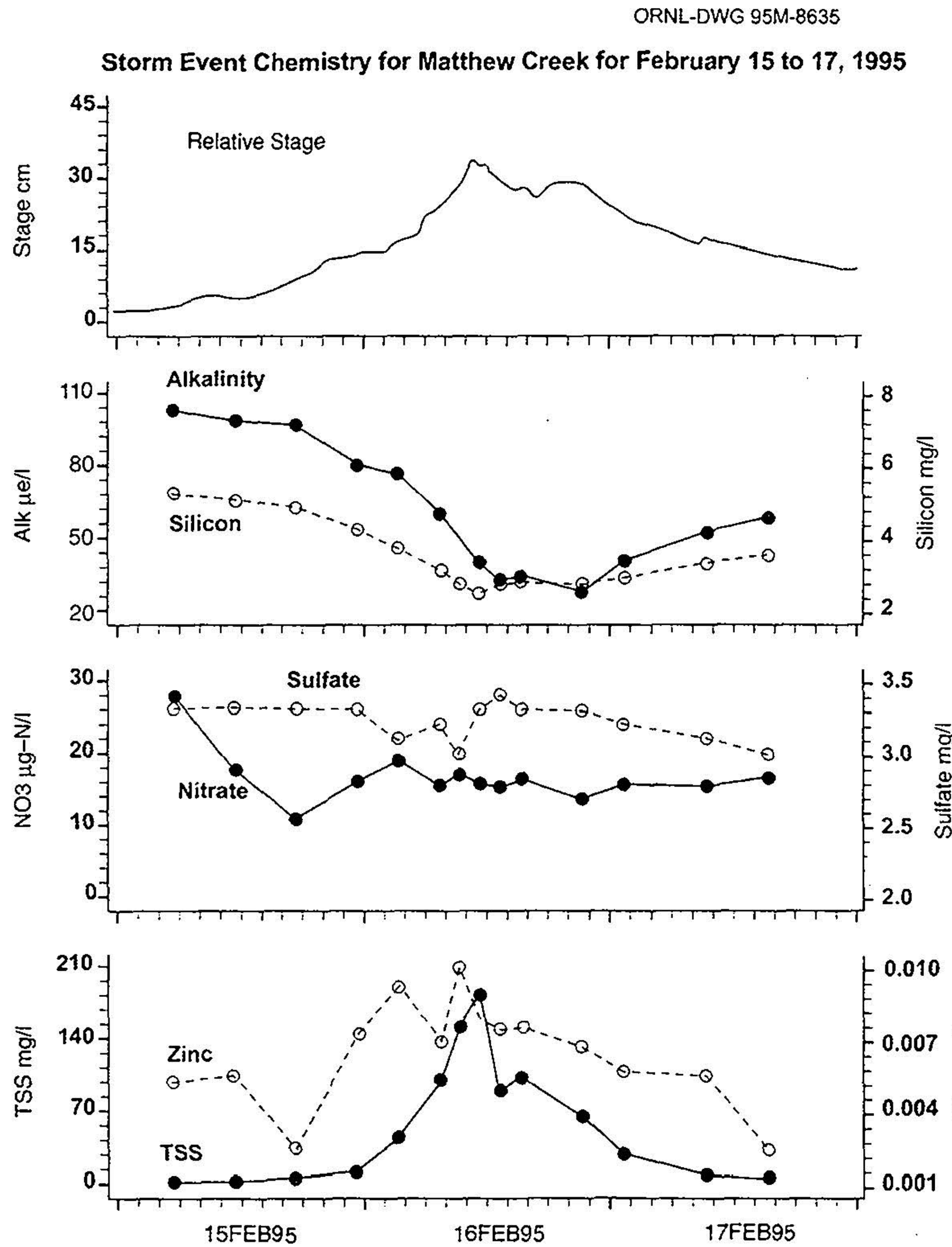


**Fig. 27. Concentrations of selected parameters during a storm in February 1995 in Matthew Creek (station 13).**

ORNL-DWG 95M-8638

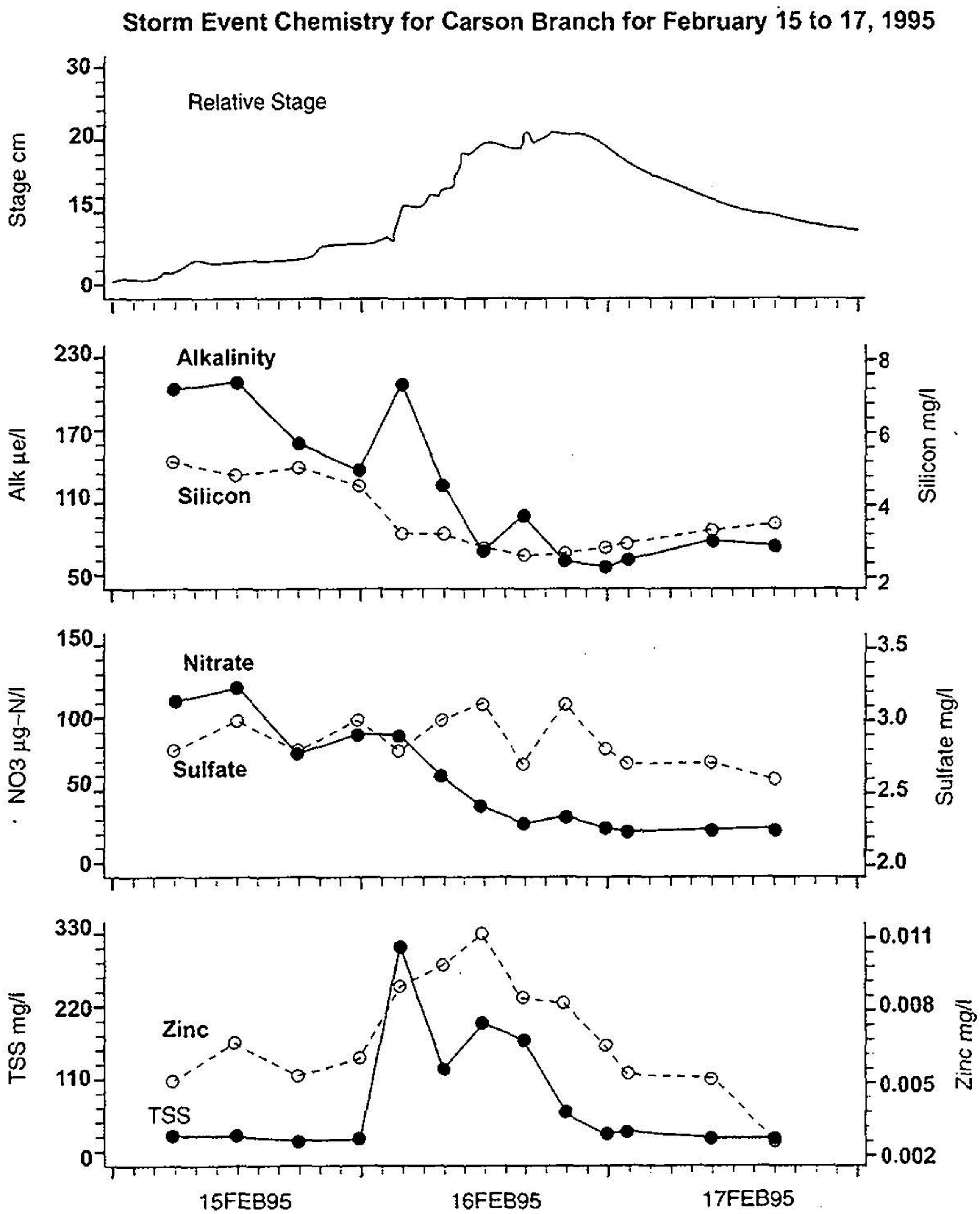


**Fig. 28. Concentrations of selected parameters during a storm in February 1995 in Carson Branch (station 21).**

concentrations were somewhat variable in Matthew and Carson, although highest concentrations were observed near peak stage height as was the case in Webb Creek. In both Matthew Creek and Carson Branch, pH declined during increasing stage, with values falling from pre-storm values of 6.7 (Matthew) and 6.8 (Carson) to 6.4 at peak stage height in both streams. Metals concentrations were generally below detection limits, except for manganese and zinc. Although zinc concentration increased with increasing stage, concentrations remained relatively low.

In May, there was a much smaller response of stage height during the storms sampled than in the winter, both a result of lower precipitation 20–30 mm (8–12 in.) and lower soil moisture levels after the growing season commenced (Figs. 29, 30, 31, and 32). Patterns in alkalinity and silicon concentration were somewhat different than during the winter storms. Only at Matthew Creek did alkalinity and silicon show a distinct dilution pattern as was observed during the winter (Fig. 31). In the other streams, sharp increases in alkalinity were observed during rising or peak stage heights. Sulfate concentration patterns were less distinct in May than in winter, except for Warden Branch where a distinct dilution pattern was again observed (Fig. 30), further confirming the presence of a geologic source of sulfate in this catchment. Nitrate concentration patterns were also less distinct in Webb Creek and Warden Branch in the May storm compared with the winter storm. In Carson Branch, nitrate concentration increased sharply near the peak and falling limb of the hydrograph (Fig. 32) in contrast to the dilution pattern observed in February. Patterns in storm pH also were somewhat different in May compared with winter in all streams, with pH increasing steadily throughout the storms from pre-storm values ranging from 6.7–7.1 to values on the declining limb of the hydrograph ranging from 7.0 to 7.5 (see Appendix C). Concentrations of metals remained relatively low during the May storms, except for a few high values of zinc observed in Warden Branch (0.015–0.025 mg/L) and in Carson Branch (0.047 mg/L).

In summary, the storm chemistry results show that patterns in solute chemistry observed over the hydrograph are more distinct in winter than in spring, and somewhat different in winter from in spring. The storm results also provide additional evidence of a geologic source of sulfate in the Warden Branch catchment. Finally, the storm results highlight the relatively undisturbed nature of the Matthew Creek and Carson Branch catchments.

## 3.3 AQUATIC ECOLOGY

### 3.3.1 Approach

Stream biological surveys have been completed at 31 stream sites to identify aquatic ecological resources potentially impacted by construction and subsequent use of the proposed Section 8B extension of the Foothills Parkway (Fig. 20). The purpose of these surveys is to describe, document, and quantify the existing taxonomic diversity of benthic macroinvertebrates and fish. The sampling strategy for both benthic invertebrates and fish was to survey the different taxa from all available habitats to the extent practicable during single sampling dates. Both qualitative and quantitative collection techniques were used during benthic invertebrate and fish sampling at 31 Section 8B streams (Table 7). The surveys also identified rare and endangered species of concern to the federal and Tennessee governments. The GSMNP has a program to reintroduce some of the Tennessee state endangered species into Abrams Creek but otherwise does not currently have any

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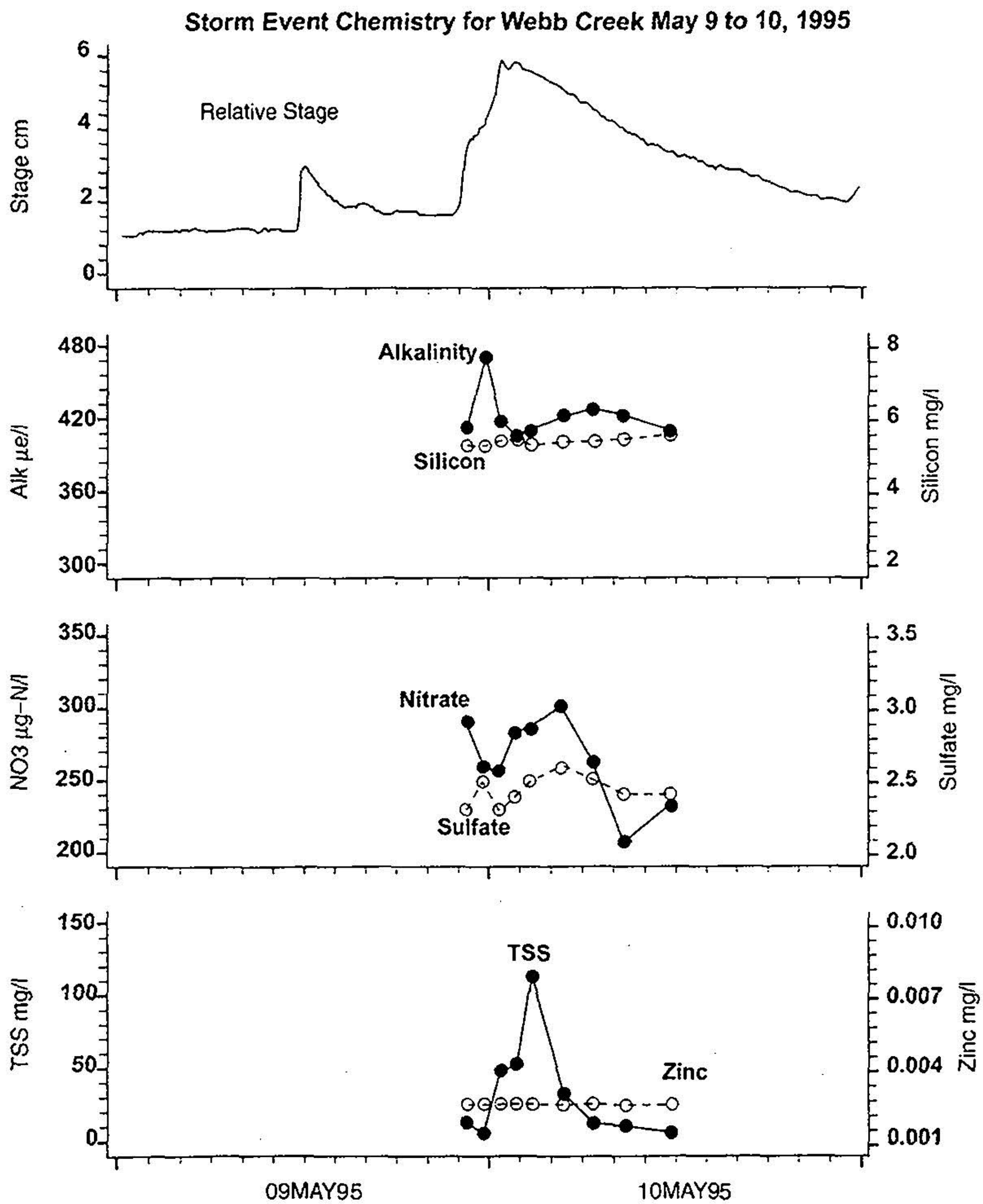


**Fig. 29. Concentrations of selected parameters during a storm in May 1995 in Webb Creek (station 8).**

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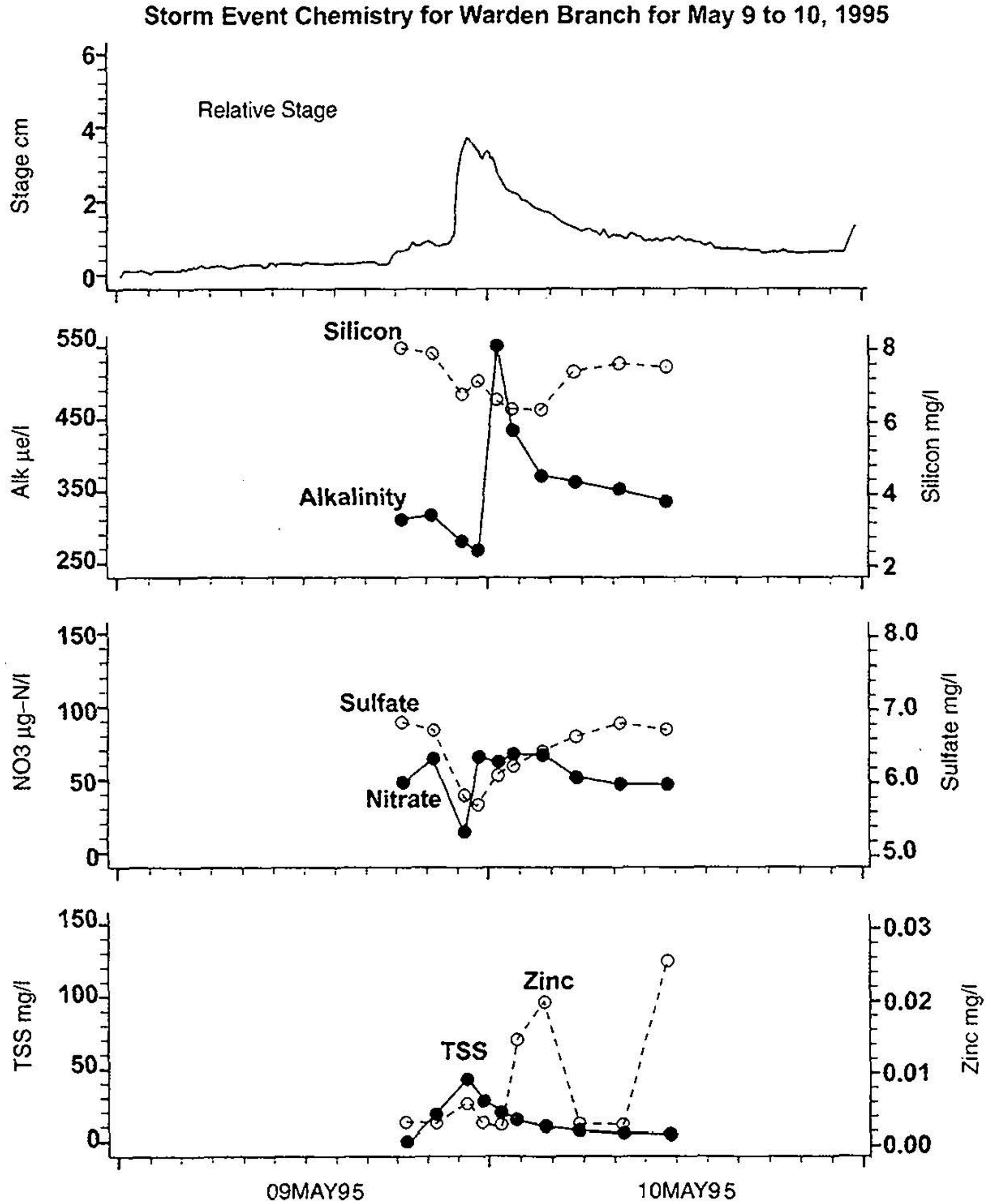


**Fig. 30. Concentrations of selected parameters during a storm in May 1995 in Warden Branch (station 11).**

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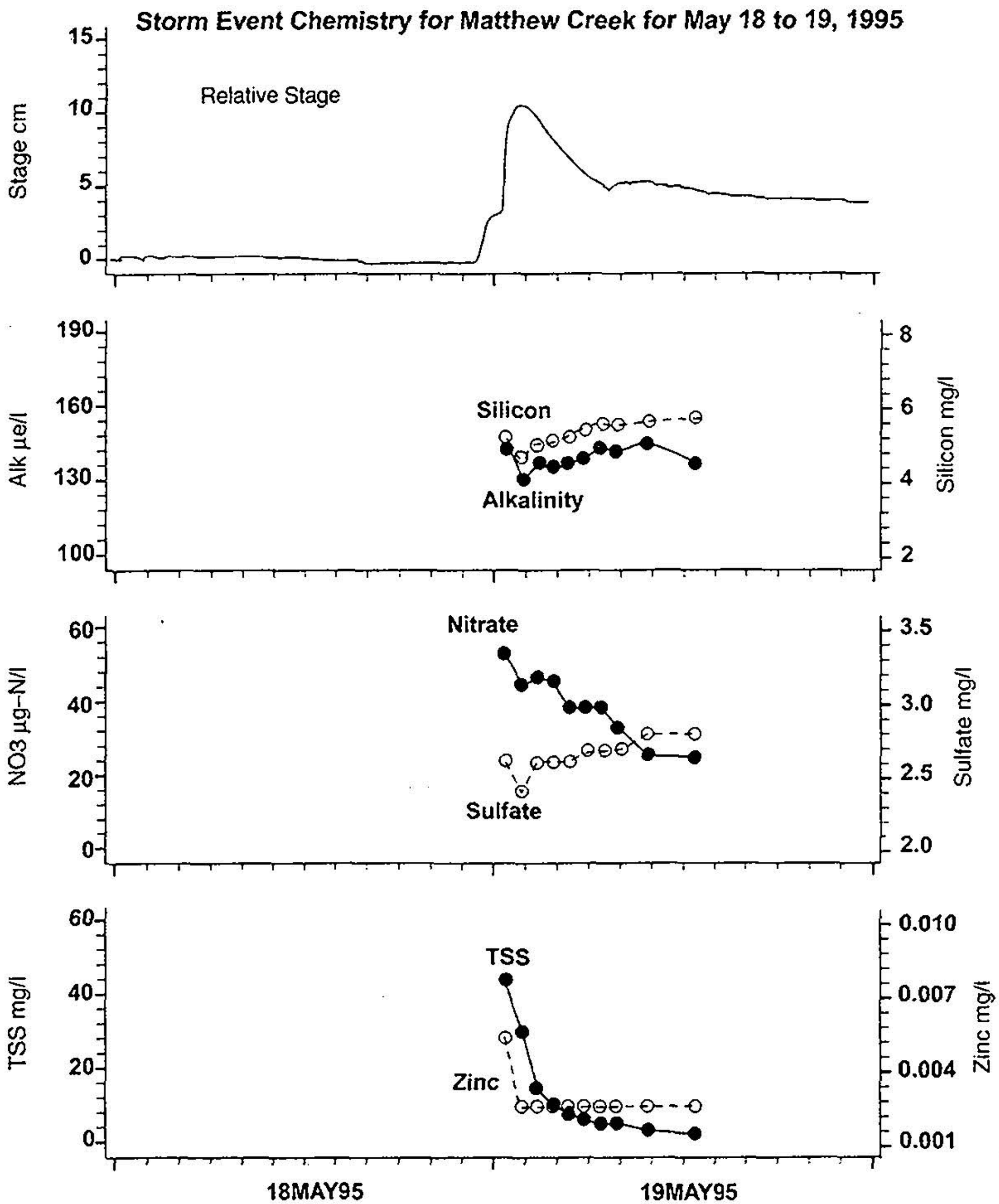


**Fig. 31. Concentrations of selected parameters during a storm in May 1995 in Matthew Creek (station 13).**

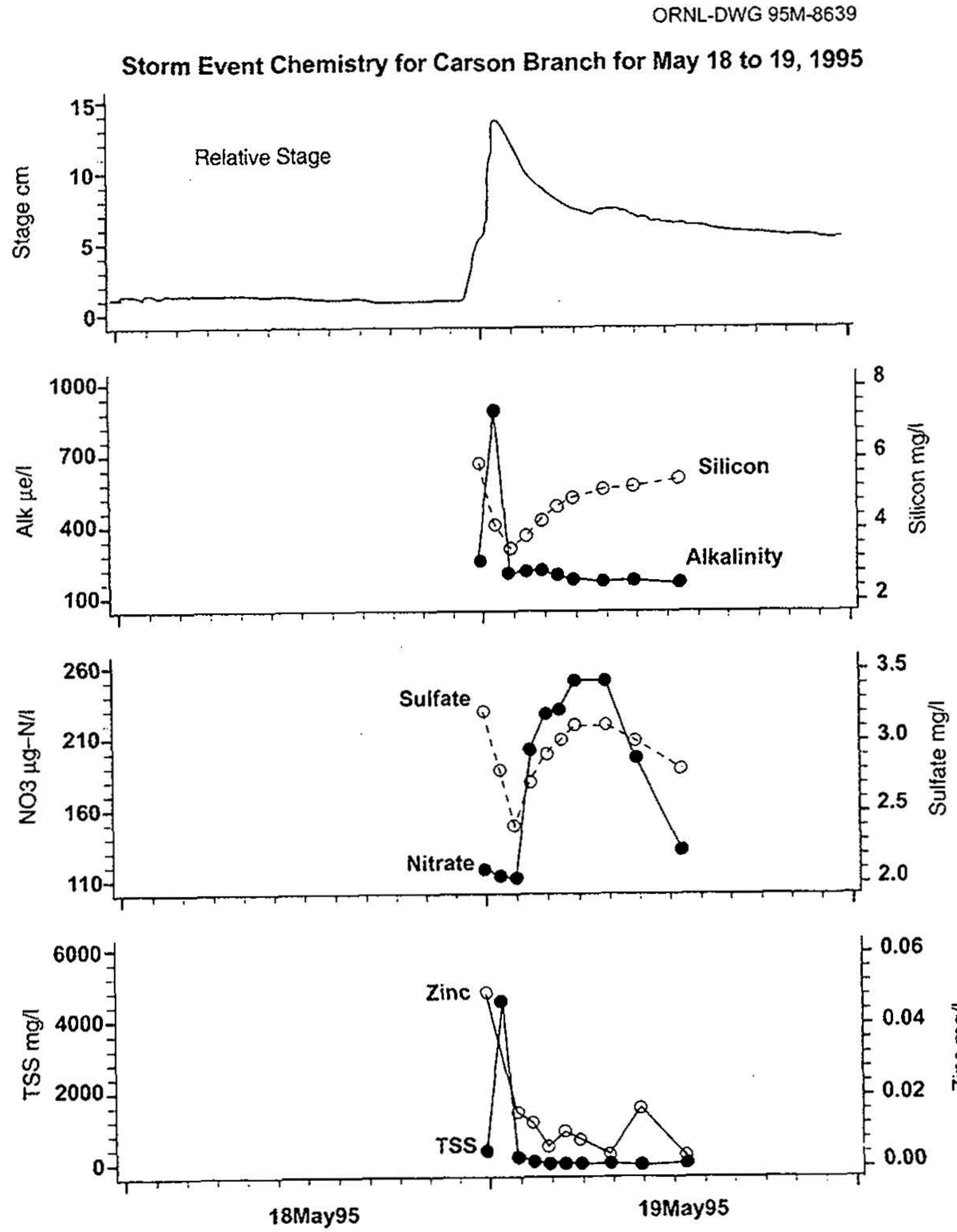


**Fig. 32. Concentrations of selected parameters during a storm in May 1995 in Carson Branch (station 21).**

**Table 7. Sampling sites for the aquatic ecological resources of proposed Section 8B of the Foothills Parkway**

| Site identifier[a] | Site description | Qualitative benthic macroinvertebrate survey sampling | Quantitative artificial substrate benthic macroinvertebrate sampling | Qualitative fish survey sampling | Quantitative fish survey sampling |
|---|---|---|---|---|---|
| | **Little Pigeon River/Copeland Creek/Lindsey Creek** | | | | |
| 1-LP-A | Little Pigeon River, above right-of-way | X | X | X | |
| 2-LP-B | Little Pigeon river, below right-of-way | X | X | | X |
| 3-CP-A | Copeland Creek, above right-of-way | X | | X | |
| 4-CP-B | Copeland Creek, below right-of-way | X | | X | |
| 5-LN-A | Lindsey Creek, above right-of-way | X | | X | |
| 6-LN-B | Lindsey Creek, below right-of-way | X | | X | |
| | **Webb Mountain/Webb Creek Drainages** | | | | |
| 32-LB-B | Laurel Creek, below right-of-way | X | | X | |
| 7-WB-A | Webb Creek, above right-of-way | X | X | | X |
| 8-WB-B | Webb Creek, below right-of-way | X | X | | X |
| 27-WBT1-B | Webb Creek Tributary, within right-of-way | X | | X | |
| 31-WBT3-B | Webb Creek Tributary, below right-of-way | X | | | |

## Table 7. continued

| Site identifier[a] | Site description | Qualitative benthic macroinvertebrate survey sampling | Quantitative artificial substrate benthic macroinvertebrate sampling | Qualitative fish survey sampling | Quantitative fish survey sampling |
|---|---|---|---|---|---|
| 9-WBT2-B | Webb Creek Tributary 2, below right-of-way | X | | X | |
| 28-SP-B | Sheep Pen Branch, within right-of-way | X | | X | |
| 10-MD-B | Mill Dam Br., below right-of-way | x | | X | |
| 11-WR-B | Warden Br., below right-of-way | X | | X | |
| 12-BT-B | Butler Br., below right-of-way | X | | X | |
| 13-MA-B[a] | Matthew Creek, below right-of-way | X | | X | |
| 13.5-MAT1-B[b] | Matthew Creek Tributary 1, below right-of-way | X | | X | |
| 15-MAT2-B | Matthew Creek Tributary 2, below right-of-way | X | | X | |
| | **Rocky Flats Drainages** | | | | |
| 14-DNW-A | Dunn Creek West Branch, above right-of-way | X | | X | |
| 16-DN-A | Dunn Creek East Branch, above right-of-way | X | X | | X |
| 17-DN-B | Dunn Creek, below right-of-way | X | X | | X |
| 18-OG-A | Ogle Spring Br., above right-of-way | X | | X | |
| 19-OG-B | Ogle Spring Br., below right-of-way | X | | X | |

**Table 7. continued**

| Site identifier[a] | Site description | Qualitative benthic macroinvertebrate survey sampling | Quantitative artificial substrate benthic macroinvertebrate sampling | Qualitative fish survey sampling | Quantitative fish survey sampling |
|---|---|---|---|---|---|
| 20-CR-A | Carson Br., above right-of-way | X | | X | |
| 21-CR-B | Carson Br., below right-of-way | X | | X | |
| | | **Big Ridge/Cosby Creek Drainages** | | | |
| 22-CH-B | Chavis Creek, below right-of-way | X | | X | |
| 23-IC-B | Indian Camp Creek, below right-of-way | X | | X | |
| 24-SH-B | Sandy Hollow Creek, below right-of-way | X | | X | |
| 25-CB-A | Cosby Creek, above right-of-way | X | X | | X |
| 26-CB-B | Cosby Creek, below right-of-way | X | X | | X |

[a]The number in the site identifier includes the corresponding water quality site.

[b]These two sites are just above the confluence of Matthew Creek and Matthew Creek Tributary 1, whereas the water quality site is immediately below the confluence.

GSMNP-listed aquatic species beyond the federal and state listed species (S. Moore, personal communication to J. Dickerman, ORNL, August 24, 1995).

These surveys establish a baseline of the existing aquatic ecological resources in 1994 for use in assessing and monitoring the potential environmental impacts of the Section 8B parkway development and operation. Because of the existing human-induced impacts and the trend of continued residential and commercial development within the watersheds of many of the surveyed streams, a reassessment of the baseline aquatic populations just prior to project construction, should that alternative be selected, would be advisable so that potential impacts can be appropriately attributed.

### 3.3.1.1 Benthic Invertebrate Survey Approach

A standardized qualitative benthic invertebrate collection technique included hand-picking rocks, logs, and leaf packs; coarse screening soft substrates for burrowing organisms; kicking in riffles with a fine-mesh screen as a downstream collecting device; and dip-netting in vegetation, undercut banks, and root mats for a recorded time period for each collector. Concerted efforts with this variety of opportunistic sampling methods in all habitat types are likely to capture from 50 to 70% of the resident benthic invertebrates during any single sampling episode. The remainder of the stream fauna are present in some resting stage (egg or pupa) or are otherwise inaccessible to normal sampling at any single sampling date (Lenat 1987; D. R. Lenat, North Carolina Environmental Management Water Quality Section, Raleigh, method testing memorandum to K. Eagleson, October 18, 1993; Appendix D).

A quantitative benthic macroinvertebrate method was also implemented that used modified Hester-Dendy samplers following the Ohio Environmental Protection Agency (OEPA) protocol (OEPA 1987). These artificial substrate samplers control for substrate variability by offering a standardized surface area for colonization (1 $ft^2$) that can be replicated. However, these samplers are selective for certain taxa, especially the Chironomids (midges) of the insect order Diptera (true flies). Four upstream-downstream paired sites, consisting of the four largest streams along this section of the ROW, were sampled with replicated Hester-Dendy samplers involving a 6-week incubation period that coincided with the qualitative benthic macroinvertebrate sampling. See Appendix D on Aquatic Ecological Resources on benthic invertebrate collection and identification methods.

### 3.3.1.2 Fish Survey Approach

All stream sites were sampled, if sufficient water was present, by using electroshocking and/or seining methods for the fish survey. Single-pass electroshock fish sampling, given the conditions in the Section 8B streams, is a qualitative sampling method that provides a nearly complete species listing and an indication of relative dominance of the fish species present (Appendix D). Multiple (triple-pass depletion) electroshock fish sampling in the four upstream-downstream paired sites of the four largest streams along the proposed Section 8B Foothills Parkway permitted calculation of fish population numbers and biomass for these stream sites. See Appendix D for specifics on fish collection and identification methods.

### 3.3.1.3 Non-Biotic Indicators of Stream Condition

Table 8 compiles information indicative of abiotic anthropogenic impacts on the Section 8B parkway streams. These include the field observations from the water quality and aquatic resources sampling crews on stream siltation and streambank stability. The four water quality parameters of phosphate, ammonia, nitrate, and chloride also indicate whether a stream chemistry value was relatively high compared with pristine water quality values for other streams in this region (Table 8). See Section 3.2 on water quality for more discussion of water chemistry.

Based on Table 8, streams that were identified as having three or more separate indications of human-induced impacts were considered as impacted sites for purposes of stream biota analyses for "affected" and "unaffected" sites. Of the 31 stream sites where both water quality and aquatic resources were sampled, 12 were designated as affected and 19 were designated as unaffected or as pristine stream sites (Table 8). On the basis of this criterion, the 12 affected sites are Copeland Creek (sites 3 and 4), Lindsey Creek (sites 5 and 6), Webb Creek and two of the three Webb Creek tributaries (sites 7, 8, 9, and 27), Ogle Spring Branch (site 18 and 19), the most downstream tributary of Matthew Creek (site 15), and Sandy Hollow Creek (site 24).

### 3.3.1.4 Biotic Indicators of Stream Condition

The total taxa richness (i.e., the number of taxa per site) of benthic invertebrates is the index of choice for assessment of ecosystem health when monitoring freshwater ecosystems (Reice and Wohlenberg 1993). Generally, total taxa richness decreases with decreasing water quality (Weber 1973; Resh and Grodhaus 1983). Relative abundance of various stress-tolerant and stress-sensitive benthic invertebrate groups (orders, families, genera, and some species) also provides important insights into the conditions and the types of stressors that may be impacting the stream system. An unstressed stream would have a more diverse benthic invertebrate community that contains numerous stress-sensitive and less stress-sensitive taxa.

A comparison of the number of stress-sensitive species and specimens to the total numbers of benthic invertebrate species and specimens is a widely accepted indicator of ecosystem condition that is relatively independent of stream size (Lenat 1988). Three orders—Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies), collectively known as the EPT—are recognized as stress-sensitive benthic invertebrate orders. Within these three orders, the stoneflies (Plecoptera) are generally considered the most sensitive group, followed closely by the mayflies (Ephemeroptera), and lastly the caddisflies (Trichoptera).

Within another insect order, the Diptera (true flies), one subfamily—Orthocladiinae of the Chironomidae family (midges)—is generally recognized as a stress-tolerant subfamily (Wiederholm 1984; Wojtowicz Report 1982). Therefore, a comparison of species and specimens in the Orthocladiinae subfamily relative to all chironomid species and specimens is another indicator of ecosystem stress. The higher the number of taxa and specimens in the subfamily Orthocladiinae, especially in the genera *Cricotopus* and *Orthocladius*, the more indicative of a stressed site. Some other specific taxa are also considered indicators of pollution problems (primarily organic enrichment) and their presence, especially if in abundance in a stream survey, is noted. These taxa include the chironomid *Microtendipes*, the caddisfly *Hydropsyche betteni/depravata*, and the

**Table 8. Indications of anthropogenic effects on the streams in the proposed Section 8B of the Foothills Parkway: abiotic indicators of stream condition**

| Site identifier | "Affected" stream site | Streambed siltation evident[a] | Streambank stability compromised[a] | Phosphate relatively high[b] | Ammonia relatively high[c] | Nitrate relatively high[d] | Chloride relatively high[e] |
|---|---|---|---|---|---|---|---|
| 1-LP-A | | | | | | • | |
| 2-LP-B | | | | | | • | |
| 3-CP-A | ♦ | • | •• | • | | | |
| 4-CP-B | ♦ | • | •• | • | | | • |
| 5-LN-A | ♦ | • | | • | • | | •• |
| 6-LN-B | ♦ | •• | | • | • | | • |
| | | | | | | | |
| 32-LB-B | | | | | | | |
| 7-WB-A | ♦ | • | • | • | | • | |
| 8-WB-B | ♦ | • | • | • | | • | |
| 27-WBT1-B | ♦ | • | | •• | | | |
| 31-WBT3-B | | • | | • | | | |
| 9-WBT2-B | ♦ | • | | •• | | | |
| 28-SPB | | • | | • | | | |
| 10-MD-B | | • | | • | | | |
| 11-WR-B | | • | | | | | |
| 12-BT-B | | • | | | | | |
| 13-MA-B | | | | | | | |
| 13.5-MAT1-B | | | | | | | |
| 15-MAT-B | ♦ | •• | | • | | | |
| | | | | | | | |
| 14-DNW-A | | | | | | | |
| 16-DN-A | | | | | | • | |
| 17-DN-B | | | | | | • | |
| 18-OG-A | ♦ | •• | | • | | •• | •• |
| 19-OG-B | ♦ | • | | • | | •• | • |
| 20-CR-A | | • | | | | | |
| 21-CR-B | | •• | | | | | |
| | | | | | | | |
| 22-CH-B | | • | | • | | | |
| 23-IC-B | | | | | | | |
| 24-SH-B | ♦ | • | •• | • | | | |

**Table 8. Continued**

| Site identifier | "Affected" stream site | Streambed siltation evident[a] | Streambank stability compromised[a] | Phosphate relatively high[b] | Ammonia relatively high[c] | Nitrate relatively high[d] | Chloride relatively high[e] |
|---|---|---|---|---|---|---|---|
| 25-CB-A | | | | | | | |
| 26-CB-B | | | | | | | |

[a]Impacts visually evident in the stream water, stream substrate and/or stream bank condition as noted by water quality and aquatic resources field crews. "Some" and "moderate" = •; "Considerable" = ••.

[b]Indicates relatively high levels of phosphate (>20 $\mu g/L$) in these generally pristine mountain streams. See Table 3.2-4 and Sect. 3.2.3.2.

[c]Indicates relatively high levels of ammonia (>30 $\mu g/L$) in these generally pristine mountain streams. See Table 3.2-4 and Sect. 3.2.3.2.

[d]Indicates relatively high levels of nitrate (>250 $\mu g/L$) in these generally pristine mountain streams. See Table 3.2-4 and Sect. 3.2.3.2.

[e]Indicates relatively high levels of chloride (>2 $\mu g/L$) in these generally pristine mountain streams. See Table 3.2-4 and Sect. 3.2.3.2.

• = single bullet indicates that mean value is equal to or greater than the threshold values for relatively high levels.
•• = double bullet indicates that mean value is equal to or greater than twice the threshold values for relatively high levels.

mayfly *Stenacron interpunctatum*. The indications of biotic anthropogenic effects for Section 8B are listed in Table 9.

Some of the effects of mild enrichment and siltation on stream benthic macroinvertebrates are known to alter certain populations. Mild enrichment of streams (e.g., from agricultural and yard fertilizers and laundry detergents) tends to increase populations of some mayflies, black flies, caddisflies, and chironomids. Prolonged siltation is known to reduce species richness and specimen density and would alter populations to favor burrowing and deposit-feeding insect forms (e.g., some chironomids; Wiederholm 1984).

### 3.3.2 Benthic Macroinvertebrates and Fish: Results and Discussion

The following subsections describe and discuss the results of the 31 stream biotic survey sites in four geographically-grouped stream drainages from west to east along the proposed Section 8B Foothills Parkway (Fig. 20). The largest stream in each of the four stream drainage clusters is discussed in more detail, while the smaller associated streams of the drainages are summarized.

Stream discussions include physical stream characteristics (Table 10); benthic macroinvertebrate taxa richness (Tables 10 and 11; Fig. 33); abiotic and biotic indicators of stream condition, especially as they relate to human-induced impact (Tables 8 and 9; Figs. 34 and 35); and the fish survey results (Table 10; Fig. 33).

The biotic indicators of stream condition include the relative abundance of stress-sensitive and stress-tolerant taxonomic groups including EPTs (stress-sensitive taxa; Fig. 36), the relative contribution of each order within the EPT (Fig. 37), EPT to total benthic taxa ratios (Fig. 34), and

**Table 9. Indications of anthropogenic effects on the streams in the proposed Section 8B of the Foothills Parkway: biotic indicators of stream condition**

| Site identifier | Ratio of EPT taxa to total invertebrate taxa[a] | Ratio of orthoclad taxa to chironomid[b] | Number of pollution indicating species present[c] | More than one pollution indicating species present |
|---|---|---|---|---|
| 1-LP-A | 0.5 | 0.63 | 4 | ♦ |
| 2-LP-B | 0.5 | 0.49 | 3 | ♦ |
| 3-CP-A | 0.48 | 0.48 | 4 | ♦ |
| 4-CP-B | 0.47 | 0.35 | 4 | ♦ |
| 5-LN-A | 0.41 | 0.35 | 2 | ♦ |
| 6-LN-B | 0.46 | 0.35 | 1 | |
| | | | | |
| 32-LB-B | 0.54 | 0.63 | 1 | |
| 7-WB-A | 0.5 | 0.61 | 4 | ♦ |
| 8-WB-B | 0.46 | 0.48 | 6 | ♦ |
| 27-WBT1-B | 0.39 | 0.5 | 0 | |
| 31-WBT3-B | 0.44 | 0.5 | 0 | |
| 9-WBT2-B | 0.48 | 0.5 | 0 | |
| 28-SPB | 0.5 | 0.62 | 0 | |
| 10-MD-B | 0.6 | 0.57 | 0 | |
| 11-WR-B | 0.51 | 0.61 | 0 | |
| 12-BT-B | 0.45 | 0.6 | 0 | |
| 13-MA-B | 0.46 | 0.67 | 1 | |
| 13.5-MAT1-B | 0.51 | 0.67 | 0 | |
| 15-MAT-B | 0.55 | 0.75 | 0 | |
| | | | | |
| 14-DNW-A | 0.56 | 0.82 | 0 | |
| 16-DN-A | 0.48 | 0.62 | 4 | ♦ |
| 17-DN-B | 0.51 | 0.65 | 2 | ♦ |
| 18-OG-A | 0.48 | 0.38 | 0 | |
| 19-OG-B | 0.53 | 0.55 | 1 | |
| 20-CR-A | 0.47 | 0.68 | 0 | |
| 21-CR-B | 0.47 | 0.5 | 0 | |
| | | | | |
| 22-CH-B | 0.53 | 0.48 | 3 | ♦ |
| 23-IC-B | 0.48 | 0.58 | 2 | ♦ |
| 24-SH-B | 0.5 | 0.5 | 4 | ♦ |

**Table 9. Continued**

| Site identifier | Ratio of EPT taxa to total invertebrate taxa[a] | Ratio of orthoclad taxa to chironomid[b] | Number of pollution indicating species present[c] | More than one pollution indicating species present |
|---|---|---|---|---|
| 25-CB-A | 0.46 | 0.58 | 5 | ♦ |
| 26-CB-B | 0.43 | 0.5 | 5 | ♦ |

[a]EPT taxa to total taxa ration—compares the number of taxa in EPT orders [Ephermeroptera (mayflies), Plecoptera (stoneflies), Tricoptera (caddisflies)] that contain insects that are generally known to be sensitive to pollutants with total taxa present, assuming that the higher the proportion of sensitive taxa, the healthier the ecosystem.

[b]Ratio of Subfamily Orthocladiinae taxa to total Family Chironomidae taxa—compares the number of taxa in the generally stress-tolerant Orthocladiinae to the total chironomids (non-biting midges). Higher relative numbers of stress tolerant taxa generally indicate the presence of stress factors in the stream environment.

[c]Pollution-indicating species include the chironomids *Cricotopus*, *Orthocladius*, and *Microtendipes*; the caddisfly *Hydropsyche betteni/depravata*; and the mayfly *Stenacron interpunctatum*.

orthoclad taxa (stress-tolerant taxa) and orthoclad to total chironomid taxa ratios (Tables 10 and 11; Fig. 38). Comparisons with other stream survey results in this region are made when the streambed substrate, stream width, and collection methods allow such comparisons. It is hoped that these comparisons help develop a larger context for the relative evaluation of the status of Section 8B stream aquatic ecological resources.

Section 3.3.2.5 summarizes the general findings of the Section 8B stream survey results.

### 3.3.2.1 Little Pigeon River/Copeland Creek/Lindsey Creek

Three of the Section 8B streams intercept the ROW in the Pittman Center valley at the westernmost end of Section 8B. Most notably, these include the largest stream in the Section 8B study—Little Pigeon River (Fig. 20). The other two streams in this valley are Copeland Creek, a small primary tributary to Little Pigeon River, and Lindsey Creek, a secondary tributary to the Little Pigeon River by way of Webb Creek.

The **Little Pigeon River** at sites 1 and 2 is approximately 18 m (59 ft) wide with a maximum depth of 150 cm (5 ft). The two small tributaries, Copeland and Lindsey Creeks (sites 3, 4, 5, and 6) are both about 2 m (6 ft) with maximum depths of around 60 cm (2 ft)] (see Fig. 20, Table 10). Little Pigeon sites were approximately 10 to 20% canopy-covered with a stream bed substrate predominantly comprised of boulder and cobbles (70%) with gravel (20%), and the remainder consisting of bedrock and silt. With 25 total fish taxa and 174 different invertebrate taxa collected in the surveys, site 1 and the very similar site 2 (24 total fish taxa; 174 total invertebrate taxa) not only are the most taxonomically rich sites sampled in Section 8B (Table 10, Fig. 33), but also compare very favorably with other temperate region sites. For example, Abrams Creek is a nearby GSMNP stream site of comparable substrate and size [about 0.40 km (0.25 mile) below Abrams Creek Campground]. The May 1993 sample for Abrams Creek (using identical collection methods exclusive of chironomid taxa) was 106 total invertebrate taxa and 59 EPT taxa. This

**Table 10. Stream width and depth and total numbers of benthic macroinvertebrates and fish taxa collected from the stream sampling sites along the proposed Section 8B of the Foothills Parkway**

| Site identifier | Mean stream width (m) | Maximum depth (cm) | Total benthic taxa | Total EPT taxa | Total orthoclad taxa | Total fish taxa |
|---|---|---|---|---|---|---|
| **Little Pigeon River/Copeland Creek/Lindsey Creek** | | | | | | |
| 1-LP-A | 18 | 100 | 174 | 88 | 21 | 24 |
| 2-LP-B | 18 | 150 | 174 | 87 | 19 | 25 |
| 3-CP-A | 3 | 60 | 130 | 62 | 14 | 6 |
| 4-CP-B | 2.5 | 70 | 115 | 54 | 8 | 10 |
| 5-LN-A | 1 | 50 | 79 | 32 | 7 | 4 |
| 6-LN-B | 1.5 | 60 | 78 | 36 | 6 | 4 |
| **Webb Mountain/Webb Creek Drainages** | | | | | | |
| 32-LB-B | 4 | 80 | 94 | 51 | 12 | 4 |
| 7-WB-A | 11 | 100 | 137 | 68 | 16 | 15 |
| 8-WB-B | 12 | 100 | 160 | 73 | 17 | 15 |
| 27-WBT1-B | 1 | 50 | 71 | 28 | 3 | 4 |
| 31-WBT3-B | 0.5 | 20 | 27 | 12 | 2 | 0 |
| 9-WBT2-B | 1.8 | 40 | 82 | 39 | 8 | 1 |
| 28-SPB | 1.2 | 20 | 68 | 34 | 5 | 0 |
| 10-MD-B | 2.5 | 70 | 100 | 51 | 8 | 1 |
| 11-WR-B | 2 | 50 | 106 | 54 | 11 | 2 |
| 12-BT-B | 2 | 45 | 86 | 39 | 9 | 1 |
| 13-MA-B | 1.8 | 15 | 109 | 70 | 18 | 4 |
| 13.5-MAT1-B | 0.6 | 40 | 73 | 37 | 8 | 0 |
| 15-MAT-B | 1.5 | 40 | 87 | 48 | 9 | 2 |

## Table 10. Continued

| Site identifier | Mean stream width (m) | Maximum depth (cm) | Total benthic taxa | Total EPT taxa | Total orthoclad taxa | Total fish taxa |
|---|---|---|---|---|---|---|
| **Rocky Flat Drainages** | | | | | | |
| 14-DNW-A | 1.5 | 20 | 91 | 51 | 9 | 0 |
| 16-DN-A | 6 | 60 | 135 | 65 | 23 | 7 |
| 17-DN-B | 6 | 75 | 113 | 58 | 15 | 9 |
| 18-OG-A | 1.5 | 20 | 87 | 42 | 5 | 2 |
| 19-OG-B | 3 | 50 | 99 | 52 | 11 | 2 |
| 20-CR-A | 1.5 | 30 | 106 | 50 | 15 | 1 |
| 21-CR-B | 1.5 | 30 | 95 | 45 | 7 | 2 |
| **Big Ridge/Cosby Creek Drainages** | | | | | | |
| 22-CH-B | 1.5 | 45 | 99 | 52 | 21 | 6 |
| 23-IC-B | 8 | 60 | 90 | 43 | 14 | 7 |
| 24-SH-B | 2 | 30 | 109 | 54 | 11 | 0 |
| 25-CB-A | 12 | 120 | 162 | 75 | 21 | 13 |
| 26-CB-B | 15 | 60 | 163 | 70 | 21 | 18 |

**Table 11. Benthic macroinvertebrate survey taxa and specimen comparisons of various stress-sensitive and stress-tolerant taxonomic groupings from the stream sampling sites along the proposed Section 8B of the Foothills Parkway**

| Site identifier | Ratio of EPT taxa to total benthic taxa[b,c] | Mayflies (E) of EPT | Stoneflies (P) of EPT | Caddisflies (T) of EPT | Ratio of EPT specimens to total benthic specimens[b] | Total EPT specimens[b] | Total benthic specimens | Ratio of orthoclad taxa to total chionomid taxa | Total orthoclad taxa | Total chironomid taxa |
|---|---|---|---|---|---|---|---|---|---|---|
| **Little Pigeon River/Copeland Creek/Lindsey Creek** | | | | | | | | | | |
| 1-LP-A | 0.5 | 34 | 19 | 35 | 0.65 | 1493 | 2296 | 0.63 | 21 | 33 |
| 2-LP-B | 0.5 | 38 | 15 | 34 | 0.69 | 2054 | 2966 | 0.49 | 19 | 39 |
| 3-CP-A | 0.48 | 29 | 10 | 23 | 0.64 | 1160 | 1818 | 0.48 | 14 | 29 |
| 4-CP-B | 0.47 | 30 | 8 | 16 | 0.64 | 814 | 1266 | 0.35 | 8 | 23 |
| 5-LN-A | 0.41 | 12 | 6 | 14 | 0.63 | 708 | 1117 | 0.35 | 7 | 20 |
| 6-LN-B | 0.46 | 16 | 8 | 12 | 0.71 | 804 | 1132 | 0.35 | 6 | 17 |
| **Webb Mountain/Webb Creek Drainages** | | | | | | | | | | |
| 32-LB-B | 0.54 | 22 | 10 | 19 | 0.74 | 1088 | 1477 | 0.63 | 12 | 19 |
| 7-WB-A | 0.5 | 30 | 16 | 22 | 0.69 | 1524 | 2215 | 0.61 | 16 | 26 |
| 8-WB-B | 0.46 | 34 | 18 | 21 | 0.64 | 1704 | 2676 | 0.48 | 17 | 35 |
| 27-WBT1-B | 0.39 | 8 | 6 | 14 | 0.57 | 337 | 590 | 0.5 | 3 | 6 |
| 31-WBT3-B | 0.44 | 5 | 2 | 5 | 0.66 | 64 | 97 | 0.5 | 2 | 4 |
| 9-WBT2-B | 0.48 | 14 | 7 | 18 | 0.72 | 873 | 1211 | 0.5 | 8 | 16 |
| 28-SPB | 0.5 | 9 | 13 | 12 | 0.73 | 540 | 1737 | 0.62 | 5 | 8 |
| 10-MD-B | 0.6 | 21 | 9 | 21 | 0.63 | 736 | 1163 | 0.57 | 8 | 14 |
| 11-WR-B | 0.51 | 22 | 11 | 21 | 0.6 | 976 | 1624 | 0.61 | 11 | 18 |
| 12-BT-B | 0.45 | 17 | 7 | 15 | 0.63 | 556 | 888 | 0.6 | 9 | 15 |
| 13-MA-B | 0.46 | 22 | 13 | 15 | 0.65 | 840 | 1294 | 0.67 | 18 | 27 |

**Table 11. Continued**

| Site identifier | Ratio of EPT taxa to total benthic taxa[b,c] | Mayflies (E) of EPT | Stoneflies (P) of EPT | Caddisflies (T) of EPT | Ratio of EPT specimens to total benthic specimens[b] | Total EPT specimens[b] | Total benthic specimens | Ratio of orthoclad taxa to total chionomid taxa | Total orthoclad taxa | Total chironomid taxa |
|---|---|---|---|---|---|---|---|---|---|---|
| 13.5-MAT1-B | 0.51 | 15 | 8 | 14 | 0.79 | 622 | 784 | 0.67 | 8 | 12 |
| 15-MAT-B | 0.55 | 23 | 10 | 15 | 0.81 | 1098 | 1356 | 0.75 | 9 | 12 |
| **Rocky Flat Drainages** | | | | | | | | | | |
| 14-DNW-A | 0.56 | 19 | 13 | 19 | 0.75 | 876 | 1170 | 0.82 | 9 | 11 |
| 16-DN-A | 0.48 | 26 | 18 | 21 | 0.75 | 1475 | 1976 | 0.62 | 23 | 37 |
| 17-DN-B | 0.51 | 31 | 12 | 15 | 0.73 | 1034 | 1407 | 0.65 | 15 | 23 |
| 18-OG-A | 0.48 | 15 | 6 | 21 | 0.64 | 641 | 996 | 0.38 | 5 | 13 |
| 19-OG-B | 0.53 | 25 | 8 | 19 | 0.78 | 943 | 1227 | 0.55 | 11 | 20 |
| 20-CR-A | 0.47 | 19 | 12 | 19 | 0.68 | 1315 | 1929 | 0.68 | 15 | 22 |
| 21-CR-B | 0.47 | 18 | 8 | 19 | 0.66 | 611 | 927 | 0.5 | 7 | 14 |
| **Big Ridge/Cosby Creek Drainages** | | | | | | | | | | |
| 22-CH-B | 0.53 | 23 | 12 | 17 | 0.6 | 742 | 1233 | 0.48 | 21 | 10 |
| 23-IC-B | 0.48 | 18 | 11 | 14 | 0.46 | 365 | 787 | 0.58 | 14 | 24 |
| 24-SH-B | 0.5 | 24 | 11 | 19 | 0.66 | 833 | 1343 | 0.5 | 11 | 22 |
| 25-CB-A | 0.46 | 33 | 19 | 23 | 0.71 | 1692 | 2384 | 0.58 | 21 | 36 |
| 26-CB-B | 0.43 | 29 | 21 | 20 | 0.61 | 1408 | 2306 | 0.5 | 21 | 42 |

[a]These numbers are combined totals for both the spring and fall benthic invertebrate qualitative surveys.
[b]EPT = Ephemeroptera (mayflies), Plecoptera (stoneflies), Tricoptera (caddisflies).
[c]EPT to total ratio—compares the number of taxa in orders (or number of specimens in those orders) that contain insects that are generally known to be sensitive to pollutants with the total taxa present, assuming that the higher the proportion of sensitive taxa, the healthier the ecosystem.

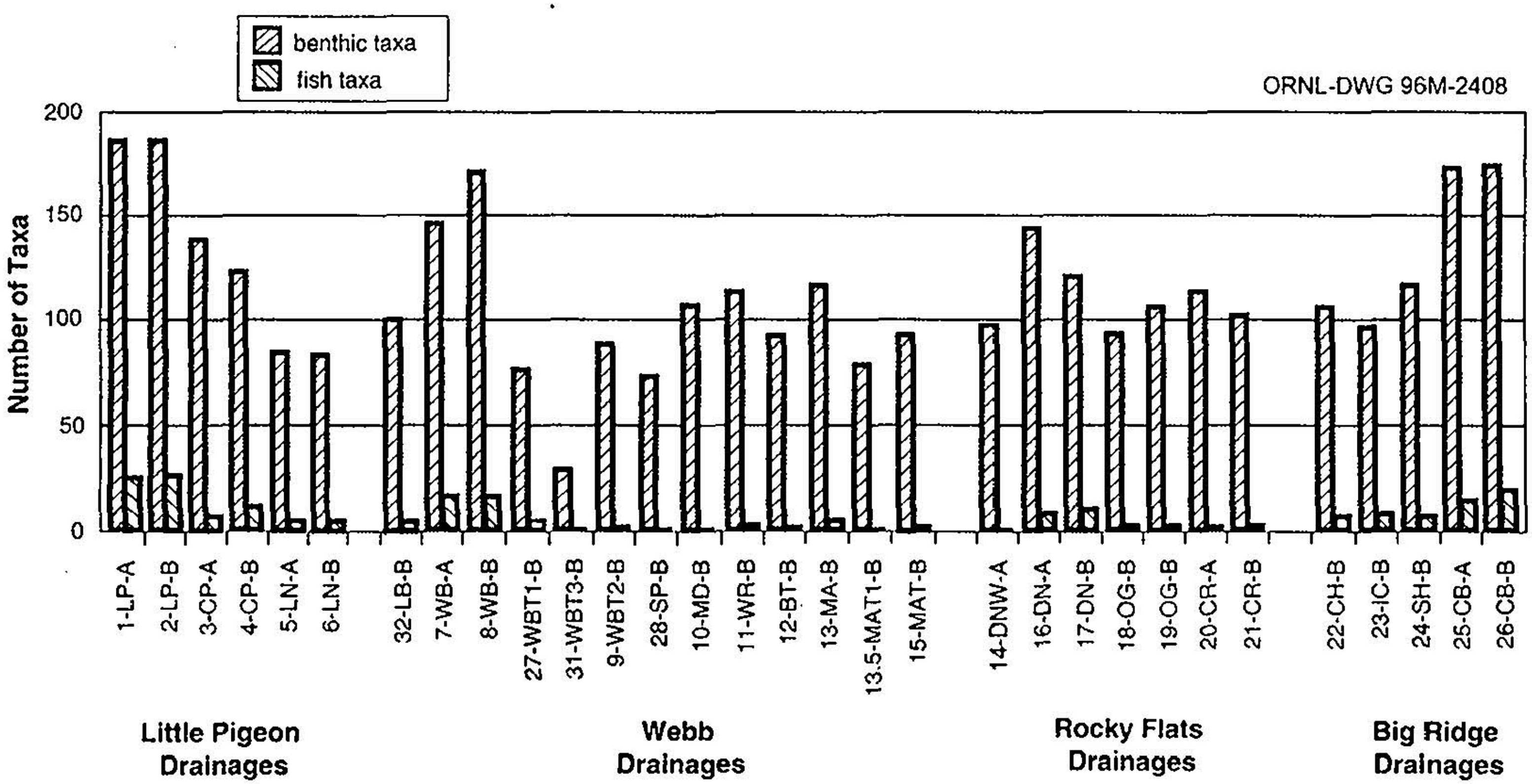


**Fig. 33. Total number of taxa for benthic macroinvertebrates and fish at the stream biological survey sites for Section 8B of the Foothills Parkway.**

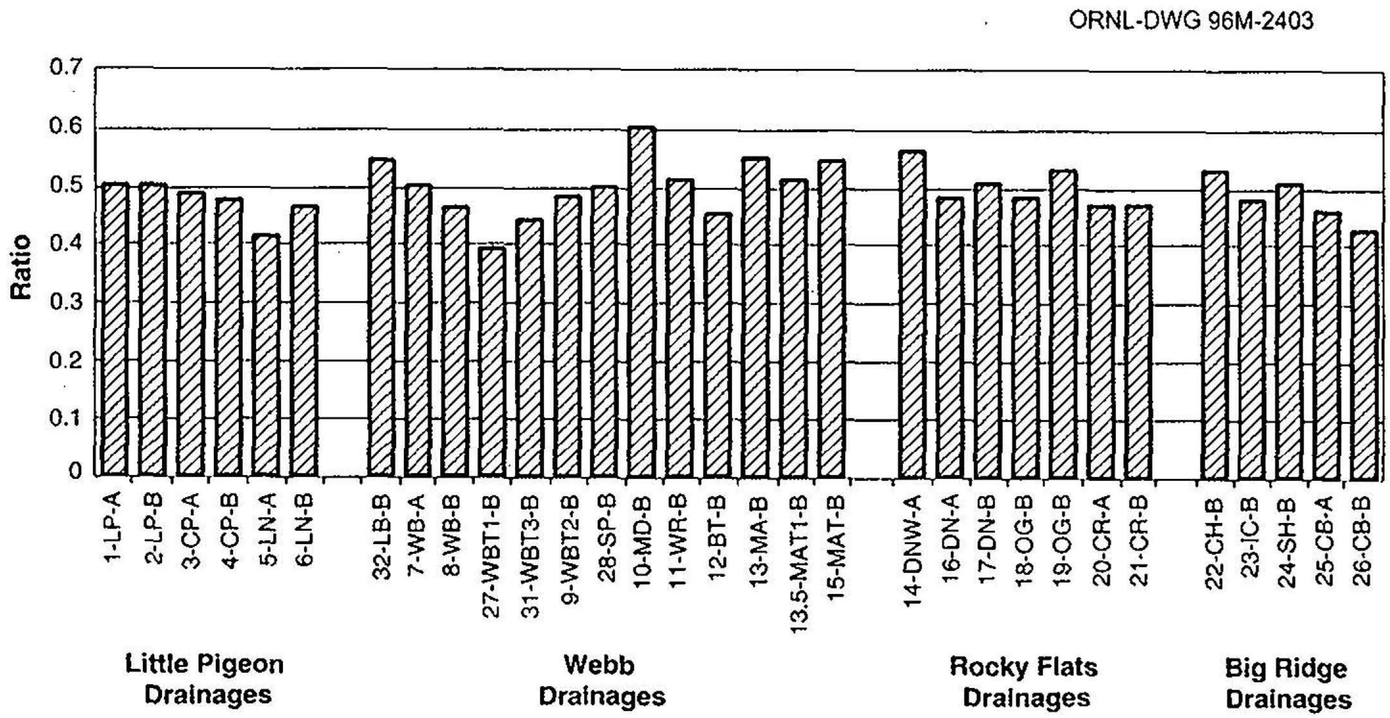


**Fig. 34. Ratio of EPT taxa to total benthic macroinvertebrate taxa at the stream biological survey sites for Section 8B of the Foothills Parkway.**

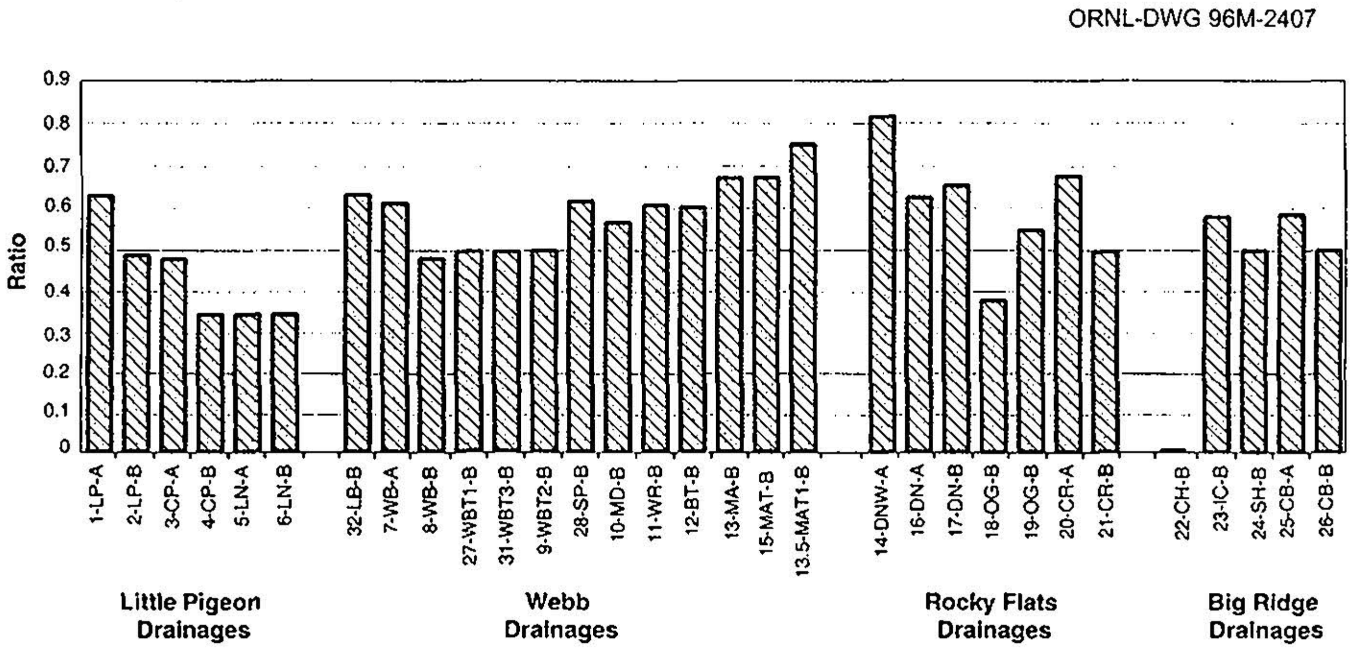


**Fig. 35. Ratio of Orthocladiinae taxa to total Chironomidae taxa at the stream biological survey sites for Section 8B of the Foothills Parkway.**

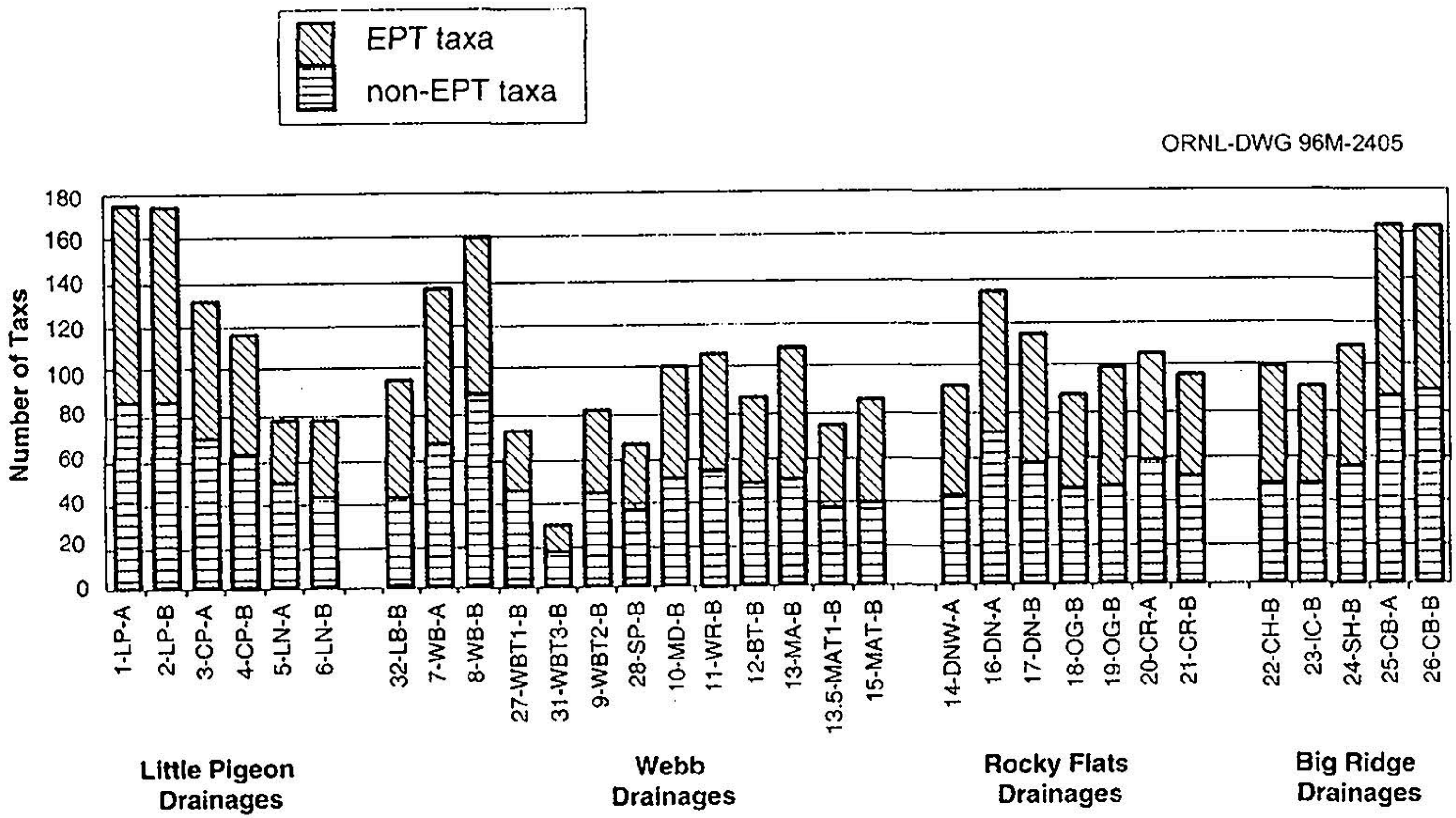


**Fig. 36. Number of Ephemeroptera, Plecoptera, and Tricoptera (EPT) taxa and non-EPT taxa at the stream biological survey sites for Section 8B of the Foothills Parkway.**

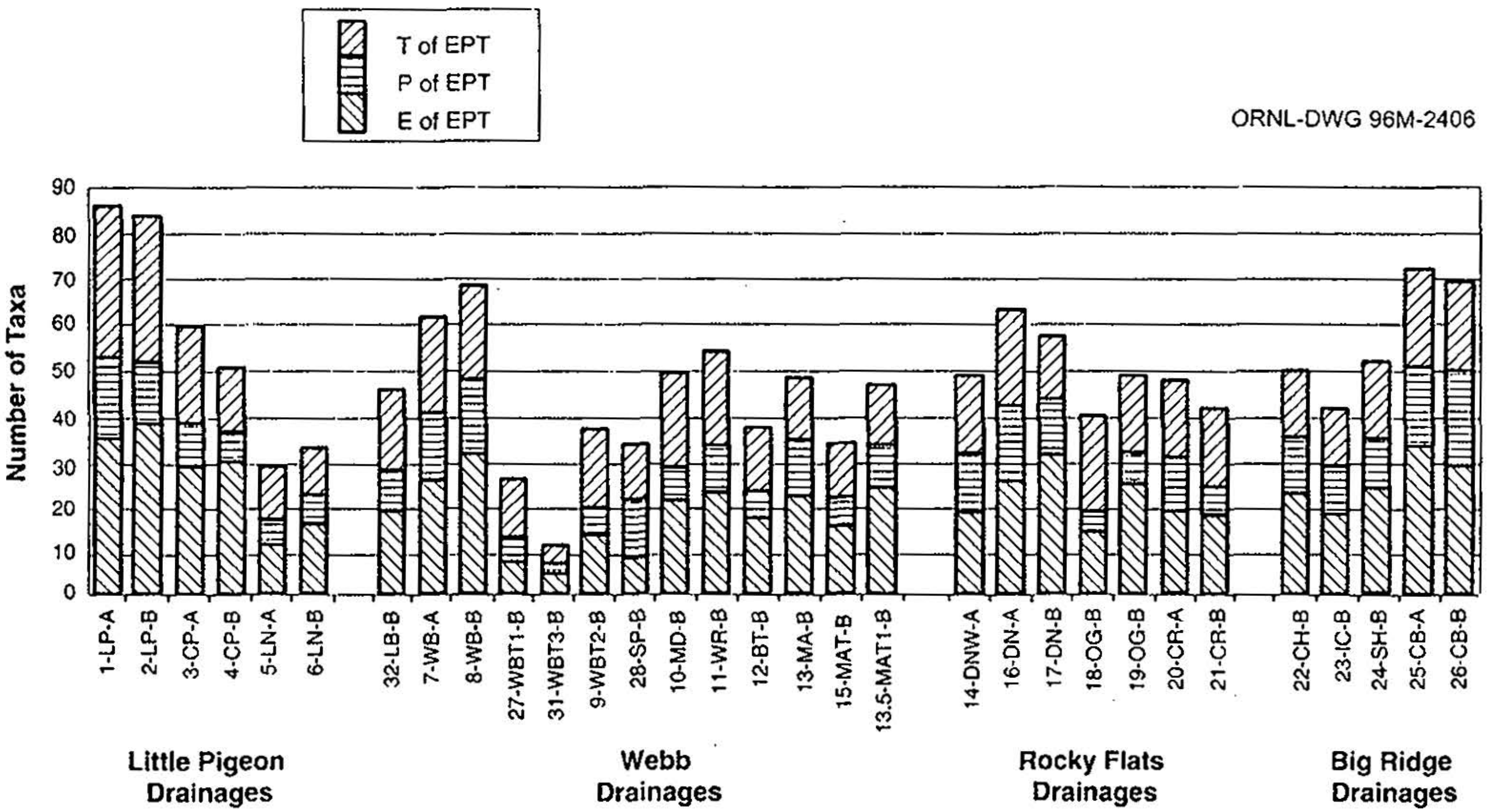


**Fig. 37. Relative contribution of Ephemeroptera, Plecoptera, and Tricoptera (EPT) to the EPT total taxa at the stream biological survey sites for Section 8B of the Foothills Parkway.**

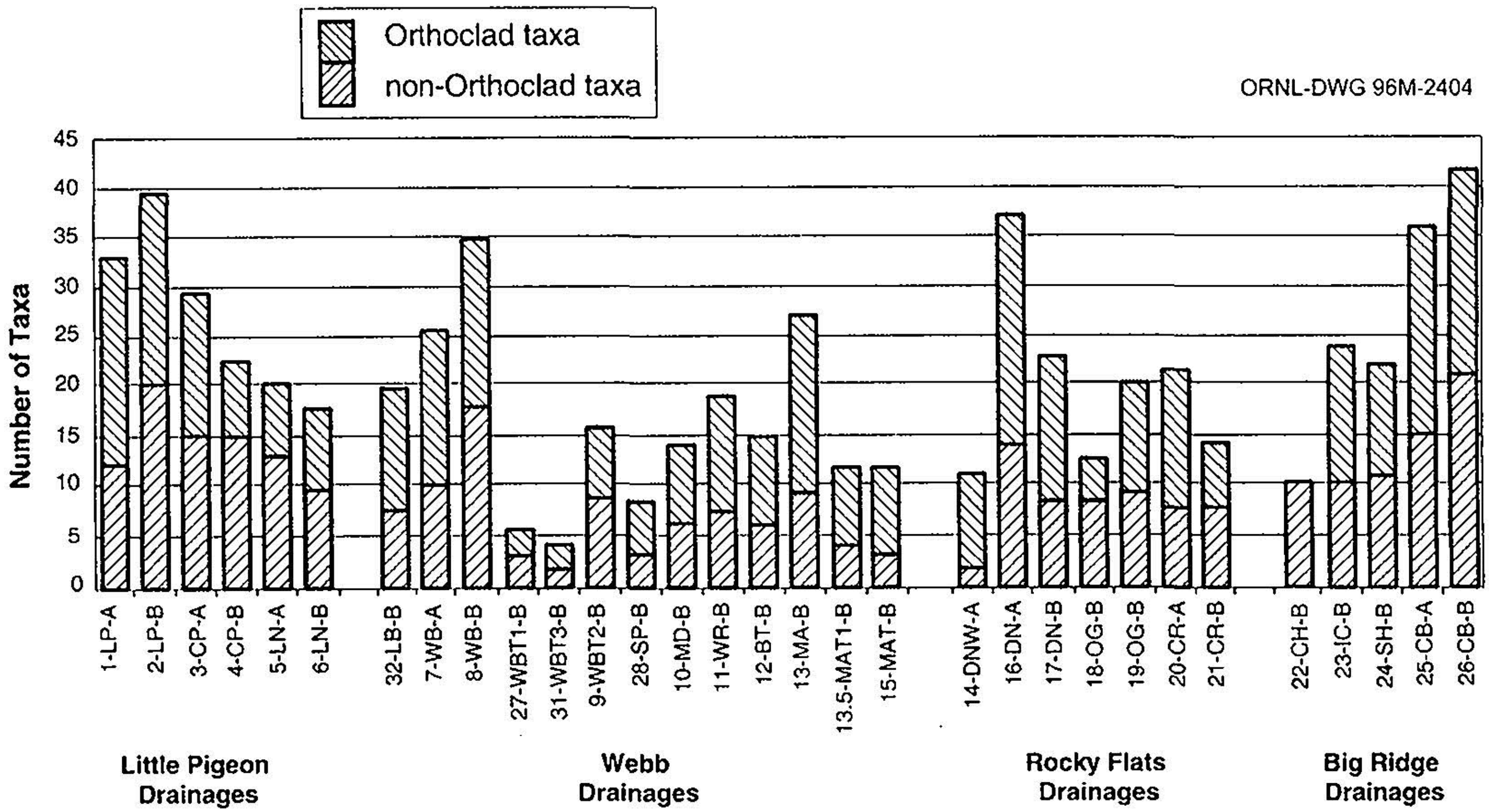


**Fig. 38. Numbers of Orthocladiinae and non-Orthocladiinae taxa at the stream biological survey sites for Section 8B of the Foothills Parkway.**

sample compares favorably with 100 non-chironomid taxa for the site 1 and 2 spring sample, including 88 EPT taxa (D. Etnier, personal communication to J. Dickerman, January 20, 1995).

The Little Pigeon River sites were rated as pristine according to the abiotic indicators of stream condition. Only one of six possible abiotic human-induced impact indicators—relatively high nitrate levels—applied to this site. This particular indicator, when occurring without other abiotic human-induced indicators, is not considered supportive of anthropogenic impact (see Sect. 3.2.3.2 discussion). All the biotic data of stream condition indicate that the Little Pigeon River sites have very rich taxonomic assemblages with diverse specimen abundances (see Appendix D). Half of the benthic invertebrate taxa were from the stress-sensitive EPT taxonomic groups, and 60% of those EPT taxa belonged to the two most sensitive orders (E and P) within the EPT groups (Tables 10 and 11, Fig. 38). The chironomid fauna were also exceptionally diverse and abundant with 50 to 60% of the chironomid taxa within the most stress-tolerant orthoclad group (Table 11, Figs. 35 and 38). The Little Pigeon River sites had three and four different species of pollution-indicating genera, *Cricotopus* and *Orthocladius*, respectively. But these taxa occurred in very low numbers, only about 30 specimens (from a total of 2 to nearly 3000 thousand specimens) in the benthic invertebrate combined surveys at these Little Pigeon River sites (Table 11; Appendix D).

Fish communities at both Little Pigeon River sites were dominated by stonerollers (*Campostoma anomalum*), accounting for an estimated 50% and 31% of the total number of fish collected at sites 1 and 2, respectively. Warpaint shiners (*Luxilus coccogenis*) and Tennessee shiners (*Notropis rubricroceus*) were the next most commonly collected fish, accounting for the same percentages of total fish at both sites—15% and 12%, respectively. At Little Pigeon River (site 10), collection efforts also yielded 12 specimens identified as hybrids between the Tennessee shiner and saffron shiner (*Notropis rubricroceus*). This hybrid is not uncommon where these species co-occur (Appendix D).

**Copeland and Lindsey Creeks** (sites 3, 4, 5, and 6) are small creeks with substrate consisting predominantly of gravel and cobble (80%–95%). The Copeland Creek sites are located in a cow pasture with 0% to 5% high canopy (consisting of a few large trees), while slightly smaller Lindsey Creek sites are adjacent to a small road and several residences in Pittman Center with around 10% canopy coverage of larger trees and 40% canopy coverage from shrubs (Fig. 20). The upstream watersheds are more forested with less residential development.

The Copeland Creek sites are similar in size, substrate, and fish taxa to Section 8D stations Machine Branch and Rymel Branch (MB-3M and MB-3R) just above their confluence in Wears Cove (ORNL 1992). Copeland Creek has greater richness for both total benthic and EPT taxa (total benthic taxa 130 and 115; EPT taxa 62 and 54), while Machine Branch and Rymel Branch have 99 and 71 total benthic taxa and 35 and 29 EPT taxa, respectively. These Section 8D sites also had a larger proportion of orthoclad taxa in their chironomid taxa. For example, Machine Branch site (MB-3M) had 17 orthoclads among 26 chironomid taxa, with 6 of these taxa being either *Cricotopus* or *Orthocladius* species; Copeland Creek had 8 to 14 orthoclad taxa in 23 to 29 chironomid taxa, with 3 of these taxa being either *Cricotopus* or *Orthocladius species*. The Copeland Creek survey results also indicated 44 specimens of the pollution-indicating taxa *Hydropsyche betteni/depravata* out of a total of about 3000 specimens from both Copeland Creek sites (Table 11).

Both Copeland and Lindsey Creek, with four separate abiotic indicators of human-induced stress, were designated as affected sites (Table 8). Both creeks showed evidence of stream bed siltation and relatively high phosphate and chloride levels. Copeland Creek had compromised stream bank stability while Lindsey Creek water had relatively high ammonia levels. The biotic indicators of stream condition also suggested some organic loading, especially in Lindsey Creek (Table 9 and Appendix D). Lindsey Creek site 5—with 32 EPT taxa and 41% EPT taxa in the benthic invertebrate total of 79 taxa—was among the lowest EPT percentage in the Section 8B stream biotic survey. The presence of *Stenacron interpunctatum* (8 specimens) and the dominance of *Hydropsyche betteni/depravata* with 70 specimens further indicates an organically enriched environment. Even so, the overall benthic taxa richness (115 to 130 for Copeland Creek and 78 to 79 for Lindsey Creek) indicates a fairly healthy benthos. The small creek fish communities for both Copeland Creek and Lindsey Creek included creek chubs (*Semotilius atromaculatus*) and blacknose dace (*Rhinichthys atractulus*) as frequently collected members of the fish community (Table 10, Appendix D).

### 3.3.2.2 Webb Mountain/Webb Creek Drainages

Thirteen of the 31 Section 8B stream sites are associated with the Webb Mountain drainages. Webb Creek is the third largest stream along the Section 8B ROW and the main stream of this drainage (Fig. 20). Webb Creek (sites 7 and 8) collects the surface waters from the southern slopes of Webb Mountain and receives the waters from seven other study sites (9, 10, 11, 12, 27, 28, and 31). Matthew Creek (site 13) drains the eastern slope of Webb Mountain and receives the waters of site 13.5 and 15, two small tributaries. One other moderately-sized stream, Laurel Branch (site 32), drains the western slope of Webb Mountain.

**Webb Creek** sites (7 and 8) have a mean width of about 12 m (40 ft) and a maximum depth of 100 cm (3 ft) with 30 to 50% mixed canopy of trees and shrubs along a stream bed substrate predominantly composed of 50 to 60% boulder and cobble and 30 to 45% gravel (Appendix D). Webb Creek, the third largest stream in Section 8B, is also the third most taxonomically rich site for benthic invertebrate taxa (137 and 160 taxa, sites 7 and 8 respectively) and fish taxa (15 taxa for each site) in Section 8B (Table 10). Around half of the total benthic taxa were from the stress-sensitive EPT groups (68 and 73 taxa, sites 7 and 8 respectively) with the two most stress-sensitive EPT orders (P and E) together contributing over 68 to 71% of the EPT group taxa (Tables 10 and 11, Fig. 37). The stress-tolerant orthoclads in the chironomid group contributed 16 and 17 taxa to the chironomid total taxa of 26 and 35, and 3 and 5 of these taxa were either *Cricotopus* or *Orthocladius* species. Webb Creek site 8 biota, more so than the other Webb Creek site, reflects an organically enriched stream as evidenced by the higher *Cricotopus* and *Orthocladius* species count (55 specimens) as well as the considerable number of *Microtendipes* specimens (110). It would appear that enrichment from runoff has been sufficient to increase stream productivity without reducing taxonomic richness.

The abiotic indicators of human-induced stress support the biotic indicators of organic enrichment. The Webb Creek sites were classified as affected sites because four separate abiotic indicators met the criteria of human-induced stress (Table 8). There was evidence of compromised stream bank stability and siltation along with relatively high phosphate and nitrate levels.

Fifteen fish taxa were collected at both Webb Creek sites (7 and 8). The five most dominant populations of fish, on the basis of numbers of individuals and their percentage contribution to the fish community are stonerollers (29, 12%), warpaint shiners (15, 10%), river chubs (*Nocomis micropogon*; 7, 11%), saffron shiners (22, 18%), and sculpins (*Cottus carolinae and C. bairdi*, 12, 37%). Game fish were not abundant (Appendix D).

These Webb Creek sites are similar to Mill Creek just above Abrams Creek in Cades Cove, GSMNP (Etnier Report in Appendix D). An early May 1994 survey, using identical collection methods, collected 53 EPT taxa out of a total (not including chironomids) of 79 benthic taxa. The spring Webb Creek (site 7) survey, also excluding chironomid taxa, collected 53 EPT taxa out of total taxa of 96. The higher Webb Creek taxa totals may be explained by the enrichment effect from the sewage and fertilizer input to this stream. This enrichment effect was evidenced in the abiotic and biotic indicators and may have actually increased the taxonomic richness. However, further increases of the anthropogenic impacts are likely to reduce the taxonomic richness within the stream community.

The seven Webb Creek tributaries range in mean width from 0.5 to 2.5 m (1 to 8 ft) with maximum stream depth ranging from 20 to 70 cm (0.5 to 2 ft; Table 20). Six of the seven tributaries flow through heavily forested areas with canopy coverage typically from 80 to 90%. Warden Branch (site 10), however, had considerably less canopy with 25 to 50% coverage. Stream bed substrates—in five of the seven streams—were composed mainly of gravel (40 to 85%); cobbles and boulders were generally the next most common substrate (15 to 35%). Bedrock (40 to 50%), however, was the dominant substrate for Warden Branch and Mill Dam Branch (sites 11 and 10, respectively; Appendix D).

All seven Webb tributaries had evidence of stream impacts, in particular stream siltation. These Webb tributaries flow down Webb Mountain, often along very steep gradients. The Butler Branch (site 12) stream had the most siltation, apparently from nearby residential construction and input from the adjacent dirt road. All Webb tributaries, except Warden Branch and Butler Branch (sites 11 and 12), had high levels of phosphate in their waters (Table 8). On the basis of the abiotic indicators of stream condition, however, only two of the seven tributaries were designated as affected because those two streams, Webb Creek Tributaries 2 and 1 (sites 9 and 27, respectively) had very high levels of phosphate in addition to the stream siltation.

Webb Creek tributaries varied widely on the basis of their taxonomic richness. Three of these tributaries had the lowest values for total benthic and EPT taxa for several different reasons. Webb Creek Tributary 2 (site 27), an anthropogenically affected site, reflects these impacts; this site had the lowest number of EPT taxa (28) and the lowest percentage of EPT taxa compared with total benthic taxa (39%) for those streams containing water throughout the year. Webb Creek Tributary 1 (site 31), the smallest stream in Section 8B, was the only intermittent stream in this survey; it was dry during the fall and consequently yielded the lowest total benthic taxa (27), lowest EPT taxa (12), and no fish (Table 10). Sheep Pen Branch (site 28) had the lowest number of total benthic taxa (68) for permanent streams. While there was no evidence of human-induced impact, the absence of moss on rocks at this site indicates that the site had been recently scoured before the spring 1994 survey, although the stream was heavily shaded (75%) (Appendix D). For the permanent Webb tributaries, the total number of benthic taxa ranged from 68 to 106, while the total number of EPT taxa ranged from 28 to 54. The orthoclad taxa ranged from 3 to 11, while the

chironomid taxa varied from 4 to 18. None of these tributaries had any *Cricotopus* or *Orthocladius* taxa. All these tributaries had many taxa found only in cool, clean water; and, for their size, the taxa richness and specimen abundance indicated fairly good (Mill Dam Branch, site 10) to very healthy assemblages of stream benthic biota (Warden Branch, site 11; Appendix D).

Where fish were present in the Webb Creek tributaries, blacknose dace populations dominated; this involved five of the seven tributaries. One stream collection yielded four fish taxa (Webb Creek Tributary 1, site 27), another stream yielded two fish taxa, while three other streams each had only blacknose dace (see Table 10 and Appendix D).

Both Mill Dam Branch (site 10) and Butler Branch (site 12) can be compared with the Caney Creek station (CC-3) from the 1991 survey of Section 8D. They are similar in size, substrate, and fish taxa, although site 12 is slightly more silty. Caney Creek had 86 total benthic taxa with 44 EPT taxa (ORNL 1992). Butler Branch has the same number of total benthic taxa with 39 EPT taxa, while Mill Dam Branch (near a swimming pool and golf course) had higher total benthic and EPT taxa (100 and 51, respectively). The Caney Creek survey found 15 chironomid taxa, 8 being orthoclads with no *Cricotopus* or *Orthocladius* specimens. Butler Branch and Mill Dam Branch were very similar with 14 and 15 chironomid taxa, respectively, and 8 and 9 orthoclad taxa, respectively. Neither had any *Cricotopus* or *Orthocladius* specimens.

While Matthew Creek (site 13) and Matthew Creek Tributary 1 (site 13.5) are similar in maximum stream depth [each 40 cm (6 in.)], Matthew Creek and Matthew Creek Tributary 2 (site 15) have similar stream widths, 1.5 to 1.8 m (5 to 6 ft). Matthew Creek proper and Tributary 1 are higher up on Webb Mountain and consequently more forested (80 to 90% forested canopy). Tributary 2, farther down Webb Mountain, is located in a more developed area with an estimated 25 to 50% canopy (Appendix D). Cobble-sized slabrock constitutes most (40 to 65%) of the two Matthew Creek tributaries substrate, and gravel comprises the rest. The Matthew Creek stream bed is nearly equal gravel and cobbles (40 to 45% each). Also noteworthy is a 85-m subsurface channel for Matthew Creek Tributary 1 that resurfaces just 15 m before its confluence with Matthew Creek (Appendix D).

Matthew Creek Tributary 2 (site 15) is considered as affected anthropogenically on the basis of heavy stream bed siltation and relatively high phosphate levels. The other two sites were relatively pristine, with no evidence of human-induced impact on stream condition. The biotic stream survey results indicate that all three of these sites have high taxonomic richness ranging from 109 total benthic taxa in Matthew Creek to 87 taxa at site 15 and 73 taxa at the narrowest stream, site 13.5. All three sites had many cool-, clean-water taxa (see Wojtowicz discussion in Appendix D). The percentage of EPT taxa ranged from 46 to 55%. Most chironomid taxa, however, were orthoclad taxa, 67% at sites 13 and 13.5 and 75% (second highest value recorded at Section 8B sites) at site 15. Even so, only one of these sites, site 13, had any *Cricotopus* or *Orthocladius* specimens (one taxa with 3 specimens), indicating that there was no significant representation of individual taxa indicative of pollution problems (Table 11; Appendix D).

The Matthew Creek Tributary 2 (site 15) can also be appropriately compared with the Caney Creek station (CC-3) of the 1991 Section 8D survey. With 48 EPT taxa and 87 total benthic taxa, site 15 is strikingly similar to the Caney Creek station (44 EPT and 86 total taxa). The orthoclad

and chironomid taxa (8 and 15 for CC-3) are also very comparable to Matthew Creek (9 and 12 at site 15), with no *Cricotopus* or *Orthocladius* at either site.

While site 13.5 had no fish taxa collected in the fall survey, the other two streams had four and two taxa of fish (sites 13 and 15, respectively; Table 10). Both streams had mainly blacknose dace and mottled sculpin populations (*Cottus bairdi*; Appendix D).

**Laurel Branch** site 32 is a medium-sized stream in the Section 8B survey with a mean stream width of 4 m (13 ft), 80 cm (2.5 ft) maximum depth, and an estimated 60% canopy coverage. The stream bed consists primarily of cobbles and boulders with 15% gravel, 10% bedrock, and the remainder silt and sand. This stream appeared to be pristine with no stream bank or water quality impairment. The biota consisted of 51 EPT taxa comprising 54% of the 94 benthic invertebrate taxa total. Nineteen total chironomid taxa were collected, including 12 orthoclad taxa. Blacknose dace were the most common of the four fish species collected, and rainbow trout (*Oncorhynchus mykiss*) were second most common. Only single specimens of longnose dace (*Rhinichthys cataractae*) and stonerollers were found in Laurel Branch.

### 3.3.2.3 Rocky Flats Drainages

In the Rocky Flats valley between Webb Mountain and Big Ridge Mountain, four streams were sampled in conjunction with the Section 8B ROW. Dunn Creek is the largest of these streams and the direct recipient of waters from the other three streams, as well as the Matthew Creek waters discussed in the preceding paragraphs (Fig. 20). Dunn Creek eventually flows into the Little Pigeon River farther to the north and west. This valley remains heavily forested with deciduous trees near the ROW, although there are strips of residential development near some portions of these streams. The canopy for Dunn Creek (sites 16 and 17) and the Dunn Creek West Branch (site 14) reflects the undisturbed surroundings for these two streams at 100% and 70% coverage. The canopy coverage for the other two streams—Ogle Spring Branch (sites 18 and 19) and Carson Branch (sites 20 and 21) ranges from 80% to 30%. While the stream bed substrates for the Dunn Creek and Ogle Spring Branch sites primarily consisted of boulders and cobbles (85 to 50%), Carson Branch substrate was more evenly divided between boulders and cobbles (30 to 35%), gravel (30 to 35%), and silt and sand (30 to 40%). The Dunn Creek West Branch substrate primarily consisted of cobble (65%), some gravel (20%), and bedrock (10%) (Fig. 20, Appendix D).

Dunn Creek is the fifth largest stream in the Section 8B stream survey with a mean stream width of 6 m (20 ft) and maximum stream depth of 60 to 75 cm (2 ft). The other streams all had a mean stream width of 1.5 m (5 ft), except the lower Ogle Spring Branch (site 19) with a maximum stream depth ranging from 20 to 50 cm (1 to 1.5 ft).

Both Ogle Spring Branch sites (18 and 19) were designated as affected sites (Table 8 and Sect. 3.2.1). Both sites had four separate abiotic indications of human-induced stream impact—siltation (heavy at site 18), high phosphate levels, very high nitrate levels, and high chloride levels (very high for site 18). Although the other streams are designated as pristine on this basis, very heavy siltation was noted in Carson Branch at site 21 where new construction and a nearby dirt road were noted (Appendix D).

These benthic invertebrate assemblages exhibited healthy, rich taxa with many cool-, clean-water species. The total benthic invertebrate taxa ranged from 135 taxa at Dunn Creek site 16—reflecting very pristine, virtually unimpacted stream conditions—to 87 in site 18, one of the affected sites. The chironomid taxa were somewhat less taxonomically rich with 12, 13, and 14 taxa at Dunn Creek West Branch (site 14), Ogle Branch (site 18), and Carson Branch (site 21), respectively. The other more taxonomically-enriched sites ranged from 20 to 37 taxa for the chironomids. The percent of orthoclad taxa in the chironomid taxa ranged from 82% at site 14 (the highest value for all Section 8B) to 38% at site 18 (the lowest value for all Section 8B) (Table 11). While neither site 14 or 18 or the Carson Branch sites had any *Cricotopus* or *Orthocladius* or other taxa indicative of pollution problems, the two Dunn Creek sites (16 and 17) did have two and three *Cricotopus* or *Orthocladius* species from 20 and 13 specimens, respectively (Appendix D).

The number of fish species varied from seven and nine in Dunn Creek down to no fish captured at Dunn Creek West Branch (site 14). Blacknose dace was the most commonly captured fish at sites with fish, comprising 33 to 38% of the captured fish in the Dunn Creek sites, 96 to 97% in the Ogle Spring Branch sites, and 98 to 100% in the Carson Branch sites. Other fish identified in Dunn Creek included mottled sculpin at 33 to 34% and stonerollers at 12 to 13% of the fish community (Appendix D).

Both Dunn Creek sites (16 and 17) can be compared to other similar streams in this region. Dunn Creek site 16, virtually unimpacted, compared very favorably with two other stream sites in Cades Cove in the GSMNP. These GSMNP sites, also considered pristine, are the upper Mill Creek site at Parsons Branch Road and Anthony Creek just above the horse camp near the Cades Cove campground. The winter 1994 survey of the two Cades Cove sites collected 41 and 45 EPT taxa out of 65 and 62 total taxa, as compared with 47 EPT and 72 total taxa for Dunn Creek (site 16) (comparison exclusive of chironomid taxa; see Etnier discussion in Appendix D). Site 16 taxonomic counts were slightly higher than at these pristine sites. Another comparison can be made between Dunn Creek site 17 and the Section 8D Wears Cove station MC-5, both with similar size stream size and fish community structure. Station MC-5 contained 112 total benthic taxa and 52 EPT taxa; 12 of 23 chironomid taxa were orthoclads, including two *Cricotopus* or *Orthocladius* species. The analogous data for site 17 are 113 total benthic taxa with 58 EPT taxa; 15 of 23 chironomid taxa were orthoclads, including two *Cricotopus* or *Orthocladius* species. Both of these sites are interpreted as being rich, healthy, and very slightly impacted by silt.

#### 3.3.2.4 Big Ridge/Cosby Creek Drainages

Four streams were sampled at the eastern-most end of the Section 8B ROW. The largest of these streams, and the second largest stream in the Section 8B stream survey, is Cosby Creek. This creek is also the recipient of the waters from the three other streams—Indian Camp Creek, Sandy Hollow Creek, and Chavis Creek (Fig. 20). Cosby Creek eventually flows into the Pigeon River farther to the north and east. This area is a mixture of deciduous forests interlaced with developed strips of land. Trees along the stream embankment comprised the canopy for Cosby Creek, which varied from 50 to 5%. The canopy coverage for the other smaller streams varied from 30 to 100% coverage depending on whether the stream was adjacent to a bridge, field, or forest. The stream bed substrate for larger streams consisted primarily of cobbles and boulders (Cosby Creek—85%;

Indian Camp Creek—70%), while the smaller streams have primarily gravel (Chavis Creek—70%; Sandy Hollow Creek—60%; Appendix D).

Cosby Creek, the second largest stream in the survey, varied in width from 12 to 18 m (40 to 60 ft) with a maximum depth of 120 cm (4 ft) at site 25. Indian Camp Creek, also a rather large stream, has a width that ranges from 6 to 9 m (20 to 30 ft) with a maximum depth of 60 cm (2 ft). Both Chavis Creek and Sandy Hollow Creek are much smaller streams [1.5 to 2 m (5 to 7 ft)] with maximum depths of 45 and 30 cm (1.5 to 1 ft), respectively (Table 10).

In this group of streams, only Sandy Hollow Creek (site 24) was considered an affected site on the basis of abiotic indicators of stream condition (Table 8 and Sect. 3.2.1). This site had considerable stream bank instability, stream bed siltation, and relatively high phosphate levels. While Chavis Creek had some stream bed siltation and relatively high levels of phosphate, neither Indian Camp Creek nor Cosby Creek sites exceeded any of the six different abiotic criteria; they were therefore considered unaffected sites.

On the basis of biotic indicators of stream condition, all of these streams appeared to exhibit some evidence of human impact, although all sites also had healthy, taxonomically-rich assemblages of benthic invertebrates (i.e., ranging from a total benthic invertebrate taxa of 90 to 163 with 43 to 53% EPT taxa) (Tables 9, 10, and 11). A hint of organic enrichment was noted at the Cosby Creek sites 25 and 26 by the presence of five different species of *Cricotopus* or *Orthocladius* species. The Cosby Creek sites had the highest number (19 and 21) of stonefly taxa—generally considered the most stress-sensitive order—for any of the Section 8B sites. The Cosby Creek sites also had the largest number of infrequently collected chironomids, five different species, of any of the Section 8B sites (Appendix D; see summary below). A moderate amount of organic enrichment was evidenced in the benthic invertebrate data at Chavis Creek. Half of the chironomid taxa belonged to the orthoclad group, including three species of *Cricotopus* or *Orthocladius*; one species, *Cricotopus bicinctus,* contributed 20 of the 65 midge specimens in the fall sample. The very stress-tolerant caddisfly, *Hydropsyche betteni/depravata,* was also present.

In Indian Creek, the diversity and abundance of biota were impoverished, indicating some disturbance greater than the spring 1994 flooding. Only 23 EPT taxa and a total of 59 benthic invertebrate taxa were collected, which is 25 to 50% lower than would be expected. In contrast, Dunn Creek yielded 54 EPT taxa and 100 benthic invertebrate taxa in the spring survey. The Indian Creek fall survey (34 EPT and 67 total benthic taxa) showed somewhat less disparity with the Dunn Creek survey results (47 EPT taxa and 97 total benthic taxa), perhaps indicating a recovery in progress. Sandy Hollow Creek, affected on the basis of abiotic indicators, exhibited some evidence of eutrophication by the presence of three taxa of *Cricotopus* and the stress-tolerant caddisfly, *Hydropsyche betteni/depravata.*

The number of fish species varied from 18 and 13 collected at the Cosby Creek sites, to a total of 6 and 7 captured in the other three smaller survey streams. Stonerollers were the most commonly captured fish in Cosby Creek comprising 40 and 44% of the captured fish. Saffron shiners, the second most commonly captured fish, comprised 18 and 38%, and mottled sculpins contributed 11 and 15% of the fish identified. In Chavis Creek (site 22) and Sandy Hollow Creek (site 24), the dominant fish population was the blacknose dace, comprising 82% in both of these streams. Mottled sculpins (48%) and longnose daces (32%) accounted for 80% of the fish surveyed in

Indian Camp Creek (site 23; see Appendix D). The seven fish taxa collected in the survey at Indian Camp Creek were fewer than would be expected for a stream of this size, 6 to 9 m (20 to 30 ft), in this region in which the water quality indicates a pristine condition.

The Cosby Creek sites (25 and 26) were similar in EPT taxa and total benthic taxa richness to Webb Creek (site 8) in the Webb Mountain/Webb Creek Drainages. These sites can also be compared to several Abrams Creek watershed sites in the GSMNP: Mill Creek just above Abrams Creek, Abrams Creek just below the confluence of Mill Creek in Cades Cove, and lower Abrams Creek below the Abrams Creek campground. Total benthic invertebrate taxa (exclusive of chironomids) and EPT taxa for these Abrams Creek sites (from a May 1994 survey) were 79 and 53, 98 and 63, 106 and 59, respectively.

### 3.3.2.5 Summary

Evaluation of the Section 8B benthic invertebrate surveys yielded several general findings. First, the Section 8B study streams in 1994 had a taxonomically rich benthic fauna ranking among the richest in the Appalachian region (Appendix D, Part 1 and Part 3). For the 31 Section 8B stream survey sites, the numbers of benthic invertebrate taxa ranged from 68 to 174 in streams ranging in width from 1 to 18 m (3 to 59 ft; Fig. 39). By way of comparison, the Section 8D benthic macroinvertebrate survey, which used the same methods and included 23 stream sites with stream widths ranging from 1.2 to 7.6 m (4 to 25 ft), had taxa values ranging from 54 to 112. If we compare only the Section 8B study streams that range in width from 1.0 to 6 m (3 to 20 ft), their taxa values range from 68 to 135, slightly higher than the Section 8D survey results. Another benthic survey at Abrams Creek in the GSMNP reports maximum taxa value for a single sampling date of 106 (exclusive of chironomid data). This value is comparable to the Little Pigeon River Section 8B sites for taxa richness of 105 for a single sampling date (also exclusive of chironomid data).

Second, this level of taxonomic richness extended through both the EPT and chironomid groups, indicating these streams, as a group, are relatively unaffected by human-induced impacts (Fig. 40). Because these streams are relatively unimpacted and have taxonomically rich assemblages of macroinvertebrates, use of the EPT to total benthic taxa ratios and the orthoclad to total chironomid taxa ratios was not definitive in differentiating sites among the Section 8B survey streams (Fig. 40). Rather, the presence of specific genera and species considered pollution-indicating taxa (e.g., *Cricotopus, Orthocladius, Microtendipes, Hydropsyche betteni/depravata,* and *Stenacron interpunctatum*), especially if numerous specimens were found, was more useful in defining the status of these streams.

Third, the number of fish and benthic invertebrate taxa increased with increasing stream size up to the largest stream surveyed—Little Pigeon River [mean width 18 m (59 ft); Fig. 39]. This site had 25 fish taxa and 174 different benthic macroinvertebrate taxa when the spring and fall survey data were combined. Cosby Creek and Webb Creek, the two next largest streams in this survey [mean stream width around 12 m (40 ft)], had 15 to 18 fish taxa and 137 to 163 different benthic macroinvertebrate taxa, respectively (Table 10).

**Stream conditions.** On the basis of abiotic indicators of stream condition, 12 sites were defined as affected by either physical or chemical human-induced impacts (Fig. 41). The chemical indicators

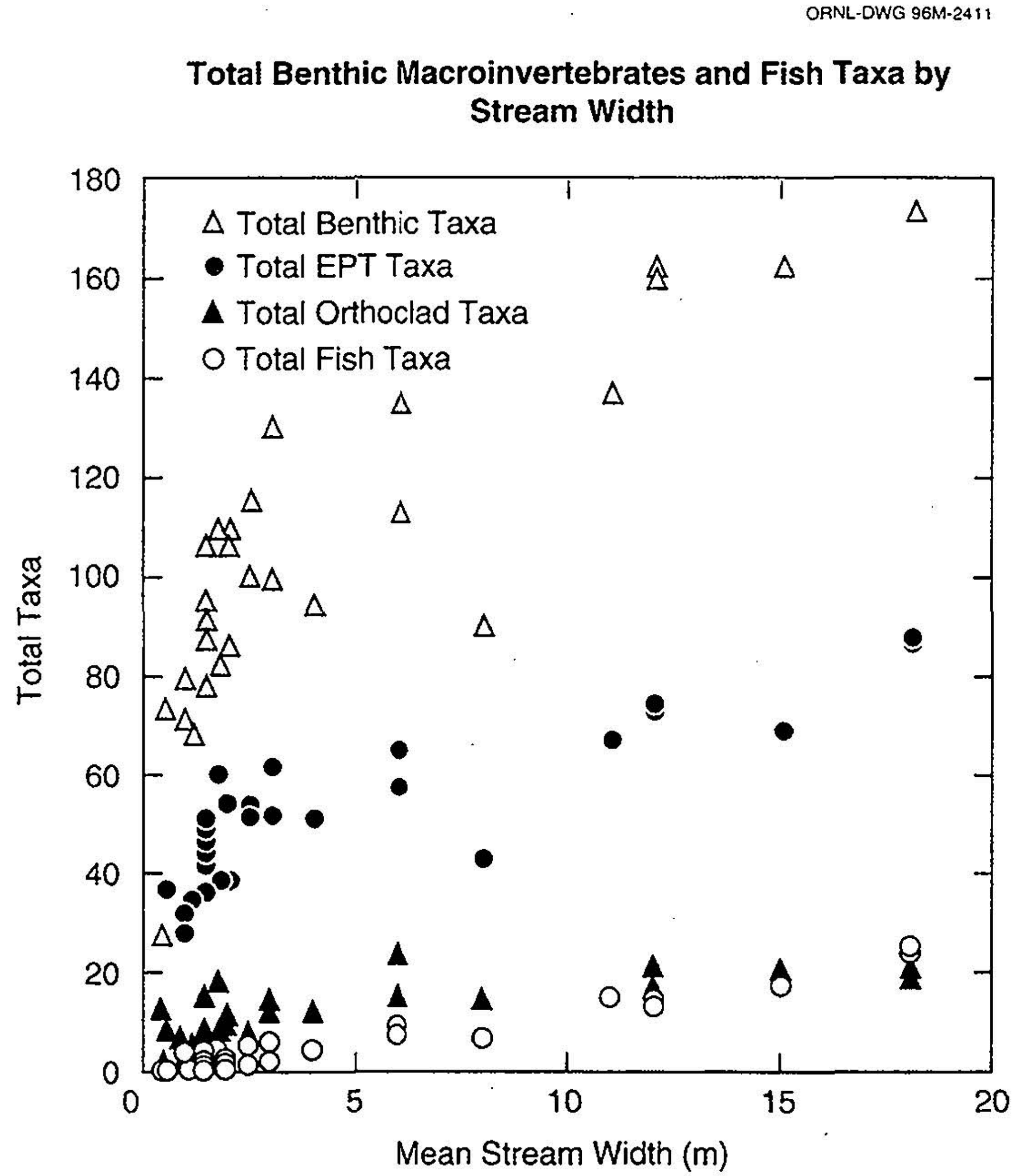


**Fig. 39. Total benthic invertebrates, EPTs, orthoclads, and fish taxa versus mean stream width at the stream biological survey sites for Section 8B of the Foothills Parkway.**

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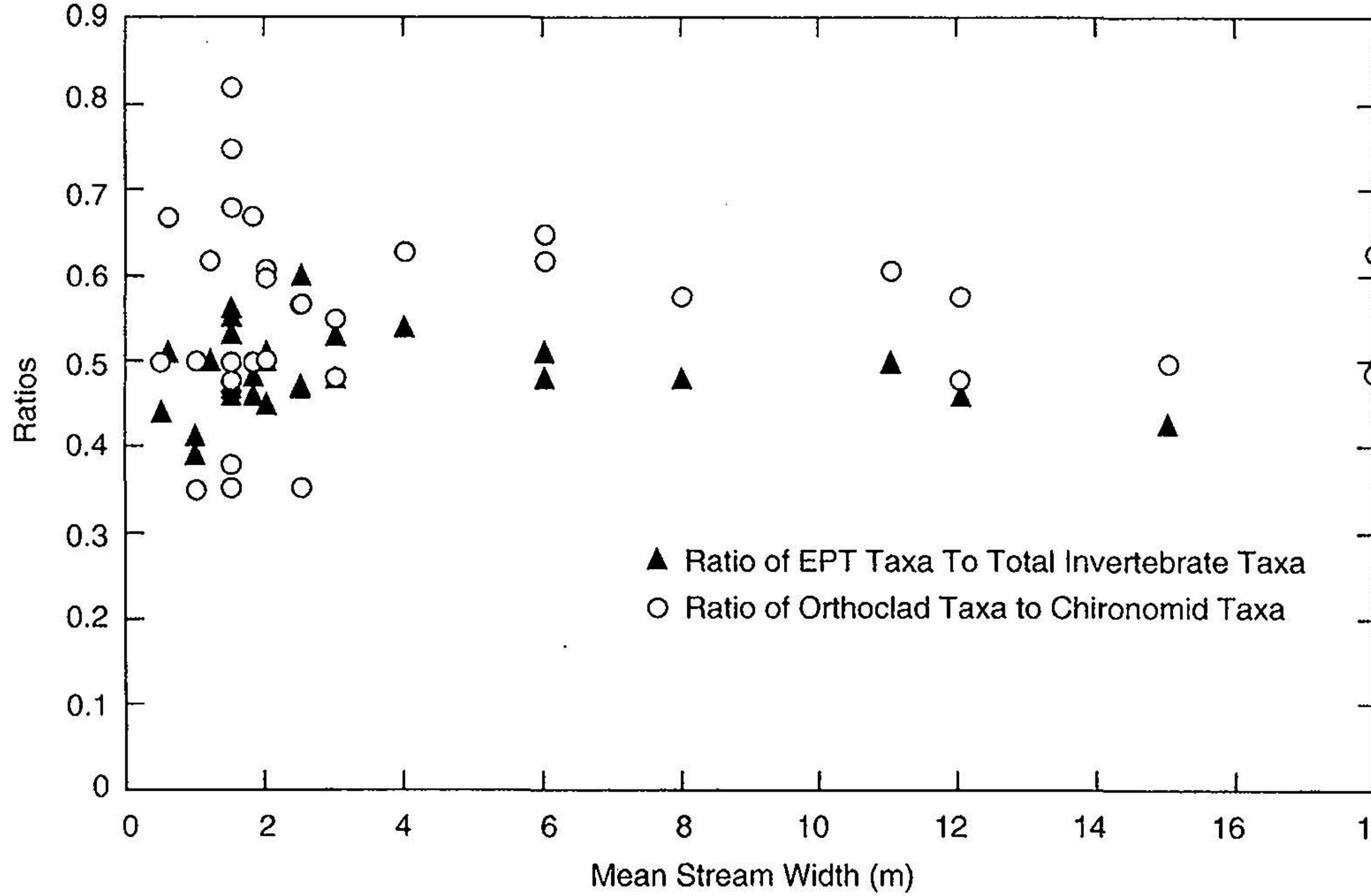



**Fig. 40. Benthic invertebrate ratios of EPT taxa to total taxa and orthoclad taxa to chironomid taxa versus mean stream width at the stream biological survey sites for Section 8B of the Foothills Parkway.**

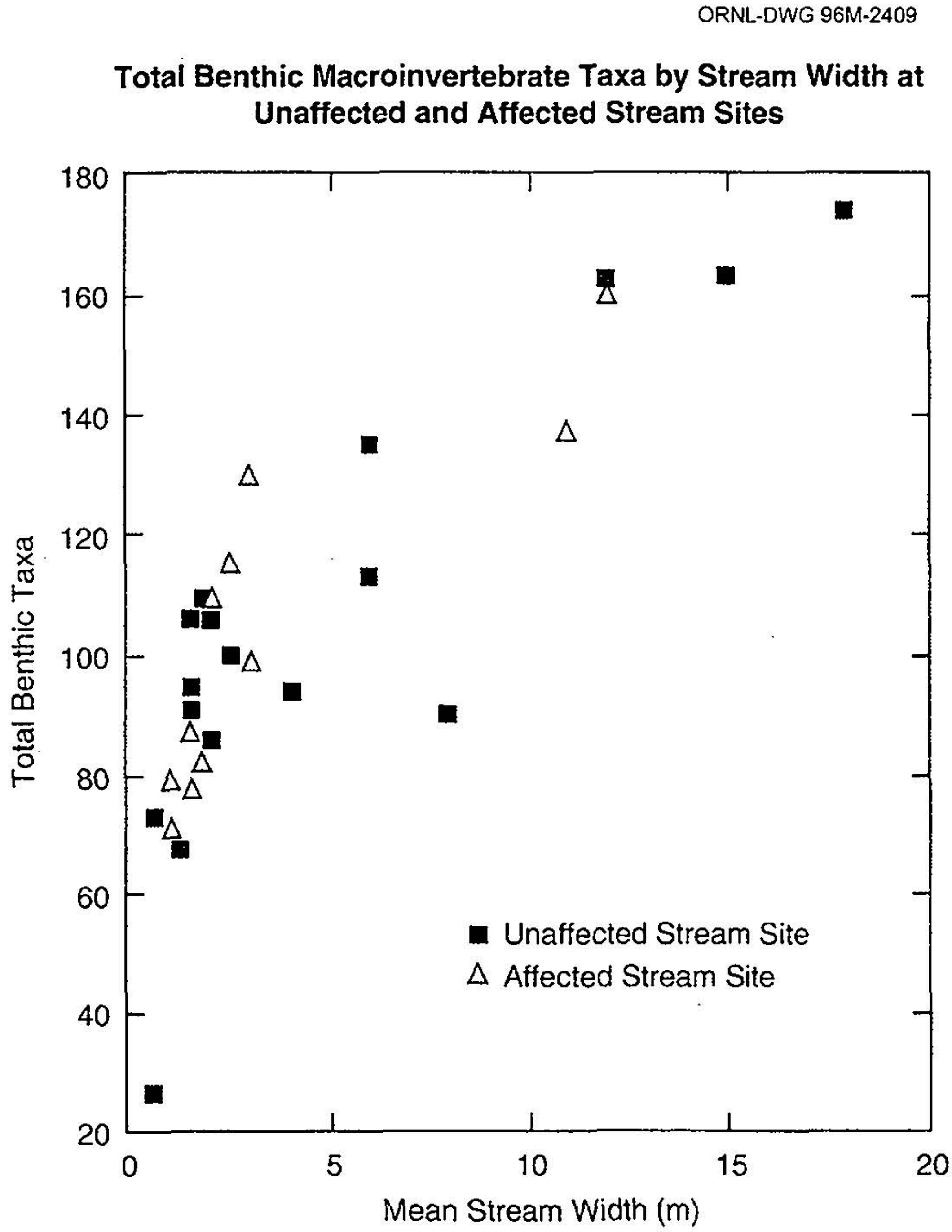



**Fig. 41. Total benthic macroinvertebrates taxa by stream width at unaffected and affected stream sites in the stream biological survey sites at Section 8B of the Foothills Parkway.**

are relative because the overall water quality in this survey is good (see Sect. 3.2). The most useful differentiating biotic indicators of stream condition were the pollution-indicating genera and species. On this basis, the survey sampling at all five of the widest streams [18 to 6 m (59 to 20 ft)] found some species specifically associated with organic enrichment (Fig. 42). Cosby Creek and Webb Creek had the highest abundance of these pollution-indicator species. There were also five smaller streams [4 to 1.5 m (13 to 5 ft)] that had pollution-indicating species. These streams were most notably Copeland Creek and the smaller Big Ridge/Cosby Creek Drainage streams (see Sects. 3.3.2.1 and 3.3.2.4 for more detail).

**Listed species.** While no federal or state listed endangered or threatened fish or macroinvertebrate species were found at any of the sites, there was one former federal candidate species and one state species of special concern. The Allegheny snaketail dragonfly (*Ophiogomphus incurvatus alleghenienisis*), the formerly C2 federal candidate species for listing under the Endangered Species Act, was found in six of the stream survey sites. *Percina aurantiaca*, the tangerine darter, was found at two stream survey sites. It is a Tennessee state special concern species (Starnes and Etnier 1980) and deemed in need of management (Hatcher 1994).

**Newly identified species.** There are several other noteworthy taxonomic findings (see Appendix D). Some specimens are tentatively identified as newly collected mayfly (Ephemeroptera) species in the family Heptageniidae (collected at two sites) and an undescribed species in the caddisfly genera *Ceratopsyche* and *Mystacides* (collected at ten sites). There are also several other new distributional records for the state of Tennessee in the caddisfly order (Trichoptera) and stonefly order (Plecoptera) at multiple stream survey sites. There are also five infrequently collected chironomids that were identified in eight different streams in the Section 8B stream survey, with all five of these chironomids occurring together at one of the stream sites.

## 3.4 TERRESTRIAL RESOURCES

Except for areas near the Little Pigeon River, Rocky Flats, and Cosby Creek, the 22.7 km (14.2 miles) ROW in Section 8B is primarily on south-east facing slopes of Webb Mountain and Big Ridge. Elevations range from about 400 m (1300 ft) in the lowlands to 950 m (3100 ft) at the highest point of Webb Mountain. The terrain is generally rugged, with very steep slopes on Webb Mountain and steeply undulating terrain on Big Ridge.

Field surveys for vegetation and wildlife were conducted to determine the presence of federal and state listed, federal candidate, park-rare, and non-native (exotic) species; sensitive habitats (including biologically significant wetlands); and general characterization of biota on the ROW (Somers 1989; 58 *Fed. Regist.* 51143–89; 59 *Fed. Regist.* 49848–59; 59 *Fed. Regist.* 58981–9028; Rock and Langdon 1991). The field surveys were also done for vascular plants, small mammals, salamanders, and reptiles; birds; and bryophytes as identified in the Section 8B Study Plan. A summary of results of these surveys and a general description of vegetation and wildlife are presented in this report. In general, biota along the Section 8B section are similar to those in the GSMNP below about 920 m (3000 ft).

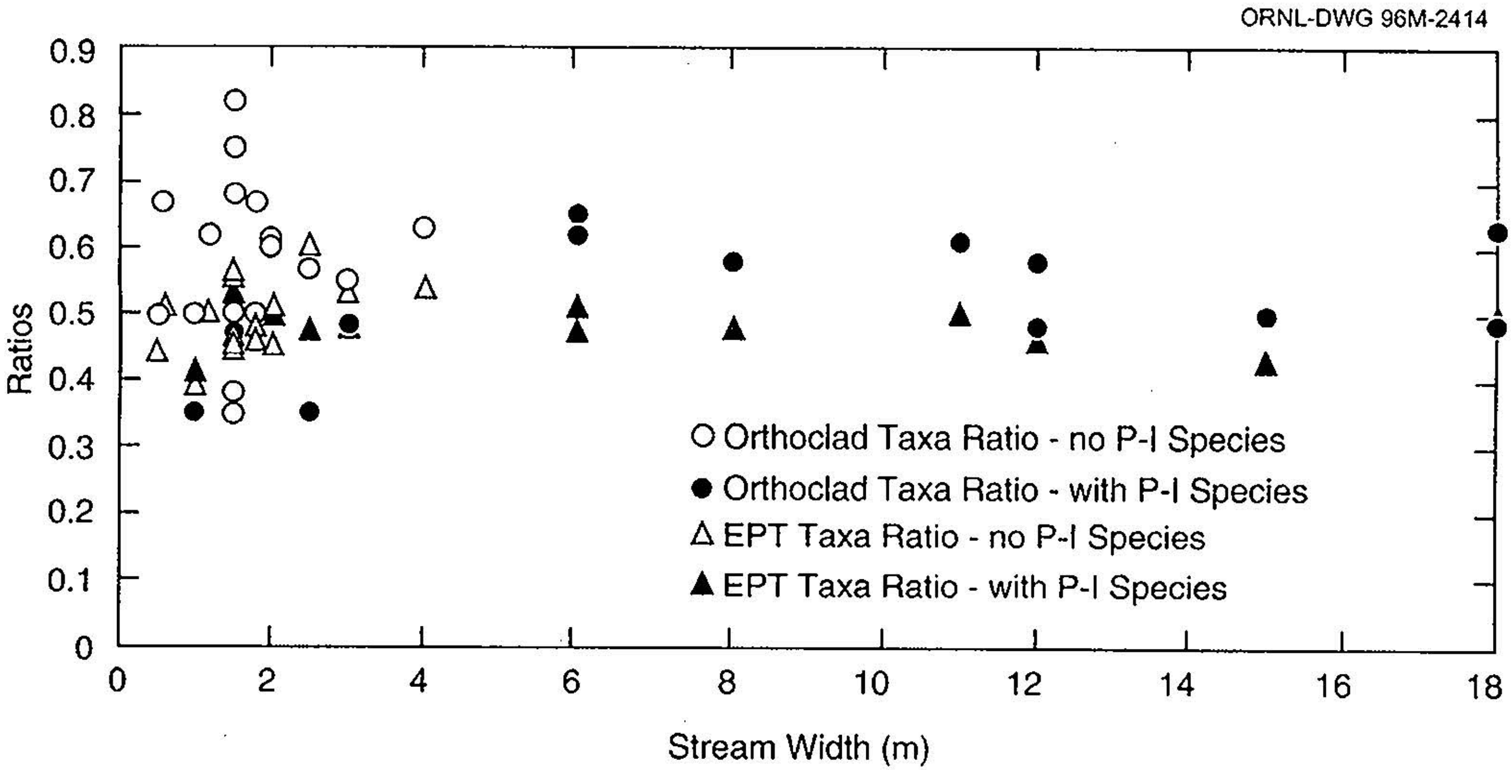



**Fig. 42. Benthic invertebrate ratios versus mean stream width at sites with and without more than one pollution indicating species in the stream biological survey sites for Section 8B of the Foothills Parkway.**

### 3.4.1 Vegetation

Distribution of plant communities on the ROW is complex as a result of interactions of slope, elevation, soil types, and a varied history of land use and fire. The general descriptions that follow are based on past vegetation surveys and observations during the current field surveys (see Appendix B, Appendix E, and Appendix F).

In an earlier survey (Baron and Mathews 1977), 26 vegetation plots were sampled along Sections 8B, 8C, 8D, and 8E over a distance of 65 km (40.4 miles). The vegetation map prepared for the 1977 environmental analysis divided Section 8B into two general vegetation types: (1) open field to successional around Pittman Center and Cosby and (2) dry pine/oak/maple through the Webb Mountain and Big Ridge areas. In the 1977 survey, much of the ROW west of Webb Mountain was characterized as old field or successional. These areas are now primarily young, dry, pine-oak forest.

Vegetation along the ROW is generally similar to the vegetation in the rest of GSMNP below 920 m (3000 ft) elevation (Whittaker 1956; Harmon, Bratton, and White 1983; MacKenzie 1991). None of the ROW is old-growth forest. Most of the area has been logged or burned, and some areas were farmed (Baron and Mathews 1977). The ROW is currently mostly forested (Fig. 43, Appendix E), is crossed by few roads, and does not contain other types of clearings. All-terrain vehicle use is common in some areas and evidence of previous disturbance is common along the ROW. Forest populations range in age from young saplings to mature trees. In this study, eight vegetation types were identified as useful for delineating habitats of plant and animal species of concern (Table 12).

Most of the vegetation along the ROW can be classified as either dry pine, mixed pine/hardwood, or more mesic (rich and moist) areas of mixed hemlock and hardwoods. Because of past disturbance, some parts of the ROW are predominantly young forest, usually with abundant pine. These areas were apparently cleared in the past and used for crops or pasture. Pines on the ROW are either Table Mountain and pitch pine (*Pinus pungens* and *P. rigida*), especially on Webb Mountain, or Virginia pine (*Pinus virginiana*), which is especially common on the ROW southwest of Webb Mountain in old field areas. The pine or pine/hardwood vegetation type ranges from nearly pure pine stands to mostly hardwood with some pine and is comparable to the xeric oak, pine-oak, and pine vegetation types of the GSMNP (MacKenzie 1991). Common hardwoods found in xeric oak and oak-pine vegetation types include chestnut oak (*Q. prinus*), scarlet oak (*Q. coccinea*), sourwood (*Oxydendron arboreum*), dogwood (*Cornus florida*), and red maple (*Acer rubrum*).

Mesic areas of hardwoods and hemlock on the ROW fall into three types: (1) sheltered, rich coves; (2) sheltered slopes and ravines; (3) mesic upper slopes. The first two types have many overstory species in common: red oak (*Quercus rubra*), basswood (*Tilia heterophylla*), tulip poplar (*Liriodendron tulipifera*), buckeye (*Aesculus octandra*), beech (*Fagus grandifolia*), and black cherry (*Prunus serotina*) are usually present; sweet birch *(Betla lenta)* is also present. Sheltered slopes and ravines often have hemlock (*Tsuga canadensis*) and rhododendron (*Rhododendron maximum*) along stream drainages. Mesic upper slope forests are of two types: (1) mixed hardwood or (2) mixed hemlock, white pine (*Pinus strobus*), and hardwoods. Hardwoods include several oak species, red maple, tulip poplar, and several other less abundant species. Herbaceous

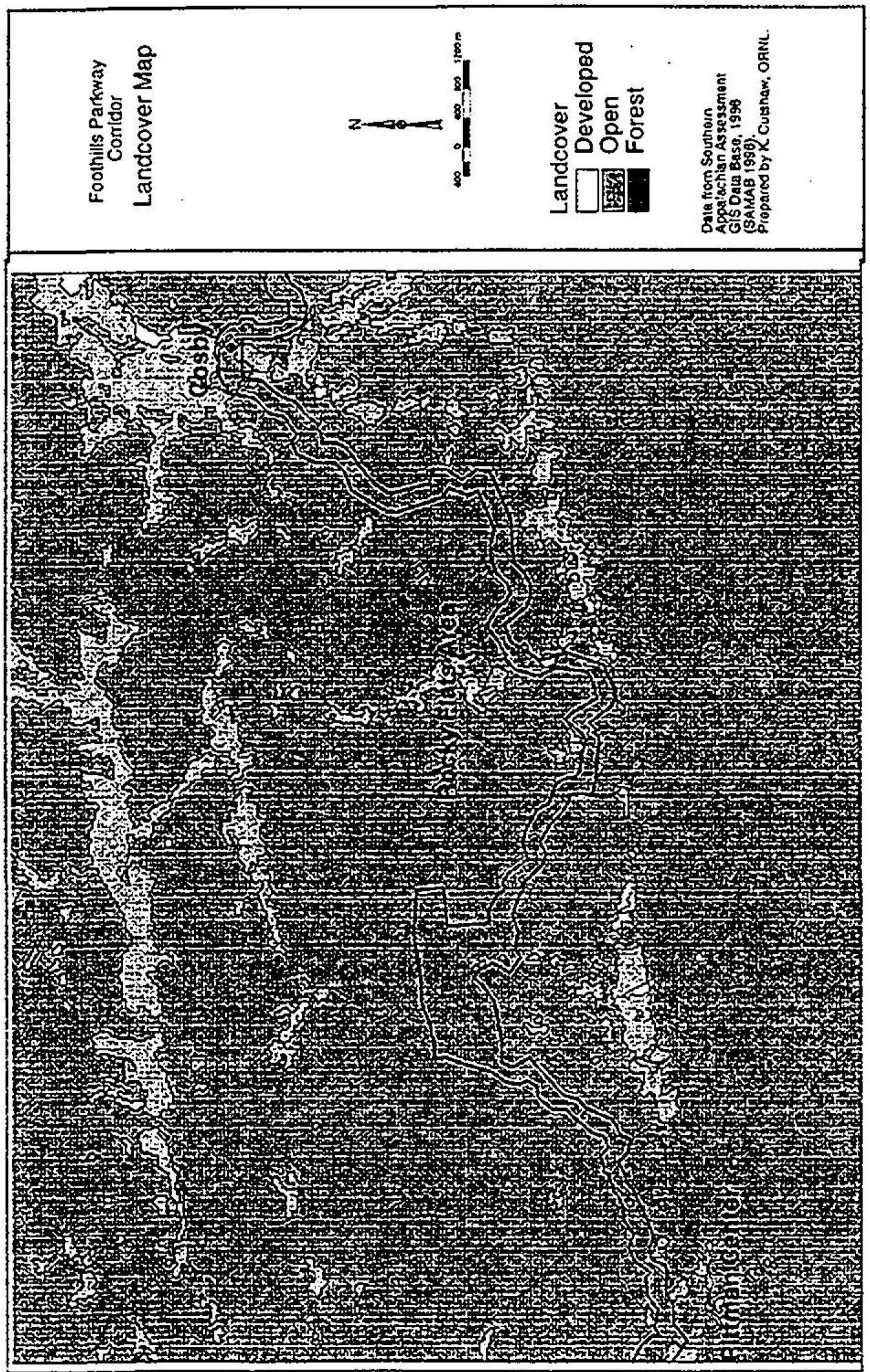



**Fig. 43. Landcover in the approximately 130 mi$^2$ (335 km$^2$) region surrounding the ROW.**

**Table 12. Important vegetation types for delineating habitats of plant and animal species of concern along Section 8B**

| | |
|---|---|
| **Forest** | |
| | Young forest in old fields—usually with abundant pine |
| | Pine or oak-pine |
| | Mesic mixed hardwoods |
| | Mesic mixed hemlock, white pine, and hardwoods on uplands |
| | Sheltered upland hardwoods with hemlock along stream drainages |
| | Bottomland hardwoods |
| **Other** | |
| | Wetlands |
| | Open areas |

vegetation is often more variable than overstory species. Mesic hardwoods on the ROW are comparable to the mesic oak, mixed mesic, and cove hardwoods (MacKenzie 1991) or northern hardwoods, cove hardwoods, hemlock hardwoods, and oaks (Eager 1984) of the GSMNP. Pines are mixed with tulip poplar in some old field areas; these areas are comparable to the tulip poplar type of GSMNP (Eager 1984; MacKenzie 1991).

Extensive floodplain vegetation is limited to two areas of the ROW. These areas contain forests composed of many bottomland tree species including sycamore (*Platanus occidentalis*), box elder (*Acer negundo)*, red maple, ironwood (*Carpinus caroliniana*), tulip poplar, hemlock, and many herbs and shrubs typical of disturbed floodplain areas. Giant cane (*Arundinaria gigantea*), old field vegetation, including dense stands of native blackberry *(Rubus* sp.) mowed powerline ROW, and some pasture for cattle are also in these areas.

The division of the ROW into segments is the same as that used in Sect. 3.1.4 and shown in Fig. 5.

**Segment 1—Little Pigeon River Terraces.** Vegetation in the vicinity of the Little Pigeon River reflects disturbances due to flooding of the river and farming activities in the lower, more level slopes. Currently part of this area is in mixed, open floodplain forest, including a substantial grove of butternut, and some pasture land.

**Segment 2—Webb Creek Ridge.** Very young forest, with many Virginia pines, is common on this segment of the ROW, especially on more level slopes and ridge tops. Xeric mixed pine and pine-hardwood forest is found on steeper south-facing slopes. Some areas of dead pine and mountain laurel (*Kalmia latifolia*) are present on small exposed ridgetops. Approaching Webb Mountain, especially in the Sheep Pen Branch area, more mesic, mature hardwood forest is found on sheltered slopes and ravines. Some hemlock is also found in this area.

**Segment 3—Webb Mountain.** Mixed pine and pine-hardwood stands with Table Mountain and pitch pines are common on the steep, south-facing slopes of Webb Mountain. Most of the mature pines on Webb Mountain have been killed within the last few years by southern pine beetle outbreaks. Sheltered slopes and ravines with mesic hardwoods, hemlock, and rhododendron are also found in this area. An extensive stand of American chestnut (*Castanea dentata*) sprouts is on the crest of Webb Mountain near Jones Gap.

**Segment 4—Matthew Branch Ridge.** Most of the vegetation on this segment of the ROW is similar to that on the lower slopes of Webb Mountain and the older forests of Webb Creek Ridge. West of Blackgum Gap, the northern slopes include some areas of mesic hardwoods containing a few red spruce (*Picea rubens)* and striped maple (*Acer pennsylvanica*). On most of this segment, however, pines are the dominant forest species, especially east of Blackgum Gap. Dead and fallen trees are abundant. Understory vegetation is primarily mountain laurel, huckleberry (*Gaylussacia* sp.), or blueberry (*Vaccinium* sp.).

**Segment 5—Rocky Flats.** Vegetation in this segment of the ROW is highly diverse, ranging from open old fields and old field pine stands to wetlands, mesic forests, and coves. A maintained powerline ROW crosses the parkway ROW in this segment.

**Segment 6—Big Ridge.** Vegetation in this segment is similar to that in the Matthew Branch Ridge segment and older forests of Webb Creek Ridge, consisting of a mosaic of dry, mixed pine and pine-hardwood forest on steeper south-facing slopes and more mesic, mature hardwood forest, often with hemlock and sweet birch, on sheltered slopes and ravines. Unlike most of the Matthew Branch Ridge and Webb Creek Ridge vegetation, that on some uplands in this segment is a mixture of hemlock, white pine, and hardwoods (Appendix B).

**Segment 7—Cosby Creek Terraces.** Vegetation in this segment is highly diverse and has mostly been affected by previous human disturbance. Young forests in old field areas near the north end of the ROW are mostly tulip poplar and pine. Young dogwood and hemlock are also present. The forest is patchy and contains floodplain species typical of eastern Tennessee. Giant cane, old field vegetation, and mowed powerline ROW are also in this segment.

### 3.4.2 Wildlife

Wildlife on the ROW probably includes most animals common at middle to low elevations of the GSMNP (Linzey and Linzey 1971; Stupka 1963; Huheey and Stupka 1967). White-tailed deer (*Odocoileus virginianus*), red fox (*Vulpes fulva*), grey fox (*Urocyon cinereoargenteus*), raccoon (*Procyon lotor*), and bobcat (*Lynx rufus*) are among the larger animals likely to be present on the ROW. Black bears (*Ursus americanus*) could be present on the ROW, but no evidence of black bears was observed during surveys. No large den trees are present on the ROW. Bears may use parts of the ROW, but present use appears to be intermittent at most. Although the non-native European wild boar (*Sus scrofus*) is abundant in parts of GSMNP, no evidence of boars was seen during any of the field surveys. The coyote (*Canis latrans*) has expanded its range into east Tennessee, but none was seen during surveys of the ROW.

Small mammals commonly occurring in the area of the ROW include gray squirrel (*Sciurus carolinensis*), eastern chipmunk (*Tamias striatus*), striped skunk (*Mephitis mephitis*), woodchuck

(*Marmota monax*), opossum (*Didelphis marsupialis*), long-tailed weasel (*Mustela frenata*), and eastern cottontail (*Sylvilagus floridanus*). Spotted skunk (*Spilogale putorius*), though not common to the area, may also be present. Habitat along Cove Creek and other streams is suitable for mink (*Mustela vison*) and muskrat (*Ondatra zibethicus*). Four species of shrews; four species of mice, including jumping mice; a bog lemming; and two species of bats were captured on the ROW during the field surveys for small mammals (Appendix G).

Alsop (1991) lists 29 commonly occurring species of birds in hardwood forests at middle and low elevations of the GSMNP and another 21 that are common in fields and pastures. Most of these species probably use the ROW. Sixty-three species were seen on the ROW during the bird survey in 1995 (Table 13 and Appendix F). Species commonly seen in openings, oldfields, and forest edges include northern cardinal, indigo bunting, American crow, Carolina wren, song sparrow, rufous-sided towhee, eastern phoebe, and northern bobwhite. Commonly seen forest-dependent species include hooded warbler, black and white warbler, worm-eating warbler, black-throated green warbler, northern parula, ovenbird, red-eyed vireo, wood thrush, black-capped and Carolina chickadees, blue-gray gnatcatcher, yellow-billed cuckoo, tufted titmouse, and pileated woodpecker. Sixteen additional species were observed during two previous surveys in the vicinity: (1) the

Breeding Bird Survey census for the Compone route, stop number 10 (page 5) near Pittman Center in the Little Pigeon River Terraces segment of the ROW and (2) the 1988 Tennessee Ornithological Society Breeding Bird Atlas survey of the USGS Jones Cove map quadrangle (Nicholson 1994), which includes most of the ROW.

Common amphibians in the area include the American toad (*Bufo americanus*), several salamanders (*Desmognathus* sp., *Plethodon* sp., *Eurycea* sp.), and several species of frogs, such as the northern cricket frog (*Acris crepitans*), tree frogs (*Hyla* sp.), upland chorus frog (*Pseudacris triseriata*), green frog (*Rana clamitans*), and wood frog (*Rana sylvatica*). Amphibians found on the ROW include the southern leopard frog (*R. sphenocephalous*) (Appendix B), Appalachian seal salamander (*Desmognathus monticola monticola*), black-bellied salamander (*D. quadramaculatus*), Blue Ridge Mountain salamander (*D. ochrophaeus carolinensis*), slimy salamander (*Plethodon glutinous glutinous*), red-backed salamander (*P. cinereus cinereus*), black-chinned red salamander (*Pseudotriton ruber schenchi*), and long-tailed salamander (*Eurycea longicauda longicauda*) (Harvey 1995).

The eastern box turtle (*Terrapene carolina*) is common in the area. Other widespread reptiles are the northern fence lizard (*Sceloporus undulatus hyacinthinus*), skink (*Eumeces* sp.), water snake (*Nerodea sipedon*), eastern garter snake (*Thamnophis sirtalis*), northern ring-neck snake (*Diadophis punctatus*), eastern worm snake (*Carphophus amoenus*), black rat snake (*Elaphe obsoleta*), and northern copperhead (*Agkistrodon contortrix mokesson*).

### 3.4.3 Protected Rare Species

#### 3.4.3.1 Vascular Plant Species

Federal (58 *Fed. Regist.* 51143–89; 59 *Fed. Regist.* 49848–59), state (Somers 1989), and GSMNP (Rock and Langdon 1991) lists of rare species were used to determine those which could potentially occur on the ROW. These provided an initial list of species with federal or state legal

**Table 13. Birds of the right-of-way[a]**

| Scientific name | Common name | Habitat[b] O | M | F | L | W |
|---|---|---|---|---|---|---|
| *Butorides striatus* | green-backed heron[c] | | | | | x |
| *Anas platyrynchos* | mallard | | | | | x |
| *Cathartes aura* | turkey vulture | x | x | x | | |
| *Buteo jamaicensis* | red-tailed hawk | x | x | | | |
| *Accipiter cooperi* | Cooper's hawk | | x | x | | |
| *Bonasa umbellus* | ruffed grouse | | x | x | | |
| *Colinus virginianus* | northern bobwhite | x | x | | | |
| *Charadrius vociferus* | killdeer[c] | x | | | | |
| *Columba livia* | rock dove | x | | | | |
| *Zenaida macroura* | mourning dove | x | | | | |
| *Coccyzuz americanus* | yellow-billed cuckoo | | x | x | | |
| *Bubo virginianus* | great horned owl | x | x | x | | |
| *Chaetura pelagica* | chimney swift | x | x | | | |
| *Archilochus colubris* | ruby-throated hummingbird[c] | x | x | | | |
| *Cercyle alcyon* | belted kingfisher | | | | | x |
| *Melanerpes carolinus* | red-bellied woodpecker | | x | | | |
| *Picoides pubescens* | downy woodpecker | x | x | x | | |
| *Picoides villosus* | hairy woodpecker | | x | x | | |
| *Colaptes auratus* | northern flicker | | x | | | |
| *Dryocopus pileatus* | pileated woodpecker | | x | x | x | |
| *Sayornis phoebe* | eastern phoebe | x | x | | | |
| *Contopus virens* | eastern wood-pewee | | x | x | | |
| *Empidonax virescens* | Acadian flycatcher | | | x | x | x |
| *Myiarchus crinitus* | great crested flycatcher[c] | | | x | x | |
| *Progne subis* | purple martin[c] | x | | | | |
| *Stelgidopteryx serripennis* | northern rough-winged swallow[c] | x | x | | | |
| *Hirundo rustica* | barn swallow | x | x | | | |
| *Cyanocitta cristata* | blue jay | | x | | | |
| *Corvus brachyrhynchos* | American crow | x | x | x | | |

**Table 13. Continued**

| Scientific name | Common name | Habitat[b] | | | | |
|---|---|---|---|---|---|---|
| | | O | M | F | L | W |
| *Parus atricapillus* | black-capped chickadee | | x | x | | |
| *Parus carolinensis* | Carolina chickadee | | x | x | | |
| *Parus bicolor* | tufted titmouse | | x | x | | |
| *Sitta canadensis* | red-breasted nuthatch | | x | x | | |
| *Sitta carolinensis* | white-breasted nuthatch | | x | x | | |
| *Thryothorus ludovicianus* | Carolina wren | | x | x | | |
| *Polioptila caerulea* | blue-gray gnatcatcher | | x | x | x | |
| *Sialia sialis* | eastern bluebird[b] | x | x | | | |
| *Hylocichla mustelina* | wood thrush | | | x | x | |
| *Turdus migratorius* | American robin | | x | x | | |
| *Dumetella carolinensis* | gray catbird | | x | x | | |
| *Mimus polyglottos* | northern mockingbird | x | x | | | |
| *Toxostoma rufum* | brown thrasher | | x | | | |
| *Bombycilla cedrorum* | cedar waxwing[c] | x | x | | | |
| *Sturnus vulgaris* | European starling[d] | x | x | | | |
| *Vireo griseus* | white-eyed vireo | x | x | | | |
| *Vireo solitarius* | solitary vireo | | x | x | | |
| *Vireo flavifrons* | yellow-throated vireo[c] | | | | | |
| *Vireo olivaceous* | red-eyed vireo | | | x | x | |
| *Parula americana* | northern parula | | | x | x | x |
| *Dendroica pinus* | pine warbler | | | x | | |
| *Dendroica petechia* | yellow warbler | x | x | | | x |
| *Dendroica caerulea* | cerulean warbler[d] | | | | x | |
| *Dendroica virens* | black-throated green warbler | | | x | | |
| *Dendroica magnolia* | yellow-rumped warbler | x | x | | | |
| *Dendroica fusca* | blackburnian warbler | | | x | | |
| *Mniotilta varia* | black and white warbler | | | x | x | |
| *Helmitheros vermivorus* | worm-eating warbler | | | x | x | |
| *Seiurus motacilla* | Louisiana waterthrush | | | x | x | x |

**Table 13. Continued**

| Scientific name | Common name | Habitat[b] | | | | |
|---|---|---|---|---|---|---|
| | | O | M | F | L | W |
| *Seiurus aurocapillus* | ovenbird | | | x | x | |
| *Opoprornis formosus* | Kentucky warbler | | | x | x | |
| *Geothylpis trichas* | common yellowthroat | x | | | | |
| *Wilsonia citrina* | hooded warbler | | | x | x | |
| *Icteria virens* | yellow-breasted chat | x | | | | |
| *Pheucticus ludovicianus* | rose-breasted grosbeak | | x | x | x | |
| *Piranea rubra* | summer tanager[c] | | | x | x | |
| *Piranga olivacea* | scarlet tanager[c] | | | x | x | |
| *Cardinalis cardinalis* | northern cardinal | | x | | | |
| *Guiraca caerulea* | blue grosbeak[c] | x | x | | | |
| *Passerina cyanea* | indigo bunting | x | x | | | |
| *Pipilo erythrophthalmus* | rufous-sided towhee | | x | | | |
| *Spizella passerina* | chipping sparrow[c] | x | x | | | |
| *Zonotricia leucophrys* | white-throated sparrow | x | x | | | |
| *Melospiza melodia* | song sparrow | x | | | | |
| *Agelaius phoeniceus* | red-winged blackbird | | | | | x |
| *Sturnella magna* | eastern meadowlark | x | | | | |
| *Quiscalus quiscula* | common grackle | x | x | | | |
| *Molothrus ater* | brown-headed cowbird | x | x | | | |
| *Icterus spurius* | orchard oriole[c] | | x | | | |
| *Carduelis tristis* | American goldfinch | x | x | | | |

[a]Unless otherwise noted, all birds were observed on the ROW during 1994–1995.

[b]O = openings, fields, and brushy areas; M = mixed forest and openings, edges, open woods; F = forest; L = optimal habitat is large blocks of contiguous forest; W = water (i.e., in or near streams and wetlands). Habitat information is from Scott 1987, Robbins et al. 1989, Alsop 1991, and Appendix F.

[c]Observed during the Breeding Bird Survey (BBS) census or the Tennessee Ornithological Society (TOS) Breeding Bird Atlas survey (Nicholson 1994). The BBS survey data used for this table were for 1989, 1990, 1992, and 1993 from the Compone (previously Walland) route. Data are from page 5 of the BBS route which includes locations near Pittman Center in the vicinity of the Little Pigeon River Terraces segment of the ROW. The TOS data used are for the 1988, 1990, and 1991 surveys of the USGS Jones Cove map quadrangle, which is in the vicinity of Webb Mountain.

[d]One individual was reported in the 1988 TOS Breeding Bird Atlas survey. None was reported otherwise.

status that were targeted for field surveys. Topographic maps and information from the Tennessee Department of Environment and Conservation data base were used to further refine the list of rare target species (Appendix E). In addition to state and federal candidate, proposed, and listed species, target species included those that might be placed on these lists (e.g., plants not previously recorded for Tennessee). Other target species of interest to GSMNP staff are discussed in Sect. 3.4.4. The search for target species was conducted along the proposed ROW and includes adjacent areas that could be affected by the construction and operation of the parkway, particularly areas downslope from the ROW. The survey encompassed one growing season, April through October 1994.

**Species with federal status.** No species with federal status were found growing on the ROW. The ROW falls within the known range of the federally endangered small whorled pogonia (*Isotria medeoloides*). This inconspicuous orchid is most often found in relatively open areas in deciduous hardwoods, and suitable habitat ranges from dry, rocky slopes to moist streambanks. Although a careful survey for this species was conducted along the ROW, it was not found.

**Species with state status.** Three species previously listed as federal candidates and six additional state protected vascular plant species were found growing on the ROW and are listed in Table 14. The distribution by segments of these nine species, as well as fourteen additional species new or rare in GSMNP, are shown in Table 15.

**Table 14. Protected vascular plant species growing on the right-of-way**

| Species | Common name | Federal status[a] | State status[b] |
|---|---|---|---|
| *Juglans cinerea* | Butternut | C2 | T |
| *Silene ovata* | Ovate catchfly | C2 | T |
| *Abies fraseri* | Fraser fir | C2 | T |
| *Carex howei* | Howe's sedge | | E |
| *Cypripedium acaule* | Pink lady's-slipper | | E |
| *Trillium rugelli* | Southern nodding trillium | | E |
| *Panax quinquefolius* | Ginseng | | T |
| *Thermopsis fraxinifolius* | Ash-leaved bush-pea | | T |
| *Heuchera longiflora var aceroides* | Maple-leaf alumroot | | S |

[a]C2—species previously under review for listing (61 *Fed. Regist.* 64481–85; 58 *Fed. Regist.* 51143–89).
[b]E—endangered, T—threatened, S—special concern (Somers 1989), Division of Natural Heritage 1995. Special concern means species are either (1) rare in Tennessee because the state represents the limit or near-limit of their geographic range, or (2) their status is undetermined because of insufficient information.

The state threatened butternut grows in two locations on floodplains within the ROW. In this region, typical habitat for this species is floodplains. The populations consist of about 30 individuals ranging in size from saplings to mature trees. Some trees appear to have been cut during the centerline surveys, and others may have been poached (cut stumps and tops are present but logs are missing). Trees on the ROW are infected with butternut canker, an introduced fungus that threatens to eliminate butternut by killing many, but not all trees, over a period of years.

**Table 15. Vascular plant distribution, traversing Section 8B of the right-of-way from southwest to northeast, of state and previous federal candidate species and species new or rare in Great Smoky Mountains National Park**
(excluding exotic species)

| Species | Common name | PRT[a] | WM | MBR | RF | BR | CCT |
|---|---|---|---|---|---|---|---|
| *Juglans cinerea* | Butternut | X | | | | | |
| *Silene ovata* | Ovate catchfly | | X | | | | |
| *Abies fraseri* | Fraser fir | | | | X | | |
| *Carex howei* | Howe's sedge | | | | X | X | |
| *Cypripedium acaule* | Pink lady's slipper | | X | | | X | |
| *Trillium rugelli* | Southern nodding trillium | | | | | X | |
| *Panax quinquefolius* | Ginseng | | X | | | X | |
| *Thermopsis fraxinifolius* | Ash-leaved bush-pea | | X | | | | |
| *Heuchera longiflora var aceroides* | Maple-leaf alumroot | | X | | | | |
| *Aronia arbutifolia* | Red chokeberry | | | | X | | |
| *Asclepias amplexicaulis* | Clasping milkweed | | X | | | | |
| *Aster sagittifolius* | Arrow-leaved aster | | X | | | | |
| *Carex prasina* | Drooping sedge | | | | X | | |
| *Carex austrocaroliniana* | South Carolina sedge | | | | | X | |
| *Carex debilis var. pubera* | Sedge | | | X | | | |
| *Carex atlantica* | Atlantic sedge | | | X | X | | |

**Table 15. Continued**

| Species | Common name | PRT[a] | WM | MBR | RF | BR | CCT |
|---|---|---|---|---|---|---|---|
| *Cyperus brevifoliodes* | Pasture flatsedge | X | | | | | |
| *Danthonia epilis* | Wild oatgrass | | | | | X | |
| *Dryopteris celsa* | Log fern | | | | | | x |
| *Eclipta alba* | Yerba-de-tajo | X | | | | | |
| *Juncus diffusissimus* | Slimpod rush | | | | X | | |
| *Muhlenbergia tenufolia* | Slender muhly | | X | | | | |
| *Tradescantia virginiana* | Virginia spiderwort | X | | | | | |

[a]PRT = Pigeon River Terraces, WM = Webb Mountain, MBR = Matthew Branch Ridge, RF = Rocky Flats, BR = Big Ridge, CCT = Cosby Creek Terraces. No species were found in the Webb Creek Ridge segment.

Three flowering stems of the state threatened ovate catchfly were found in hardwood forest in two stream drainages. The hardwood forest habitat of the ovate catchfly is a common habitat on Section 8B of the ROW. This species may be present in other parts of the ROW, but intensive survey of this extensive habitat type is beyond the current scope of this project.

One 6-foot-tall sapling of the state threatened Fraser fir was found on the ROW growing in an area of abandoned homesteads in mixed hardwood and hemlock. The natural habitat of this species is high elevation, where it is threatened by the Balsam wooly adelgid, an exotic insect pest. However, it is commonly grown commercially for Christmas trees and as a landscaping ornamental at lower elevations. The presence of this individual in such an atypical location is not considered ecologically significant.

State endangered Gray's saxifrage (*Saxifraga caroliniana*), state threatened Smoky Mountain manna grass (*Glyceria nubigena*), state threatened Rugel's ragwort (*Cacalia rugelia*), state endangered Cain's reed grass (*Calamagrostis cainii*), and state threatened mountain bittercress (*Cardamine clematitis*) are additional species that may occur in the vicinity of the parkway that were previously federal candidate species under review for possible listing. All except the saxifrage are found only at high elevations, were not expected to occur on this section of the ROW, and were not seen during the survey. Suitable habitat for the saxifrage, which grows on steep, rocky terrain with dense shade and abundant moisture (e.g., steep, moist, moss-covered rocks, cliffs, and seepage slopes) is not present on this section of the ROW. Other potentially occurring previously federal candidate plant species include state threatened piratebush (*Buckleya distichophylla*), state endangered Frasier's loosestrife (*Lysimachia fraseri*), and state threatened sweet pinesap (*Monotropsis odorata*). None of these species was found on the ROW.

The state endangered southern nodding trillium grows in a north-facing stream drainage on the ROW. Southern nodding trillium is a southern Appalachian endemic species. This species is endangered in Tennessee but is more common in North Carolina.

The endangered Howe's sedge grows in two wetland seep areas on the ROW. This species is sometimes considered by taxonomists to be a subspecies of *Carex atlantica*; however, both taxa (*C. atlantica howei* and *C. atlantica*) are present in this location. It is associated with several mosses (*Polytrichum commune*, *Thuidium delicatulum*, and *Climacium americanum* var *kindbergii*) in a boggy area and has not been previously reported in Tennessee east of the Cumberland Plateau.

The endangered pink lady slipper, which is found throughout the ROW, is more common than is normally the case for a Tennessee listing. It and the threatened ginseng are listed because of the potential threat from commercial exploitation. There are several populations of pink lady slipper on the ROW, mostly in dry pine forest. Some were also found in dry, oak-pine forest. Two populations of ginseng are in mesic forest sites.

The threatened ash-leaved bush-pea was found on the ROW at three sites. Two populations are in open, dry mixed forest containing pine killed by southern pine beetle. The other population is in oak forest in a ravine. It is possible that other populations are present on the ROW. There are large areas of potential habitat for this species on the ROW, and an intensive search of this habitat

type was beyond the scope of this survey. This species was previously known in the GSMNP only on Section 8D of the ROW.

The maple-leaf alumroot, a state species of special concern, was found in two locations on the ROW and one location downslope from the ROW on non-calcareous sites. Plants were scattered over a fairly large area and may be present in other areas of hardwood forest on the Webb Mountain segment. This species has been previously reported in rich calcareous woods (Radford, Ahles, and Bell 1968) and calcareous shales or bluffs (Wofford 1981). It has previously been reported only in Greene and Cocke counties and may be a new finding for Sevier County.

No other state listed vascular plant species were found on the ROW (Appendix D).

#### 3.4.3.2 Bryophyte and Lichen Species

The bryophyte and lichen survey was conducted by Dr. David Smith of the University of Tennessee and his graduate students during the fall of 1994 and winter and early spring of 1995. Field surveys and identifications were completed for all segments of the ROW. Bryophytes and lichens do not currently have protected legal status in Tennessee and no federally endangered, threatened, or previously candidate species have been identified.

#### 3.4.3.3 Animal Species

Federal (59 *Fed. Regist.* 58981–9028; 59 *Fed. Regist.* 49848–59) lists of rare species were used to determine which rare animal species might occur on the ROW. This list provided an initial list of species with federal or state legal status that were targeted for field surveys. Information from the Tennessee Department of Environment and Conservation data base and GSMNP staff were used to further refine the list of rare target species. From these lists and examination of topographic maps, lists of small mammal (Appendix G) and bird species of concern to GSMNP that are likely to be present in the study area were developed.

**Mammals, reptiles, and upland salamanders.** The small mammal, reptile, and upland salamander survey was conducted by Dr. Michael Harvey of Tennessee Technological Institute and his assistants in late summer and fall of 1994. No endangered or threatened species, or candidate species for listing as endangered or threatened, was captured (Appendix G).

**Species with federal status.** Three listed endangered mammal species could occur on the ROW: the Indiana bat (*Myotis sodalis*), the gray bat (*M. grisescens*), and the Carolina northern flying squirrel (*Glaucomys sabrinus coloratus*) (Appendix G). The largest known hibernating colony of the Indiana bat in the GSMNP region (about 8500) occupies Whiteoak Blowhole Cave in the northwestern section of GSMNP [about 35 to 45 km (22 to 28 miles) from the study area]. Another small colony of about 200 bats hibernates in Bull Cave, also in the northwestern section of GSMNP. Although not seen during field surveys, the endangered Indiana bat might be present along the ROW in summer. Despite protection of important hibernacula—usually limestone caves—where Indiana bats winter, populations of this species have continued to decline (Rommé, Tyrell, and Brack 1995). Important components of summer habitat include maternity roost and foraging habitat. Female Indiana bats establish nursery colonies or roosts in dead trees or under loose bark of large mature hardwoods. Open subcanopy space over streams provides an open

travel corridor where bats concentrate, but Indiana bats eat primarily terrestrial insect species (Rommé, Tyrell, and Brack 1995). Upland and riparian hardwood forest are foraging and maternity roost habitat for this species.

The gray bat occurs primarily in areas of abundant caves and is not known in GSMNP. It is unlikely that it is present in the vicinity of the ROW. No suitable habitat for the Carolina northern flying squirrel, which has previously been found only above 1230 m (4000 ft) elevation, is present on the ROW.

**Species with state status.** Seven small mammal species, one snake, and two salamanders that were previously candidates for federal listing could occur on the ROW (Appendix G), but none were observed. Suitable habitat is present on the ROW for state "in need of management" Rafinesque's big-eared bat (*Corynorhinus rafinesquii*), the eastern small-footed bat (*Myotis leibii*), southeastern bat (*Myotis austroriparius*), eastern woodrat (*Neotoma floridana*), southern water shrew (*Sorex palustris punctulatus*), southern rock vole (*Microtus chrotorrhinus carolinensis*), and Appalachian cottontail (*Sylvilagus obscurus*). The big-eared bat is apparently one of the most common bats in the GSMNP and was found on the Section 8D ROW about 20 to 35 km (12.5 to 22 miles) away. It is probably present on the Section 8B ROW during summer. The small-footed bat is apparently rare in the GSMNP region. There is a single record from Greenbrier Cove in GSMNP [about 6 to 17 km (4 to 11 miles) from the ROW]; and it is possible, but not probable, that this bat would occur along the ROW during summer. There are no records of the southeastern bat in the GSMNP, and it is unlikely to be present on the ROW.

The woodrat is found up to elevations of 800 m (2500 ft) and is likely to be present on the ROW, especially in rocky areas. The other three species are generally found at higher elevations and are uncommon in the GSMNP. Some of the streams on the ROW are similar habitat to areas where the water shrew has been found; however, the shrew has been found only at elevations above 1138 m (3700 ft) and is unlikely to be present on the ROW (Appendix G). The rock vole has been reported in the GSMNP only above 815 m (2650 ft) (Appendix G). It could possibly occur in the higher-elevation rocky areas in the Webb Mountain segment of the ROW. Although the Appalachian cottontail was not captured during the field study, cottontails were seen on the ROW (Appendix G). It was not possible to determine whether they were Appalachian cottontails or the more common eastern cottontail (*Sylvilagus floridanus*) but suitable habitat is present in the higher elevations of the Webb Creek Ridge, Webb Mountain, and Matthew Branch Ridge segments of the ROW.

Neither of the potentially occurring upland species which were previously federal candidates, state "in need of management" Junaluska salamander (*Eurycea junaluska*) and green salamander (*Aneides aeneus*), or the state threatened northern pine snake (*Pituophis melanoleucas melanoleucas*) was observed during the survey (Appendix G). The Junaluska salamander is currently known only in the Cheoah River Valley in Graham County, North Carolina, and in the GSMNP about 14 to 30 km (9 to 19 miles) away (Appendix G). Although the green salamander is known historically in Sevier County at Cherokee Orchard near Gatlinburg about 12 to 26 km (7.5 to 16 miles) away, no suitable cave or cliff habitat is on the ROW. This species is unlikely to be present. The pine snake has been historically reported from GSMNP and was not thought to be uncommon in the western regions of the park below about 600 m (2000 ft) (Huheey and Stupka

1967). Suitable habitat is present throughout the ROW where this relatively secretive snake may be present.

The state "in need of management" hellbender (*Cryptobranchus alleganiensis*), also previously a candidate for federal listing, has been reported in the Little Pigeon River drainage system (J. Widlak, USFWS, Cookeville, Tennessee, telephone conversation with L. Mann, ORNL, April 11, 1994).

Five species listed by the state of Tennessee as in need of management (Tennessee Wildlife Resources Commission 1994) were captured (Table 16). The masked and smoky shrews are probably throughout the ROW, but other need of management species are probably more localized in damp areas. The meadow jumping mouse and bog lemming are found in grassy areas and the woodland jumping mouse in wooded areas. Although not observed on the Section 8B ROW, the "in need of management" hairy-tailed mole was found on Section 8A of the ROW in 1995 (K. Langdon, GSMNP, Gatlinburg, Tennessee, telephone conversation with L. Mann, ORNL, Aug. 11, 1995).

**Table 16. Mammals captured on the Section 8B of the right-of-way that were listed as "In Need of Management" by the state of Tennessee[a]**

| Species | Common name | Segment of right-of-way |
|---|---|---|
| *Sorex cinereus* | Masked shrew | Webb Mountain, Matthew Branch Ridge |
| *Sorex fumeus* | Smoky shrew | Webb Mountain, Matthew Branch Ridge |
| *Zapus hudsonius* | Meadow jumping mouse | Cosby Creek Terraces |
| *Napaeozapus insignis* | Woodland jumping mouse | Matthew Branch Ridge, Rocky Flats |
| *Synaptomys cooperi* | Southern bog lemming | Cosby Creek Terraces |

[a]Species "in need of management" need data to determine management measures necessary to sustain populations Hatcher (1994).

**Bird species with federal status.** No federally listed birds are known to occur on the ROW. According to the U.S. Fish and Wildlife Service, the only bird species of possible concern on the ROW is the threatened peregrine falcon (*Falco peregrinus*). Historically, the American peregrine falcon (*F. peregrinus anatum*) occurred in the vicinity of the parkway; transients and occasional migrants are still seen, but no recent sitings are on record (J. Widlak, USFWS, Cookeville, Tennessee, telephone conversation with L. Mann, ORNL, April 11 and June 1, 1994). The peregrine is being successfully reintroduced to the southern Appalachians (WWF 1990) and was hacked in the GSMNP (Henry 1988) at a hack site about 7 to 14 km (5 to 9 miles) from the ROW. Peregrines prefer cliffs for nest sites, but reintroduced birds also regularly nest on tall buildings and bridges (WWF 1990; Henry 1988). Birds often travel up to 11 km (7 miles) from the nest site to hunt in a variety of habitats, including grasslands and open country. They tend

especially to hunt near water, along large lakes and rivers (WWF 1990; Eagar and Hatcher 1980). They may range as far as 30 km (20 miles) (R. M. Hatcher, Tennessee Dept. of Conservation, Nashville, Tennessee, telephone conversation with L. Mann, ORNL, 1991).

Two other listed species of birds, the threatened American bald eagle (*Haliaeetus leucocephalus*) and the endangered red-cockaded woodpecker (*Picoides borealis*), could occur on the ROW. According to Stupka (1963), the American bald eagle was historically an irregular and infrequent visitor to the GSMNP despite nearby water impoundments. It is highly unlikely that this species would be found on the ROW. The nearest historically known population of red-cockaded woodpeckers is near Fontana, about 60 km (38 miles) south of the study area. Suitable habitat for this species is on the ROW, but nest trees, which are conspicuous, were not seen.

**Bird species with state status.** Three species of birds that were previously candidates for federal listing and are either state threatened or endangered occur on the ROW. These species are the state threatened Appalachian Bewick's wren (*Thryomanes bewickii altus*), the loggerhead shrike (*Lanius ludovicianus*), and state endangered Bachman's sparrow (*Aimophila aestivalis*).

Appalachian Bewick's wren, the loggerhead shrike, and Bachman's sparrow prefer open pastures and old fields. Historically, Bewick's wren was a very uncommon summer resident and a rare winter visitor in the GSMNP (Stupka 1963). The wren was somewhat more frequent at low altitudes and often occupied old homesites (Eagar and Hatcher 1980). It has been reported in the past in the Pigeon Forge area (Stupka 1963). Bachman's sparrow has been an uncommon spring migrant and a scarce summer resident in GSMNP (Stupka 1963). Preferred habitat for this species is open pastures and old fields, usually with some woody brush and briars. This species has abundant unused habitat in Tennessee and does not appear to be habitat-limited (Eagar and Hatcher 1980). The loggerhead shrike is a winter resident near the GSMNP and breeds in Sevier County (R. J. Shelley, NPS, letter to R. M. Reed, ORNL, March 24, 1992).

No species of concern at the federal level were seen during the survey, but Cooper's hawk, a species "deemed in need of management" (Hatcher 1994) in Tennessee was seen in the Webb Mountain segment of the ROW (Appendix F).

### 3.4.4 Additional Species of Interest to the NPS

**Park-rare species.** Because one of the purposes of national parks is conservation of biotic diversity, the GSMNP staff is concerned with protecting its rare species. The park maintains a data base of plant species similar to that of the Heritage Program, which ranks species according to rarity. In the park, species with five or fewer small populations (P1 status) or with six to 20 small populations (P2 status) are most vulnerable to extinction. The search for rare vascular plants and bryophytes on the ROW included these P1 and P2 species (Rock and Langdon 1991; Smith, McFarland, and Davison 1991).

**Vascular plants.** Seven species new to GSMNP, seven P1 species, and three P2 species were found on the ROW (Table 17). Their distributions are shown in Table 15. The slimpod rush was new to both GSMNP and East Tennessee. Of the new or rare species in the GSMNP, all but the two exotic species (coltsfoot and ivy-leaved speedwell) and three species growing on Webb

**Table 17. Vascular plants found during surveys on Section 8B of the right-of-way which were either new or considered rare in GSMNP, other than state and federally listed species in Table 14**

| Species | Common name | Park status[a] |
|---|---|---|
| *Aronia arbutifolia* | Red chokeberry | P2 |
| *Asclepias amplexicaulis* | Clasping milkweed | P1 |
| *Aster sagittifolius* | Arrow-leaved aster | P1 |
| *Carex prasina* | Drooping sedge | P2 |
| *Carex austrocaroliniana* | South Carolina sedge | P2 |
| *Carex debilis var. pubera* | Sedge | P1 |
| *Carex howeii* | Howe's sedge | New |
| *Carex atlantica* | Atlantic sedge | New |
| *Cyperus brevifoliodes* | Pasture flatsedge | P1 |
| *Danthonia epilis* | Wild oatgrass | New |
| *Dryopteris celsa* | Log fern | P1 |
| *Eclipta alba* | Yerba-de-tajo | P1 |
| *Juncus diffusissimus* | Slimpod rush | New |
| *Muhlenbergia tenufolia* | Slender muhly | P1 |
| *Tradescantia virginiana* | Virginia spiderwort | New |
| *Tussilago farfara* | Coltsfoot | New (exotic) |
| *Veronica hederifolia* | Ivy-leaved speedwell | New (exotic) |

[a]New = previously not reported in GSMNP (exotic species are non-native to the region); P1 = extremely rare in GSMNP; P2 = rare in GSMNP (Rock and Langdon 1991).

Mountain (clasping milkweed, arrow-leaved aster, and slender muhly) were found in wetlands or the Little Pigeon River floodplain. This abundance of GSMNP rare wetland species may be a result of the relative rarity of wetland and floodplain habitats in the park and the quality of wetlands present on the ROW. The plant in the Cosby Creek floodplain identified as log fern, a P1 species, may be of hybrid origin. Dr. Murray Evans of the Botany Department at the University of Tennessee, concluded that it is best assigned to *Dryopteris celsa* but it may have some genes from *D. cristata* as a result of hybridizing (M. Evans, University of Tennessee, personal communication with L. Pounds, Jaycor, Dec. 1994). *D. cristata*, a state listed species of special concern, was not found during the field searches.

**Bryophyte and lichens.** Of the 43 liverwort species, 106 moss species, and 2 hornwort species identified on the ROW, 14 park-rare and one state-rare liverwort species and 29 park-rare moss species were found (Appendix H). A rare aquatic hornwort (*Megaceros aenigmaticus*), previously known globally in only one stream in North Carolina in the GSMNP and in the Tellico River drainage in Tennessee, was found in one of the streams in the Rocky Flats segment. Although not currently listed, this species is globally rare enough to be considered for protection (K. Langdon, GSMNP, telephone conversation with L. Mann, ORNL, 1995).

Five species (three mosses, one liverwort, and one hornwort) rare in both GSMNP and in Tennessee (P1, S1) (Smith, McFarland, and Davison 1991; Appendix H) were found. Two of the mosses (*Brachethelium rutabulum* and *Fissidens appalachensis*) and the hornwort (*Megaceros aenigmaticus*) were in or near streams and wetlands. The other moss (*Fissidens bushii*) was growing on disturbed soil, and the liverwort (*Frullania kunzei*) was growing on boulders in mesic woods. An additional 23 species rare in GSMNP (P1, P2) but more common elsewhere in Tennessee were also growing on the ROW. Nine of these species were on bark, five were in streams or wetlands, three were on rock, one was on wet, decaying wood, and three were on disturbed soils. Three taxa were new to GSMNP: two liverworts (*Frullania eboracensis* subsp. *virginica* and *F. ericoides*) and a moss (*Dicranum spurium*). No new state records resulted from this study. A sphagnum (*Sphagnum affine*, P1, P2) bog was found during the vascular plant survey (Appendix E).

**Small mammals.** Three small mammal species that are considered to be rare in the GSMNP were captured on the ROW: the northern long-eared bat (*Myotis septentrionalis*) in the Little Pigeon Terraces segment, the pygmy shrew (*Sorex hoyi*) in the Big Ridge segment, and the golden mouse (*Ochrotomys nuttalli*) in the Cosby Creek Terraces segment (Appendix G). One individual of each of these species was caught. The pygmy shrew was previously only reported from one high-elevation site in the park.

**Birds.** Because of apparent population declines in neotropical migratory songbirds (Askins 1995; Robinson et al. 1995), many of which are dependent on large blocks of unfragmented forest, these birds are of concern to GSMNP. They are particularly vulnerable to medium-sized mammalian predators (e.g., raccoons and opossums) and egg-eating birds (e.g., American crows and blue jays), and to parasitism by brown-headed cowbirds. These predators and parasites thrive in fragmented forests in landscapes containing abundant forest edge and field vegetation. Although some migrant songbirds experiencing population declines (e.g., the cerulean warbler, Kentucky warbler, and wood thrush) breed only in large blocks of contiguous forest, some non-forest migrants (e.g., the northern prairie warbler) also seem to be declining in some regions of the United States (Hunter et al. 1993; Hunter, Pashley, and Escano 1993). Conservation Concern Scores have been developed by the Southeast Management Working Group for Partners in Flight as preliminary priorities for conservation of migratory songbirds (Hunter et al. 1993; Hunter, Pashley, and Escano 1993; Roedel, Miles, and Ford 1996). These scores were developed using 7 criteria, with each given from 1 to 5 points (low to extremely high concern). The criteria are (1) global abundance, (2) global breeding distribution, (3) global wintering distribution, (4) threats during breeding season, (5) threats during non-breeding migration and wintering season, (6) local population trend, and (7) importance of the area compared with other distribution. In the Blue Ridge Physiographic province, 16 species of neotropical migrants and one temperate migrant of very high concern, or

vulnerable and likely in need of management and/or monitoring were observed on or near the ROW (Table 18 and Appendix F).

**Table 18. Songbirds identified by the Southeast Management Working Group for Partners in Flight as preliminary priorities in need of increased conservation attention in the Southeastern United States and Blue Ridge Physiographic Province (Hunter et al. 1993a, b; Roedel et al. 1996) which were observed on or near the right-of-way** (Appendix F; Nicholson 1994)

| Species | | Habitat |
|---|---|---|
| **Neotropical migrants** | | |
| Cerulean warbler[a] | *Dendroica cerulea* | Forest |
| Blackburnian warbler | *Dendroica fusca* | Forest |
| Worm-eating warbler | *Helmitheros vermivorous* | Forest |
| Hooded warbler | *Wilsonia citrina* | Forest |
| Kentucky warbler | *Oporornis formosus* | Forest |
| Black-throated green warbler | *Dendroica virens* | Forest |
| Ovenbird | *Seiurus aurocapillus* | Forest |
| Wood thrush | *Hylocichla mustelina* | Forest |
| Acadian flycatcher | *Epidonax virescens* | Forest |
| Scarlet tanager | *Piranga olivacea* | Forest |
| Northern parula | *Parula americana* | Forest, streams |
| Louisiana waterthrush | *Seiurus motacilla* | Forest, streams |
| Yellow-throated vireo | *Vireo flavifrons* | Forest, open woods |
| Eastern wood-pewee | *Contopus virens* | Forest, open woods |
| Northern prairie warbler | *Dendroica discolor discolor* | Fields, edges |
| Gray catbird | *Dumetella carolinensis* | Fields, edges |
| **Temperate migrants** | | |
| Field sparrow | *Spizella pusilla pusilla* | Fields |

[a]Observed during the Tennessee Ornithological Society (TOS) Breeding Bird Atlas survey (Nicholson 1994). The TOS data used were for the 1988, 1990, and 1991 surveys of the USGS Jones Cove map quadrangle, which is in the general vicinity of Webb Mountain.

One of these species, the cerulean warbler (*Dendroica cerulea*), was previously a candidate for federal listing. Cerulean warblers are undergoing precipitous population declines throughout their

range. They nest in large tracts of mature hardwood forest on hilly to steep slopes in the mountains, with greatest reported abundance in the central Cumberland Mountains (Hamel 1992). Breeding density of this species is low in the Parkway ROW area and it is described as rare in northeast Tennessee (Robinson 1990). Although one cerulean warbler was reported from the 1988 Breeding Bird Survey in or near the Webb Mountain segment of the ROW (Nicholson 1994), Stupka (1963) reported it as "very uncommon" in GSMNP even before population declines were reported. This species might nest on the ROW, but it is not likely to occur as more than an occasional breeding pair and was not observed during an extensive search for this species during the 1995 bird survey of the ROW.

Many of these species require large tracts of forest for successful nesting. Most of the Section 8B ROW is contained within tracts of deciduous forest larger than about 400 ha (1000 acres) (Fig. 1). Tracts of this size were identified by the Southern Appalachian Assessment as suitable habitat for birds requiring interior deciduous forest (SAMAB 1996).

Several species that breed at high elevations in the park were observed on the ROW during the 1995 survey. The rose-breasted grosbeak, black-capped chickadee, red-breasted nuthatch, solitary vireo, and blackburnian warbler are considered high elevation species, usually found above about 1100 m (3500 ft) (Alsop 1995). All but the rose-breasted grosbeak are reported by other sources as breeding as low as 600 m or 900 m (2000 or 3000 ft) in or near the park (Stupka 1963). These species were all observed on or near Webb Mountain (Appendix F), whose peak of 950 m (3100 ft) is the highest elevation on the ROW. The individual rose-breasted grosbeak may have been a visitor from nearby higher elevations (Stupka 1963).

The rock dove, also known as the pigeon of urban areas, was found in the Webb Creek Ridge segment of the ROW. It was the only bird species observed during the 1995 survey that is considered rare in GSMNP (Alsop 1995). This species is not of concern to GSMNP.

**Non-native (exotic) invasive species.** The presence of non-native or exotic plant species on and near the ROW is important to staff of GSMNP because aggressive non-native species compete with native species and detract from the GSMNP visitor experience (Clebsch and Wofford 1989; Remaley 1996). Vegetation on most of the ROW is native, although a few areas are infested with aggressive, non-native species, especially in disturbed areas and up drainage systems from disturbed areas outside the ROW (Table 19). Other non-native species may be present on the ROW but were not included as part of this study.

The greatest exotic plant threat to native vegetation on the ROW is from privet (*Ligustrum vulgare*), which is spreading along streams into relatively undisturbed areas, especially along the tributaries to Webb Creek west of Mill Dam Branch. Although not currently abundant on the ROW, Japanese grass (*Microstegium vimineum*) is another aggressive exotic species found in shaded moist areas. Garlic mustard (*Allialaria petiolata*) was not found on the ROW, but it grows nearby and may invade mesic forest areas. Coltsfoot (*Tussilago farfara*) and ivy-leaved speedwell (*Veronica hederaefolia*) are new exotic species for the GSMNP. The potential effects of these species on natives is unknown. Coltsfoot dominates bare ground on roadside banks and is not a threat for any of the rare species found in this section of the ROW.

**Table 19. Non-native (exotic) species growing on or near Section 8B of the right-of-way**

| Species | Common name | Section of right-of-way |
|---|---|---|
| *Microstegium vimineum* | Japanese grass | Along streams |
| *Alliaria petiolata* | Garlic mustard | Rocky Flats Road, south of right-of-way |
| *Lonicera japonica* | Japanese honeysuckle | In many locations, especially those with past history of disturbance |
| *Veronica hederaefolia* | Ivy-leaved speedwell | Along Dunn Creek |
| *Ligustrum vulgare* | Privet | In disturbed areas and drainages above disturbed areas |
| *Broussonetia papyrifera* | White mulberry | Seen previously by NPS staff—location unknown; not relocated during survey |
| *Vinca minor* | Periwinkle | On ROW in vicinity of Chavis Road |
| *Dioscorea batatas* | Cinnamon vine, Chinese yam | Little Pigeon River and Cosby Creek floodplains; near Chavis Road |
| *Pueraria lobata* | Kudzu | Vicinity of Chavis Road |
| *Tussilago farfara* | Coltsfoot | Branam Hollow Road |
| *Rosa Multiflova* | Multiflora rose | Near Webb Creek, Crosby Creek, and Little Pigeon River |

Mimosa (*Albizzia julibrissin*), princess tree (*Pawlonia tomentosa*), catalpa (*Catalpa speciosa*), and wineberry (*Rubus phoenicolasius*) were not found on the ROW. Mimosa is common in the general area, and the princess tree is locally abundant in some other sections of the ROW and on other roadsides, such as on I-40 north of Cosby. Catalpa is neither common nor considered an aggressive exotic species in this area (K. Langdon, GSMNP, telephone conversation with L. Mann, ORNL, 1995).

### 3.4.5 Unique or Sensitive Habitats Including Wetlands

For purposes of this ER, unique or sensitive habitats are defined as fairly discrete landscape units that provide habitat for one or more species of plants or animals that are of interest to the GSMNP; that are listed, proposed, or candidates for listing by state or federal governments; or that

are plant communities recognized as globally or nationally threatened or endangered (Noss, LaRoe, and Scott 1995).

Such biologically important habitats on the ROW include floodplains, boulder slopes, mesic slopes, and wetlands. All are of limited extent in the region as a result of either the rare occurrence of physical features or increasing conversion of native landscapes to urbanization, land clearing, or agricultural use.

**Wetlands.** National Wetlands Inventory (NWI) maps were examined initially to identify possible locations of wetlands along the ROW. Although potential wetlands were identified along the Little Pigeon River, Copeland Creek, Webb Creek, and Cosby Creek in the Little Pigeon Terraces, Webb Creek Ridge, Rocky Flats, and Cosby Creek Terraces segments of the ROW, these maps proved inadequate to locate other wetlands on the ROW. Wetlands discussed in this section were identified during soil, vegetation, and aquatic surveys. A detailed wetlands survey was conducted in 1994 and 1995 for several of the more extensive wetlands on the Little Pigeon River, Webb Creek, Dunn Creek, and Carson Branch (Appendix I). Most other wetlands were smaller than 1 ha (0.5 acres).

Although small areas of wetlands are found along most of the stream drainages crossing the ROW, the high gradient of the streams and their rocky nature result in little wetland development. Areas of more extensive wetlands are on cobble bars of the Little Pigeon River in the Little Pigeon Terraces segment, along a tributary to Webb Creek in the Webb Creek Ridge segment, and near seeps and streams along Dunn Creek and Carson Branch in the Rocky Flats segment. Vegetation in most of these larger wetland areas is similar to vegetation in smaller [less than 9 $m^2$ (100 $ft^2$)] wetlands types found throughout the ROW along small streams and drainages. Typical wetland (e.g., hydrophytic) vegetation includes several species of sedges, fowl manna grass (*Glyceria striata*), ferns, spotted touch-me-not (*Impatiens capensis*), and Japanese grass. In areas without standing water, Japanese grass often forms a dense ground cover, obscuring native vegetation. Smooth alder (*Alnus serrulata*), ironwood, elderberry (*Sambucus canadensis*), and black willow (*Salix nigra*) are typical hydrophytic shrubs in open, shrub-dominated wetlands. Typical forest vegetation in larger wetlands includes sycamore, red maple, sweetgum (*Liquidambar styriciflua*), and elm (*Ulmus americana*). In small wetlands, the overstory canopy is often formed by the surrounding forest rather than by trees that are actually growing in the wetland. Hemlock, oaks, red maple, tulip poplar, and rhododendron often grow near these drainages. The soils in small wetland areas are typical wetland, hydric soil types (either Aquolls, Aquepts, or Aquents) (see Appendix B).

Biologically important wetlands are present on the ROW in three drainages containing fairly extensive networks of seeps. One is in a steep-sided, narrow ravine in mesic forest. The area containing the seeps is about 30 m (100 ft) long and 3 to 6 m (10 to 20 ft) wide. This mountain wetland seep contains a diverse flora, including several sedges (*Carex atlantica*, previously unknown in the GSMNP; *C. debilis*, P1 or the most rare category for GSMNP; *C. scabrum*; and *C. crinata*), a wetland grass (*Sphenopholis pennsylvanicum*), and yellow fringed orchid (*Platanthera ciliaris*).

Another biologically important seepage area originates at the base of a steep slope below a roadcut. Many small pools and boggy areas occur under pine and mixed pine-hardwood canopy, as

well as under a mowed area paralleling the creek. This wetland complex contains a moss bog and a diverse wetland flora, including the state endangered Howe's sedge; slimpod rush, new to the park; and red chokeberry, a park P2 species.

The third biologically important wetland area consists of small seeps in multiple tributaries of a stream system. These wetlands contain wild oatgrass (a species new to the park), and the state endangered Howe's sedge.

**Floodplain and other unique habitats.** Despite disturbance from flooding and human activity, the Little Pigeon River and Cosby Creek floodplains contain assemblages of native bottomland species representative of large streams and small rivers in the region, including a population of the federal candidate butternut. Although no listed species are known to be present on the Cosby Creek floodplain, there is a small stand of giant cane (*Arundinaria gigantea*). Canebrake communities in the Southeast are among those listed by Noss, LaRoe, and Scott (1995) as critically endangered ecosystems (more than 98% of such communities have been lost). Native riparian or floodplain communities are threatened by urban development and agricultural use throughout the region and are threatened (70 to 84% decline) throughout the United States (Noss, LaRoe, and Scott 1995).

A well developed cobble bar with mostly native vegetation is also present in the Little Pigeon River. No listed plant species have been observed in this frequently flooded habitat, but Yerba-de-tajo and pasture flatsedge, both rare species of disturbed sites in the park, were found there.

Boulder or talus slopes and rocky areas are present on the ROW in the Webb Mountain segment. One of these rocky areas is habitat for the federal candidate ovate catchfly. At present, no other listed species are known to be present in these sites.

The vegetation in one area of the ROW on the Big Ridge segment is somewhat different from the rest of the ROW. Redbud (*Cercis canadensis*), glade fern (*Athyrium pycnocarpon*), and the state endangered southern nodding trillium are species often found in calcareous areas, or areas of basic to neutral soil. Therefore, the geology of this area may be less acidic than that of the rest of the ROW. Some of this general area is highly disturbed and contains extensive kudzu (*Pueraria lobata*), but the relative rarity of calcareous soils in the GSMNP makes this an area of ecological interest to the park.

### 3.4.6 Summary

Of the 14 species with federal or state endangered, threatened, previous candidate, or special concern status, the populations of the state threatened ovate catchfly and ash-leaved bush-pea are of greatest concern because of their potential global rarity. Of the sensitive habitats and protected species identified or found on the ROW, those of greatest concern are the floodplains of the Little Pigeon River and Cosby Creek; Webb Mountain, including drainages and slopes; wetlands and streams in the Rocky Flats area; and some upper drainages on Big Ridge. Although not currently protected, the globally rare population of hornwort is also of concern.

## 3.5 METEOROLOGY AND AIR QUALITY

### 3.5.1 Meteorology

The climate of the region may be broadly classified as humid continental. The Cumberland Mountains to the northwest help to shield the region from cold air masses that frequently penetrate far south over the plains and prairies in the central United States during the winter months. In summer, tropical air masses from the south provide warm and humid conditions that often produce thunderstorms. However, anticyclonic (clockwise) circulation around high-pressure systems centered in the western Gulf of Mexico can bring dry air from the southwestern United States into the region, leading to occasional periods of drought. Elevation affects the temperature and precipitation over the region; cooler temperatures and greater precipitation generally occur at the higher elevations of the Great Smoky Mountains. Severe storms are relatively rare because the region lies east of the tornado belt, south and east of most blizzard occurrences, and too far inland to be much affected by hurricanes (Gale Research Company 1985).

The nearest locations to Section 8B for which climatic data are available are Gatlinburg [elevation 443 m (1454 ft)], about 24 km (15 miles) to the west-southwest, and Newport [elevation 317 m (1040 ft)], about the same distance to the north-northeast. The elevation of the proposed parkway Section 8B varies from about 411 m (1350 ft) to about 747 m (2450 ft), averaging close to 579 m (1900 ft).

Average annual temperature in Gatlinburg is 13.2°C (55.7°F); in Newport it is 14.1°C (57.3°F). The coldest month is January, averaging 2.5°C (36.5°F) at both locations; the warmest month is July, averaging 23.0°C (73.4°F) at Gatlinburg and 24.8°C (76.6°F) at Newport (Gale Research Company 1985). The temperature falls below freezing on an average of 115 days per year at Gatlinburg and 98 days per year at Newport, with about 90% of those days occurring during November through March. Temperatures fall below −17.8°C (0°F) on an average of only one day per year at both locations. Daytime high temperatures rise above 32.2°C (90°F) on an average of 24 days per year at Gatlinburg and 42 days per year at Newport, mostly during June, July, and August (Gale Research Company 1985). Temperature summaries for Gatlinburg and Newport are given in Table 20. Up-to-date records of extreme temperatures are not readily available from those stations. The nearest stations with such records are Knoxville [McGhee-Tyson Airport, elevation 299 m (980 ft)], located about 58 km (36 miles) west of Webb Mountain, and Asheville, North Carolina [elevation 652 m (2140 ft)], about 72 km (45 miles) east-southeast of Webb Mountain. (Webb Mountain is a convenient reference point, being located about midway along the route of proposed parkway Section 8B.) The lowest temperature ever recorded in Knoxville was −31°C (−24°F), and the highest was 39°C (103°F). The lowest temperature ever recorded at Asheville was −27°C (−16°F), and the highest was 38°C (100°F).

Average precipitation in the GSMNP varies with elevation. The highest elevations, around Clingman's Dome, receive an average of over 204 cm (80 in.) of precipitation annually (NPS 1982). The annual average at Gatlinburg is 144.6 cm (57.9 in.); at Newport it is 114.0 cm (44.9 in.). Precipitation amounts of 0.25 cm (0.1 in.) or more occur on an average of 96 days per year at Gatlinburg and 88 days per year at Newport (Gale Research Company 1985). Average monthly precipitation amounts do not vary greatly over the course of the year, ranging from 7.95 cm (3.13 in.) in October to 15.37 cm (6.05 in.) in July at Gatlinburg, and from 6.53 cm

**Table 20. Temperature data for Gatlinburg and Newport, Tennessee (°F)**

| | Mean monthly | | Mean daily maximum | | Mean daily minimum | |
|---|---|---|---|---|---|---|
| Month | Gatlinburg | Newport | Gatlinburg | Newport | Gatlinburg | Newport |
| January | 36.5 | 36.5 | 48.2 | 47.2 | 24.7 | 25.9 |
| February | 39.1 | 39.3 | 51.9 | 51.1 | 26.2 | 27.5 |
| March | 47.2 | 47.6 | 61.0 | 60.4 | 33.3 | 34.8 |
| April | 56.5 | 57.9 | 71.5 | 71.8 | 41.5 | 44.0 |
| May | 63.7 | 65.8 | 78.0 | 79.0 | 49.2 | 52.6 |
| June | 70.1 | 73.1 | 83.5 | 85.5 | 56.7 | 60.6 |
| July | 73.4 | 76.6 | 86.3 | 88.6 | 60.6 | 64.5 |
| August | 72.8 | 75.9 | 85.5 | 88.1 | 60.0 | 63.6 |
| September | 67.6 | 70.3 | 80.8 | 83.0 | 54.4 | 57.5 |
| October | 56.2 | 57.9 | 70.8 | 71.7 | 41.6 | 44.0 |
| November | 46.2 | 47.2 | 60.0 | 59.9 | 32.4 | 34.5 |
| December | 39.2 | 39.1 | 51.7 | 50.4 | 26.7 | 27.7 |
| Annual | 55.7 | 57.3 | 69.1 | 69.7 | 42.3 | 44.8 |

[a]Climatic normals for 1951–1980. To convert °F to °C, subtract 32 and divide by 1.8.
*Source:* Gale Research Company 1985.

(2.57 in.) in October to 12.62 cm (4.97 in.) in March at Newport. The summer peak at Gatlinburg is the result of thunderstorm activity that is particularly evident in the mountainous areas. The driest months generally occur in the fall when anticyclonic (high-pressure) systems are most frequent. Average annual snowfall at Gatlinburg is 31 cm (12.2 in.) and 32 cm (12.6 in.) at Newport. Precipitation summaries for Gatlinburg and Newport are given in Table 21.

Information on thunderstorm days and precipitation extremes is available from Knoxville and Asheville. The average number of thunderstorm days per year is 47 at Knoxville and 46 at Asheville, with most thunderstorms coming during the summer months. Maximum precipitation during a single month was 29.82 cm (11.74 in.) at Knoxville and 28.65 cm (11.28 in.) at Asheville, and maximum precipitation during a 24-hour period was 12.90 cm (5.08 in.) at Knoxville and 13.03 cm (5.13 in.) at Asheville. More information on precipitation extremes is given in Table 22.

The nearest long-term records of relative humidity are for Knoxville. Relative humidity in Knoxville averages about 72%, which is about average for the eastern United States. In Asheville, the annual average relative humidity is about 76%. The relative humidity at Asheville is slightly higher because of its higher elevation and corresponding lower air pressure and temperature; the actual amount of water vapor per kilogram of air is about the same at both locations. In general, relative humidity is highest early in the morning, during the coolest hours, and lowest during the afternoon.

**Table 21. Precipitation data for Gatlinburg and Newport, Tennessee (inches)[a]**

| | | | | | Snow | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean monthly | | Maximum monthly | | Mean monthly | | Maximum monthly | |
| Month | Gatlinburg | Newport | Gatlinburg | Newport | Gatlinburg | Newport | Gatlinburg | Newport |
| January | 4.80 | 3.98 | 12.17 | 10.77 | 4.5 | 5.4 | 17.4 | 16.0 |
| February | 4.34 | 3.61 | 9.42 | 8.31 | 3.8 | 3.8 | 16.8 | 13.6 |
| March | 5.81 | 4.97 | 11.32 | 10.82 | 1.5 | 1.1 | 17.4 | 10.0 |
| April | 4.88 | 3.96 | 7.41 | 6.03 | 0.0 | 0.1 | 0.0 | 2.0 |
| May | 4.81 | 4.22 | 8.57 | 8.73 | 0.0 | 0.0 | 0.0 | 0.0 |
| June | 5.60 | 3.81 | 10.97 | 7.81 | 0.0 | 0.0 | 0.0 | 0.0 |
| July | 6.05 | 4.37 | 14.74 | 7.70 | 0.0 | 0.0 | 0.0 | 0.0 |
| August | 5.08 | 3.63 | 12.64 | 8.65 | 0.0 | 0.0 | 0.0 | 0.0 |
| September | 3.93 | 3.20 | 8.80 | 5.99 | 0.0 | 0.0 | 0.0 | 0.0 |
| October | 3.13 | 2.57 | 6.71 | 5.61 | 0.0 | 0.0 | 0.0 | 0.0 |
| November | 4.12 | 3.18 | 8.52 | 5.36 | 0.5 | 0.3 | 3.8 | 3.5 |
| December | 4.38 | 3.48 | 9.24 | 7.85 | 1.9 | 1.9 | 8.7 | 8.8 |
| Annual | 56.93 | 44.88 | 14.74 | 10.82 | 12.2 | 12.6 | 17.4 | 16.0 |

[a]Climatic normals for 1951–1980. One inch = 2.54 cm.
*Source:* Gale Research Company 1985.

**Table 22. Expected precipitation extremes (inches of precipitation) in Sevier County, for selected lengths of time and return periods[a]**

| | Duration | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Return period (years) | Hours | | | | | | Days | | | | |
| | 0.5 | 1 | 2 | 3 | 6 | 12 | 1 | 2 | 4 | 7 | 10 |
| 2 | 1.2 | 1.5 | 1.9 | 2.1 | 2.5 | 2.9 | 3.3 | 3.8 | 4.5 | 5.1 | 5.8 |
| 5 | 1.6 | 1.9 | 2.4 | 2.6 | 3.1 | 3.7 | 4.3 | 5.0 | 5.9 | 6.9 | 7.6 |
| 10 | 1.8 | 2.2 | 2.8 | 3.0 | 3.5 | 4.2 | 4.9 | 5.7 | 6.6 | 7.8 | 8.9 |
| 25 | 2.0 | 2.6 | 3.2 | 3.5 | 4.0 | 4.8 | 5.6 | 6.6 | 7.8 | 9.3 | 10.5 |
| 50 | 2.2 | 2.8 | 3.5 | 3.8 | 4.8 | 5.5 | 6.3 | 7.4 | 9.0 | 10.5 | 11.3 |
| 100 | 2.5 | 3.2 | 3.9 | 4.2 | 5.0 | 5.9 | 6.7 | 8.0 | 9.5 | 11.1 | 12.2 |

Recorded maximum precipitation

| | 24 hours | Monthly |
|---|---|---|
| Knoxville (52-year record) | 5.08 | 11.74 |
| Asheville (25-year record) | 5.13 | 11.28 |

[a]Based on Hershfield (1961) and Miller (1964). 1 in. = 2.54 cm.

Air stagnation is relatively common in eastern Tennessee (about twice as common as in western Tennessee, for example). An average of about two multi-day air stagnation episodes occur annually in eastern Tennessee, to cover an average of about 8 days per year (Korshover 1976, p. 10). August, September, and October are the most likely months for air stagnation episodes (Table 23).

**Table 23. Number of Korshover stagnation episodes, by month, during the 40-year period 1936–1975** (Korshover 1976, pp. 14–19)

| Jan. | Feb. | Mar. | Apr. | May. | Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Number by month** | | | | | | | | | | | |
| 0 | 0 | 0 | 3 | 8 | 8 | 5 | 12 | 9 | 18 | 6 | 1 |
| **Cumulative number by month** | | | | | | | | | | | |
| 0 | 0 | 0 | 3 | 11 | 19 | 24 | 36 | 45 | 63 | 69 | 70 |

Near-surface winds in the region are greatly influenced by local terrain features. Prevailing winds near the surface are often parallel to the nearest ridge. Mountain-valley winds are upslope (moving upward along the valley floor and adjacent slopes) during the day and downslope (opposite of upslope) at night. In some cases, converging ridges can channel the near-surface wind, causing air to converge and leading to a "throttling" effect in which the winds speed up considerably. On rare occasions, such winds have been known to uproot trees in GSMNP.

Prevailing winds aloft are from the west, and these winds interact with the complex pattern of surface air flow to produce different wind patterns at different locations. Near-surface winds at any specific location may not be accurately described by data from a station as near as 5 km (3 miles) away. Therefore the wind patterns from nearby stations such as the Knoxville airport, or even from a single station located on the proposed route of Section 8B, would not indicate the varying wind patterns along the entire route. Further, no records of wind data are available from anywhere along the proposed route. Therefore it is not possible to present a documented summary of the wind patterns along the route of the proposed parkway section.

### 3.5.2 Air Quality and Visibility

National Ambient Air Quality Standards (NAAQS) exist for sulfur dioxide ($SO_2$), nitrogen dioxide ($NO_2$), carbon monoxide (CO), ozone ($O_3$), lead (Pb), and two sizes of particulate matter: particles less than 10 $\mu m$ in diameter (PM-10) and particles less than 2.5 $\mu m$ in diameter (PM-2.5). The NAAQS are expressed as concentrations of the above pollutants that are not to be exceeded in the ambient air—that is, in the outdoor air to which the general public has access [40 CFR 50.1(e)]. Primary NAAQS are designated to protect human health; secondary NAAQS are designated to protect human welfare by safeguarding environmental resources (e.g., soils, water, plants, and animals) and manufactured materials. Primary and secondary NAAQS are presented in Table 24.

**Table 24. Air quality standards[a]**

| Pollutant | Averaging period | National ambient air quality standard | | Allowable increment for prevention of significant deterioration | |
|---|---|---|---|---|---|
| | | Primary | Secondary | Class I | Class II |
| Sulfur dioxide ($SO_2$) | 3-hour[b] | | 1300 | 25 | 512 |
| | 24-hour[b] | 365 | — | 5 | 91 |
| | annual | 80 | — | 2 | 20 |
| Nitrogen dioxide ($NO_2$) | annual | 100 | 100 | 2.5 | 25 |
| Carbon monoxide (CO) | 1-hour[b] | 40,000 | — | — | — |
| | 8-hour[b] | 10,000 | — | — | — |
| Ozone ($O_3$) | 1-hour[c] | 245[d] | 245[d] | — | — |
| | 8-hour[e] | 167[d] | 167[d] | — | — |
| PM-10[f] | 24-hour[g] | 150 | 150 | 8 | 30 |
| | annual[h] | 50 | 50 | 4 | 17 |
| PM-2.5[i] | 24-hour[j] | 65 | 65 | — | — |
| | annual[h] | 15 | 15 | — | — |
| Lead (Pb) | 3-month[k] | 1.5 | 1.5 | — | — |
| Additional state of Tennessee secondary standards for fluorides | | | | | |
| Fluorides (HF)[l] | 30-day[b] | 1.2 | | | |
| | 7-day[b] | 1.6 | | | |
| | 24-hour[b] | 2.9 | | | |
| | 12-hour[b] | 3.7 | | | |
| Additional state of North Carolina standards | | | | | |
| Total suspended particles (TSP) | annual | 75[m] | — | — | — |
| | 24-hour | 150[b] | — | — | — |

[a]All concentrations are in units of micrograms per cubic meter.
[b]Not to be exceeded more than once per year.
[c]Not to be exceeded more than 1 day per year on the average over 3 years.
[d]These figures include the allowance for rounding off the measured values, as per EPA (1979) and 40 CFR 50, Appendix I.
[e]The 8-hour standard will apply when sufficient data are available to determine attainment status; technically, the 1-hour standard is no longer applicable, as of June 5, 1998 (*Fed. Reg.* 63 31014).
[f]Particulate matter less than or equal to 10 μm in diameter.
[g]Within 3 years, the standard will apply to a 3-year average of annual 4th-highest daily values.
[h]A 3-year average of the annual means.
[i]Particulate matter less than or equal to 2.5 μm in diameter.
[j]The 3-year average of annual 8th-highest daily values.
[k]Calendar quarter.
[l]Gaseous fluorides expressed as HF.
[m]Geometric mean.

In addition to these standards, Tennessee has adopted secondary standards for gaseous fluorides expressed as hydrogen fluoride (HF), and North Carolina has general standards for total suspended particulate matter (TSP). These standards are also summarized in Table 24.

In addition to ambient air quality standards, which represent an upper bound on allowable pollutant concentrations, standards exist for the prevention of significant deterioration (PSD) of air quality. The PSD standards differ from the NAAQS in that the NAAQS provide maximum allowable *concentrations* of pollutants, while PSD requirements provide maximum allowable *increases in concentrations* of pollutants for areas already in compliance with the NAAQS. PSD standards are therefore expressed as allowable *increments* in the atmospheric concentrations of specific pollutants. Allowable PSD increments currently exist for three pollutants, $NO_2$, $SO_2$, and PM-10. PSD increments are particularly relevant when a major proposed action (involving a new source or a major modification to an existing source) may degrade air quality without exceeding the NAAQS, as would be the case, for example, in an area where the ambient air is very clean.

Allowable PSD increments are given in Table 24. One set of allowable increments exists for Class II areas, which cover most of the United States, and a much more stringent set of allowable increments exists for Class I areas, which are specifically designated areas where the degradation of ambient air quality is to be severely restricted. Class I areas include many national parks and monuments, wilderness areas, and other areas as specified in 40 CFR 51.166. The nearest Class I area is GSMNP. The northern boundary of GSMNP is almost adjacent to the proposed ROW just west of Rocky Grove.

Sevier and Cocke Counties are in attainment of all federal and state air quality standards (40 CFR 81:334 and 343). Surrounding counties in Tennessee and North Carolina are also in attainment of all state and national standards. Knox County was in marginal nonattainment of the ozone standard from January 6, 1992, until October 27, 1993 (40 CFR 81:343). That nonattainment classification was based on exceedances during 1988 at the Rutledge Pike monitoring station, located in the eastern part of Knoxville, about 56 km (35 miles) west-northwest of the midpoint of the proposed parkway section.

Existing air quality data from the GSMNP and surrounding stations are summarized in Table 25. Ozone is monitored in and near the Park; $SO_2$ and PM-10 are monitored near the Aluminum Company of America (Alcoa) Aluminum Plant (the nearest major source of these pollutants); CO is produced and monitored primarily in urban areas; and lead and $NO_2$ are only monitored at a few distant locations because of their low background levels in eastern Tennessee and western North Carolina.

Because of the reduction in the use of leaded gasolines, ambient air concentrations of lead have diminished markedly in recent years. The major sources of air pollutants near the proposed ROW are to the west. The Alcoa plant in the city of Alcoa is about 56 km (35 miles) from the midpoint of the proposed parkway section. McGhee-Tyson Airport is about 58 km (36 miles) distant in almost the same direction. Bull Run Steam Plant is roughly 80 km (50 miles) west-northwest of Section 8B. As noted above, the eastern part of Knoxville is about 56 km (35 miles) to the west-northwest of the midpoint of the ROW. Major pollutants from these sources that are most likely to adversely affect GSMNP include $SO_2$, oxides of nitrogen ($NO_x$) (the collective term for NO and

**Table 25. Air quality monitoring data[a]**

| Pollutant | Monitoring location[b] | Year | Averaging period | Highest concentration | NAAQS | Highest concentration as a percentage of NAAQS |
|---|---|---|---|---|---|---|
| Sulfur dioxide ($SO_2$) | Alcoa, Tenn. | 1992 | 3-hour | 382 | 1300 | 29 |
| | | 1993 | 3-hour | 504 | 1300 | 39 |
| | | 1994 | 3-hour | 339 | 1300 | 26 |
| | | 1995 | 3-hour | 364 | 1300 | 28 |
| | | 1996 | 3-hour | 343 | 1300 | 26 |
| | | 1992 | 24-hour | 149 | 365 | 41 |
| | | 1993 | 24-hour | 178 | 365 | 49 |
| | | 1994 | 24-hour | 156 | 365 | 43 |
| | | 1995 | 24-hour | 140 | 365 | 38 |
| | | 1996 | 24-hour | 194 | 365 | 53 |
| | | 1992 | annual | 25 | 80 | 31 |
| | | 1993 | annual | 25 | 80 | 31 |
| | | 1994 | annual | 25 | 80 | 31 |
| | | 1995 | annual | 27 | 80 | 34 |
| | | 1996 | annual | 24 | 80 | 30 |
| Nitrogen dioxide ($NO_2$) | McMinn County, Tenn. | 1992 | annual | 24 | 100 | 24 |
| | | 1993 | annual | 28 | 100 | 28 |
| | | 1994 | annual | 26 | 100 | 26 |
| | | 1995 | annual | 24 | 100 | 24 |
| | | 1996 | annual | 26 | 100 | 26 |
| | Sullivan County, Tenn. | 1992 | annual | 34 | 100 | 34 |
| | | 1993 | annual | 32 | 100 | 32 |
| | | 1994 | annual | 32 | 100 | 32 |
| | | 1995 | annual | 34 | 100 | 34 |
| | | 1996 | annual | 34 | 100 | 34 |
| Carbon monoxide (CO) | Knoxville, Tenn. | 1992 | 1-hour | 10,350 | 40,000 | 26 |
| | | 1993 | 1-hour | 12,075 | 40,000 | 30 |
| | | 1994 | 1-hour | 8,280 | 40,000 | 21 |
| | | 1995 | 1-hour | 8,625 | 40,000 | 22 |
| | | 1996 | 1-hour | 6,210 | 40,000 | 16 |
| | | 1992 | 8-hour | 6,210 | 10,000 | 62 |
| | | 1993 | 8-hour | 6,095 | 10,000 | 61 |
| | | 1994 | 8-hour | 5,520 | 10,000 | 55 |
| | | 1995 | 8-hour | 5,060 | 10,000 | 51 |
| | | 1996 | 8-hour | 4,600 | 10,000 | 46 |
| | Kingsport, Tenn. | 1992 | 1-hour | 7,820 | 40,000 | 20 |
| | | 1993 | 1-hour | 8,625 | 40,000 | 22 |
| | | 1994 | 1-hour | 6,785 | 40,000 | 17 |
| | | 1995 | 1-hour | 6,900 | 40,000 | 17 |
| | | 1996 | 1-hour | 6,210 | 40,000 | 16 |
| | | 1992 | 8-hour | 4,485 | 10,000 | 45 |
| | | 1993 | 8-hour | 8,165 | 10,000 | 82 |
| | | 1994 | 8-hour | 4,485 | 10,000 | 45 |
| | | 1995 | 8-hour | 3,910 | 10,000 | 39 |
| | | 1996 | 8-hour | 3,910 | 10,000 | 39 |

**Table 25. continued**

| Pollutant | Monitoring location[b] | Year | Averaging period | Highest concentration | NAAQS | Highest concentration as a percentage of NAAQS |
|---|---|---|---|---|---|---|
| Ozone ($O_3$) | Look Rock GSMNP, Tenn. (Blount Co.) | 1992 | 1-hour | 192 | 245[c] | 82 |
| | | 1993 | 1-hour | 210 | 245[c] | 89 |
| | | 1994 | 1-hour | 227 | 245[c] | 97 |
| | | 1995 | 1-hour | 241 | 245[c] | 103 |
| | | 1996 | 1-hour | 208 | 245[c] | 89 |
| | | — | 8-hour[d] | — | 167[c] | 157 |
| | Cove Mountain GSMNP, Tenn. (Sevier Co.) | 1992 | 1-hour | 174 | 245[c] | 74 |
| | | 1993 | 1-hour | 221 | 245[c] | 94 |
| | | 1994 | 1-hour | 235 | 245[c] | 100 |
| | | 1995 | 1-hour | 231 | 245[c] | 98 |
| | | 1996 | 1-hour | 218 | 245[c] | 93 |
| | | 1992 | 8-hour | 165 | 167[c] | 99[e] |
| | | 1993 | 8-hour | 174 | 167[c] | 104[e] |
| | | 1994 | 8-hour | 172 | 167[c] | 103 |
| | | 1995 | 8-hour | 182 | 167[c] | 109 |
| | | 1996 | 8-hour | 180 | 167[c] | 108 |
| | Clingman's Dome, GSMNP | 1993 | 1-hour | 161 | 245[c] | 69 |
| | | 1994 | 1-hour | 200 | 245[c] | 85 |
| | | 1995 | 1-hour | 210 | 245[c] | 89 |
| | | 1996 | 1-hour | 208 | 245[c] | 89 |
| | | — | 8-hour[d] | — | 167[c] | — |
| Particulate matter (PM-10)[f] | Maryville, Tenn. | 1992 | 24-hour | 51 | 150 | 34 |
| | | 1993 | 24-hour | 63 | 150 | 42 |
| | | 1994 | 24-hour | 38 | 150 | 25 |
| | | 1995 | 24-hour | 51 | 150 | 34 |
| | | 1996 | 24-hour | 46 | 150 | 31 |
| | | 1992 | annual | 25 | 50 | 50 |
| | | 1993 | annual | 23 | 50 | 46 |
| | | 1994 | annual | 22 | 50 | 44 |
| | | 1995 | annual | 24 | 50 | 48 |
| | | 1996 | annual | 22 | 40 | 44 |
| | Asheville, N.C. | 1992 | 24-hour | 41 | 150 | 27 |
| | | 1993 | 24-hour | 56 | 150 | 37 |
| | | 1994 | 24-hour | 34 | 150 | 23 |
| | | 1995 | 24-hour | 41 | 150 | 27 |
| | | 1996 | 24-hour | 44 | 150 | 29 |
| | | 1992 | annual | 23 | 50 | 46 |
| | | 1993 | annual | 22 | 50 | 44 |
| | | 1994 | annual | 19 | 50 | 38 |
| | | 1995 | annual | 18 | 50 | 36 |
| | | 1996 | annual | 19 | 50 | 38 |

**Table 25. continued**

| Pollutant | Monitoring location[b] | Year | Averaging period | Highest concentration | NAAQS | Highest concentration as a percentage of NAAQS |
|---|---|---|---|---|---|---|
| Particulate matter | | — | 24-hour | — | 65 | — |
| (PM-2.5)[g] | | — | annual | — | 15 | — |
| Total suspended particles (TSP)[h] | Asheville, N.C. | 1992 | 24-hour | 63 | 150 | 42 |
| | | 1993 | 24-hour | 85 | 150 | 57 |
| | | 1994 | 24-hour | 67 | 150 | 45 |
| | | 1995 | 24-hour | 58 | 150 | 39 |
| | | 1996 | 24-hour | 82 | 150 | 55 |
| | | 1992 | annual[i] | 27 | 75 | 36 |
| | | 1993 | annual[i] | 30 | 75 | 40 |
| | | 1994 | annual[i] | 30 | 75 | 40 |
| | | 1995 | annual[i] | 30 | 75 | 40 |
| | | 1996 | annual[i] | 36 | 75 | 48 |
| Lead (Pb) | Nashville, Tenn. | 1992 | 3-month[j] | 0.11 | 1.5 | 7 |
| | | 1993 | 3-month[j] | 0.10 | 1.5 | 7 |
| | | 1994 | 3-month[j] | 0.08 | 1.5 | 5 |
| | | 1995 | 3-month[j] | 0.08 | 1.5 | 5 |
| | | 1996 | 3-month[j] | 0.07 | 1.5 | 5 |

[a]Units are micrograms per cubic meter.

[b]For monitoring stations not located in GSMNP, approximate distances and directions from Webb Mountain (which is located about midway along the proposed parkway route) are as follows: Alcoa and Maryville, Tenn., 37 mi. W; McMinn Co., Tenn., 70 mi. SW; Kingsport, Tenn., 65 mi. NE; Knoxville, Tenn., 35 mi. WNW; Nashville, Tenn., 200 mi. W; Asheville, N.C., 45 mi. ESE.

[c]These figures include the allowance for rounding off the measured values, as per EPA (1979) and 40 CFR 50, Appendix I.

[d]The 8-hour standard will apply when sufficient data are available to determine attainment status; technically, the 1-hour standard is no longer applicable, as of June 5, 1998 (*Fed. Reg.* 63 31014).

[e]The EPA data completeness requirement for 3-year averages was not met.

[f]Particles less than or equal to 10 μm in diameter.

[g]Particles less than or equal to 2.5 μm in diameter. These standards were recently added to the NAAQS; sufficient monitoring data are not yet available for comparison of this size of particulate matter with standards.

[h]Regulated by North Carolina; standards are state standards (not NAAQS).

[i]Geometric mean.

[j]Calendar quarter.

$NO_2$), and hydrocarbons. $SO_2$ can oxidize to form sulfate particles, which impair visibility; $SO_2$ and $NO_x$ are precursors of acid precipitation; $NO_x$ and hydrocarbons are precursors of ozone.

### 3.5.3 Potential Effects of Pollutants on Resources at GSMNP

#### 3.5.3.1 Visibility

Many pollutants contribute to visibility reductions, although $SO_2$ (which oxidizes to form sulfate particles) is the primary source of concern at GSMNP. Unfortunately, no consistent historical quantitative data base exists for visibility in GSMNP (Reisinger and Valente 1985). Estimates of background visual range since 1980 have been obtained from nephelometer measurements at Look

Rock, about 40 km (25 miles) west-southwest of Gatlinburg. These estimates were summarized on a seasonal basis through 1983 by Reisinger and Valente (1985), who found that *geometric* averages of visual range varied from about 19 km (12 miles) in summer to about 72 km (45 miles) in spring, with the annual (geometric) average being about 53 km (33 miles). More recently, Shaver, Tonnessen, and Maniero (1994) have indicated that the annual *median* is now closer to 39 km (24 miles), suggesting a decline from the earlier (early 1980s) value. However, the more recent figures suggest that the typical (median) summer visibility is still around 19 km (12 miles) (Shaver, Tonnessen, and Maniero 1994). Note that the statistics used to summarize visibility often vary from one study to the next (e.g., geometric mean is used one time and median the next, as above), so that the documentation and quantification of visibility trends remains difficult.

There are six integral vista observation points in GSMNP. These are relatively high elevation locations from which distant scenic objects can be viewed over a wide range of directions. These observation points and their distances from the proposed parkway section are listed in Table 26.

**Table 26. Integral vista observation points of the Great Smoky Mountains National Park**

| Observation point | Approximate distance and direction from Webb Mountain[a] |
|---|---|
| Mount Cammerer Tower | 18 km (11 miles) E |
| Mount Sterling Tower | 23 km (14 miles) E |
| Newfound Gap | 21 km (13 miles) SSE |
| Clingman's Dome Tower | 29 km (18 miles) SSE |
| Cove Mountain Tower | 26 km (16 miles) WSW |
| Look Rock Tower | 56 km (35 miles) WSW |

[a]Webb Mountain is a convenient reference point, located about midway along the route of proposed Section 8B.

### 3.5.3.2 Acid Precipitation

Acid precipitation is associated mainly with $SO_2$ and $NO_x$. The acidity of precipitation is measured on the pH scale, in which lower numbers indicate more acidic compounds. Natural precipitation has a pH of about 5.6. The pH of precipitation in GSMNP averages about 4.4, while the lowest in North America is about 4.15 in western New York and northwestern Pennsylvania. Acid precipitation has been associated with a reduction in frost-hardiness in high-elevation red spruce in the northeastern United States, and there is some evidence that the same phenomenon may be occurring in the southeastern United States (NAPAP 1991).

### 3.5.3.3 Ozone

Ozone is formed when an ordinary oxygen molecule ($O_2$) combines with a single oxygen atom (O). Single oxygen atoms are formed when ultraviolet radiation breaks the molecular bonds

between two oxygen atoms, which may be joined together simply ($O_2$) or associated with other elements (e.g., in $NO_2$). The separation of $O_2$ molecules takes place primarily in the stratosphere [the layer of the atmosphere from about 13 to 48 km (8 to 30 miles) above the earth's surface].

Most of the sun's radiation that penetrates below the stratosphere is in wave lengths that are too long to break the $O_2$ molecule into single atoms. However, the waves are still short enough to separate single oxygen atoms from $NO_2$, and these atoms subsequently combine with $O_2$ to form $O_3$. Formation of $NO_2$ in the troposphere (the layer of air between the earth's surface and the stratosphere) may be due to natural phenomena (e.g., lightning), or to human activities (e.g., burning fossil fuels). Natural processes and human activities also produce hydrocarbons, which can act to inhibit ozone destruction and to promote the formation of $NO_2$ from nitric oxide (NO). Thus, $NO_x$ and hydrocarbons react (sometimes in complex ways) to account for most of the ozone produced in the troposphere.

An important mechanism for ozone destruction is deposition at the earth's surface (e.g., on plants, soil, and certain manufactured materials) where it reacts with other chemicals, often causing damage. Because a significant amount of ozone destruction occurs at the earth's surface, ozone concentrations tend to be lower in the air near the surface than in the overlying air unless mechanisms are present to replenish the ozone near the surface. Sunlight is an important mechanism to replenish near-surface ozone because it is a required catalyst in ozone formation and because it heats the earth's surface and the near-surface atmosphere. The warm air rises from the surface and cooler overlying air sinks to replace it, resulting in vertical mixing that brings ozone-rich air from aloft to near the surface. Most of this vertical mixing takes place in the lower troposphere, within about 2.4 km (1.5 miles) of the surface.

The troposphere receives ozone from the lower stratosphere, where ozone is abundant and is occasionally transported downward by vertical motions known as stratospheric intrusions and by further mixing in the troposphere. Those natural processes are augmented by another mechanism for ozone enrichment of the troposphere, in which vertical mixing transports ozone-rich air from aloft to urban areas with high levels of ozone production, where the air becomes even further enriched before rising again.

During the daylight hours, especially in urban areas, there is often a pronounced peak in ozone concentrations because of the transport of ozone-rich air from aloft into a region of ozone production where further ozone-enrichment takes place. At night, sunlight is not present to (1) act as a catalyst in ozone formation and (2) induce vertical mixing of the atmosphere by heating the earth's surface. Therefore, ozone deposited on surface materials at night is not replenished. The absence of vertical mixing at night may also cause substances originating at the surface to tend to remain there, so that substances with which ozone reacts (e.g., terpenes) sometimes accumulate in the near-surface air during the night, resulting in further depletion of atmospheric ozone. The result is a tendency for atmospheric ozone concentrations to be greatly reduced during the night and early morning hours at low-elevation sites.

The situation is different at exposed high-elevation sites, where ozone-rich air does not have to be transported downward to reach the surface. Exposed high-elevation sites tend to have high levels of surface-air ozone concentrations during all hours of the day and night. The result is that daily

and longer-term average ozone values are often higher at exposed locations within the GSMNP than at lower-elevation sites in the Tennessee Valley.

Several plant species in the park show varying degrees of evidence of ozone sensitivity. There appears to be a correlation between elevation, ozone concentration, and visible tree injury among certain species, notably black cherry (*Prunus serotina*), and sassafras (*Sassafras albidum*). Visible ozone injury on native plant species within the park has been reported by Chappelka, Renfro, and Somers (1994). More information about vegetation responses to air pollutants in GSMNP is provided in Sect. 4.4.1.5.

#### 3.5.3.4 Regulated Pollutants of Lesser Concern at GSMNP

In addition to PM-10, $SO_2$, $NO_2$, and $O_3$, pollutants regulated by NAAQS or by Tennessee or North Carolina include lead, CO, fluorides, and TSP. No major sources of atmospheric lead have been identified close to the proposed parkway. The nearest sources of CO are Knoxville, about 56 km (35 miles) west-northwest of Webb Mountain; Maryville and Alcoa, about the same distance west of Webb Mountain; and the Sevierville-Gatlinburg strip of U.S. 441 that runs about 19 km (12 miles) west of Webb Mountain and intersects the proposed parkway about 11 km (7 miles) west of the western end of Section 8B. (Webb Mountain is a convenient reference point, being located about midway along the route of proposed parkway section.) Since 1989, CO concentrations in the metropolitan areas near GSMNP have not exceeded two-thirds of the NAAQS, and no resources within the park currently appear to be threatened by atmospheric CO.

The Tennessee secondary standards for fluorides arise primarily from work that was carried out at the Oak Ridge Gaseous Diffusion Plant (now the East Tennessee Technology Park), southwest of the city of Oak Ridge and about 97 km (60 miles) west of Webb Mountain. That plant ceased operation several years ago, and the stored supply of chlorofluorocarbon (CFC-114) has been transferred to other gaseous diffusion plants at Paducah, Kentucky, and Portsmouth, Ohio. As recently as 1993, more than 5000 cylinders containing uranium hexafluoride ($UF_6$) were stored at the East Tennessee Technology Park.

Concentrations of TSP in the area around GSMNP seldom exceed 50% of the North Carolina standards and are not considered a threat to vegetation. Visibility reductions arise primarily from particles less than about 2.5 $\mu$m in diameter. As noted above, sulfates are the particles of major concern regarding visibility in GSMNP.

## 3.6 EXISTING SOCIOECONOMIC CONDITIONS

### 3.6.1 Introduction

Socioeconomic impact analysis begins by defining the impact region—that area where project-related effects are expected to be most intense. For the proposed Foothills Parkway project, the impact region consists of the area where most inmoving construction workers would locate and where most operations-related traffic, land-use changes, economic impacts, and associated effects would occur.

Section 8B is located approximately 80 km (50 miles) southeast of Knoxville, Tennessee, and 400 km (250 miles) northeast of Atlanta, Georgia. During the construction period, when the socioeconomic impacts generated by a small work force are expected to be minor, the impact area would include most of Sevier and Cocke Counties—the two Tennessee counties in which Section 8B is located (Fig. 44). During the operations period, when increased tourist visits to the area could occur, impacts are likely to be more intense but are expected to be largely confined to southeastern Sevier County and the southwest corner of Cocke County. Specifically, Pittman Center—at or near the proposed western terminus of Section 8B—and, to a lesser extent, Cosby—at the eastern terminus of Section 8B—are likely to bear the largest share of any parkway-induced impacts (Fig. 45).

Existing conditions for each important socioeconomic subject area are discussed below. Each of the following sections will provide some information on Cocke and Sevier Counties as a whole and on the towns of Gatlinburg and Pigeon Forge, which are located near the western terminus of Foothills Parkway Section 8C—the section immediately to the west of Section 8B. However, this report will focus most closely on Pittman Center and Cosby because their small size, rural nature, and location at either end of Section 8B make them most susceptible to potential impacts. The towns of Newport (the county seat and largest municipality of Cocke County) and Sevierville (Sevier County's seat and largest municipality) are described briefly in the population section, but a further discussion of these towns is unnecessary because they are not likely to be affected to any significant extent by the parkway project.

### 3.6.2 Population

#### 3.6.2.1 Current Population

The current populations of Sevier and Cocke Counties and their largest towns are presented in Table 27. While population growth in Cocke County was moderate between 1960 and 1980, the rate of population expansion decreased to almost zero between 1980 and 1990. Since 1990, however, this trend seems to have been reversed; population grew by almost 6% between 1990 and 1994. Cocke County's average 1994 population density was 69.5 persons per square mile. The population of Newport—Cocke County's largest city—actually declined during the 1980s; more recent data are not yet available to show whether this pattern has held since 1990. Cosby is an unincorporated town in southeastern Cocke County, whose approximate borders enclose an area south of Cosby Creek and west of the ridges traversed by Foothills Parkway Section 8A. This area, referred to by longtime residents as Lower Cosby, had a population of roughly 1200 in 1990. Although more recent population numbers are not available, local officials report that the Cosby area is the fastest growing part of Cocke County (J. Grooms, executive director of the Cocke County Economic Development Commission, personal communication with M. Schweitzer, ORNL, January 11 and May 9, 1995; F. James, Attendance Supervisor, Cocke County School System, personal communication with M. Schweitzer, ORNL, May 9 and 10, 1995).

Sevier County, which has experienced substantial tourism-related growth and development in recent decades, has grown at a significantly greater rate than Cocke County. Sevier County's most rapid population growth occurred between 1970 and 1980. The rate of increase slowed during the 1980s but has picked up again since 1990. The average 1994 population density in Sevier County was 97.3 persons per square mile. Gatlinburg and Pittman Center both grew substantially in the

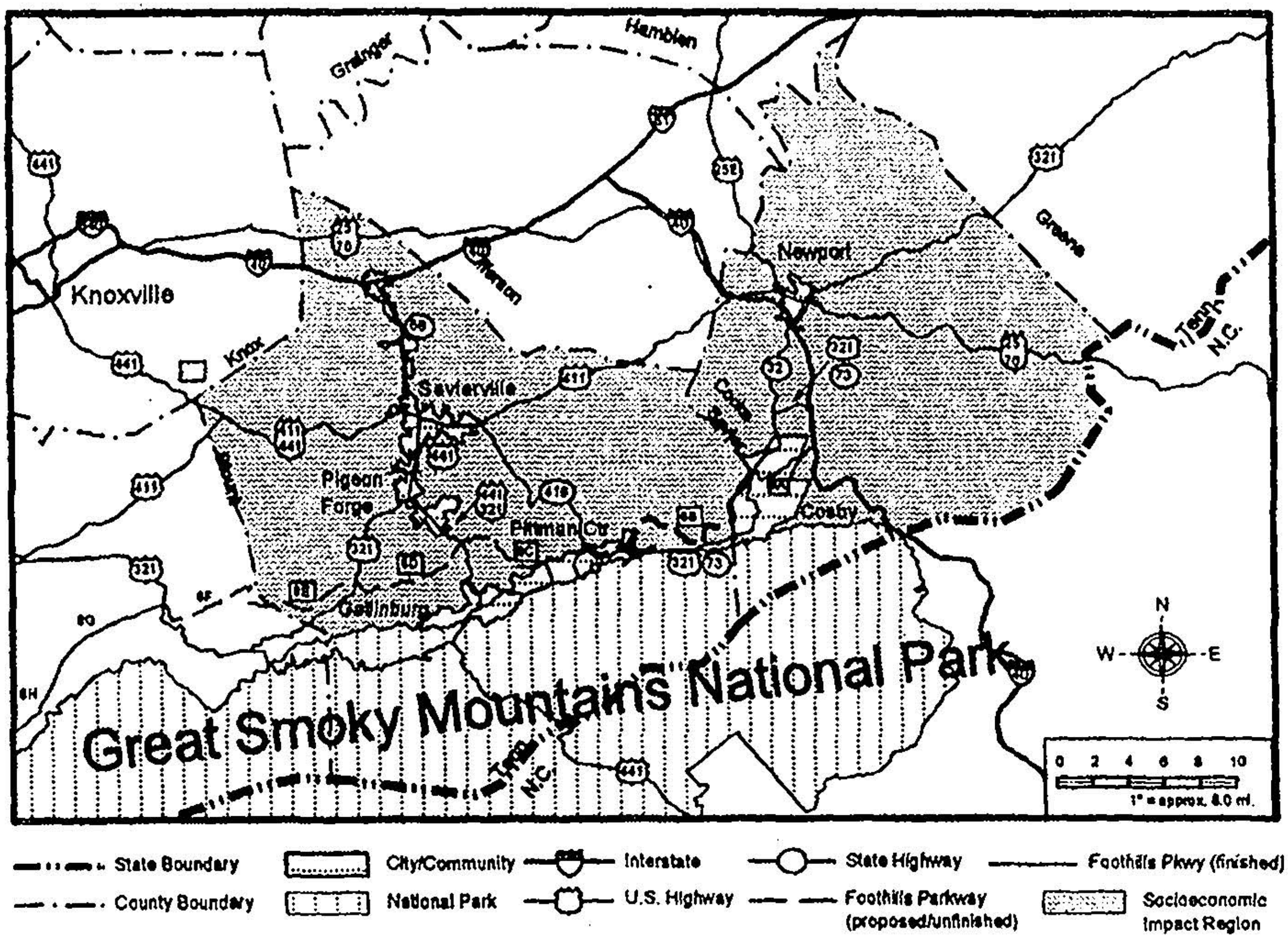



Fig. 44. Socioeconomic impact region, Foothills Parkway Section 8B.

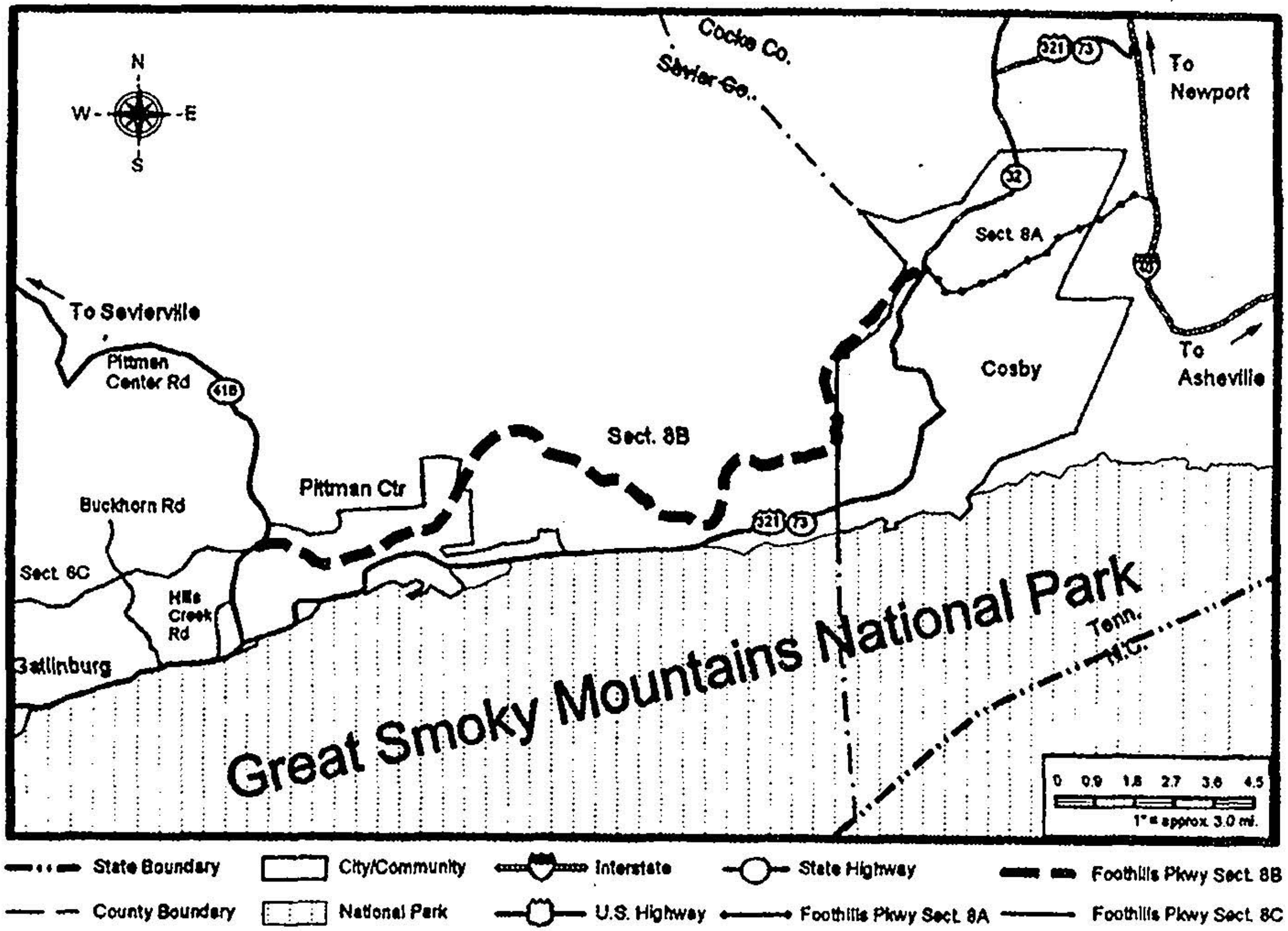



**Fig. 45. Foothills Parkway Section 8B and immediate vicinity.**

**Table 27. Population in the area of Foothills Parkway Section 8B**

| | 1960 population | 1970 population | 1980 population | 1990 population | 1994 population | Percent change 1960–70 | Percent change 1970–80 | Percent change 1980–90 | Percent change 1990–94 |
|---|---|---|---|---|---|---|---|---|---|
| **Sevier County** | 24,251 | 28,241 | 41,418 | 51,043 | 58,184 | 16.5 | 46.7 | 23.2 | 14.0 |
| Gatlinburg | 1,764 | 2,329 | 3,500 | 3,417 | NA | 32.0 | 50.3 | −2.4 | NA |
| Pigeon Forge | NA | 1,361 | 1,822 | 3,027 | NA | NA | 33.9 | 66.1 | NA |
| Pittman Center | NA | 315 | 488 | 478 | NA | NA | 54.9 | −2.0 | NA |
| Sevierville | 2,890 | 2,661 | 5,444 | 7,178 | NA | −7.9 | 104.6 | 31.9 | NA |
| **Cocke County** | 23,390 | 25,283 | 28,792 | 29,141 | 30,801 | 8.1 | 13.9 | 1.2 | 5.7 |
| Cosby | NA | NA | NA | 1,220 | NA | NA | NA | NA | NA |
| Newport | 6,448 | 7,328 | 7,580 | 7,123 | NA | 13.6 | 3.4 | −6.0 | NA |

NA= not available

*Source:* Vickers (1993); U.S. Bureau of the Census 1991, 1995; *Land Use Plan: Pittman Center, Tennessee* (1987).

1970s but experienced slight population declines during the 1980s. Pigeon Forge and Sevierville also grew rapidly during the 1970s, and their growth continued in the 1980s. Sevierville, which more than doubled in population between 1970 and 1980, was the county's most rapidly growing municipality during that decade. Pigeon Forge led the county's population growth in the 1980s, increasing its number of residents by approximately two-thirds. Although updated population figures are not available for the county's municipalities, a recent count of new residences based on the 911 emergency system indicates that Sevierville and Pigeon Forge continue to grow rapidly and that Gatlinburg and Pittman Center have also shared in the county's most recent expansion (*The Mountain Press*, February 14, 1995).

In 1994, more than 300 new residences were built in Pigeon Forge and about 220 new dwelling units were added in Sevierville. In Gatlinburg, about 50 new residences were added and Pittman Center, despite its small size, was the site of nearly 40 new dwellings.

Both Sevier and Cocke Counties are much more racially homogeneous than the state as a whole. As shown in Table 28, 16% of the state's population is black, while blacks represent only 2.1% of Cocke County's and 0.4% of Sevier County's residents. In each county, the proportion of the population under 18 is sightly less than the statewide figure. And while the relative size of the under-18 population has declined throughout the state since 1980, it has fallen more rapidly in Cocke and Sevier Counties than in the state as a whole. In contrast, the proportion of the Sevier and Cocke County populations that is 65 or over is slightly greater than for the state as a whole; this population has increased faster in these two counties than it has statewide, probably partly because of the inmigration of retirees. Of all births in Sevier County, 17.2% involve mothers under 20 years of age, the same as for the state as a whole. In Cocke County, a much higher proportion of all births (23.0%) are to women under 20. The final column in Table 28 shows that about half of Cocke County's adult population has graduated from high school, compared with about two-thirds of the population statewide. The proportion of high school graduates in Sevier County is substantially higher than in Cocke County, but still slightly below the state figure.

**Table 28. Key demographic features of Cocke County, Sevier County, and Tennessee**

| | Percentage white (1990) | Percentage black (1990) | Percentage under 18 (1990) | Percentage 65 and over (1994) | Percentage of births to mothers under 20 (1988) | Percentage of high school graduates[a] (1990) |
|---|---|---|---|---|---|---|
| Sevier County | 98.9 | 0.4 | 24.0 | 12.9 | 17.2 | 63.0 |
| Cocke County | 97.5 | 2.1 | 23.9 | 13.3 | 23.0 | 50.4 |
| Tennessee | 83.0 | 16.0 | 24.9 | 12.6 | 17.2 | 67.1 |

[a]Percentage of the population aged 25 and over receiving at least an high school diploma.
*Source:* U.S. Bureau of the Census (1995); *County and City Data Book 1994* (1994).

### 3.6.2.2 Population Projections

Sevier County and its three largest towns can expect continued population growth as a result of ongoing tourism-related development and the continued inmigration of retirees. The population of

Sevier County in 2005—the projected completion date for Section 8B—is expected to be somewhere between 60,000 and 70,000. The U.S. Bureau of Economic Analysis projected in 1992 that the county's population would be 59,700 in 2005 (U.S. Department of Commerce 1992), an increase of only 17% over the number of residents in 1990. Based on the growth that has already occurred during the current decade, this projection appears to be very low. In contrast, state projections made at approximately the same time envisioned a 2005 population of 68,942 (Hastings 1992), representing a growth rate of 35% for the 15-year period beginning in 1990. The state figure was projected by considering age-specific population trends and adjusting these figures according to fertility and mortality rates. Pittman Center probably will not grow as rapidly as the county as a whole, because it is not at the center of recent tourism-related development and it plans to limit commercial growth in order to maintain its more traditional mountain character (see Sect. 3.6.5.2.).

True to past trends, Cocke County is expected to grow much more slowly than Sevier County. The U.S. Bureau of Economic Analysis projected that Cocke County would have 31,400 residents in 2005 (U.S. Department of Commerce 1992), an increase of less than 8% over its 1990 population. State projections were that the county's population would be 29,096 in 2005 (Hastings 1992), a loss of 45 residents over the 15-year period. Based on the observed rate of growth between 1990 and 1994, both of these projections seem unrealistically low. Population projections are not available for Cosby because the town is not incorporated and is not directly served by any planning agency. However, much of the county's recent growth has been concentrated in the Cosby area, and this trend is likely to continue because of the demand for homes in the vicinity of the GSMNP. A major attraction of this area seems to be its natural beauty and relatively undeveloped nature.

### 3.6.3 Housing

Housing in Sevier and Cocke Counties consists mainly of single-family, owner-occupied structures. General housing information is provided in Table 29. In Sevier County, the number of housing units increased by 45.5% from 1980 to 1990. Housing in Gatlinburg grew at about the same rate, while the number of units in Pigeon Forge increased more rapidly than the countywide average. Pittman Center had 291 housing units in 1990, approximately 80% of them single-family structures, but the historic growth rate for the town is unavailable. A small part of the residential/ recreational development known as Cobbly Nob is located in Pittman Center, but most of that community—including nearly all its housing units—lies to the east of Pittman Center. In addition to its golf courses, Cobbly Nob contains both year-round residences and vacation rental units. This area contains nearly 100 condominium units in two separate complexes and approximately 570 lots. There currently are 245 houses in Cobbly Nob and another 75 lots have been set aside by the Cobbly Nob Property Owners Association as open space. This leaves about 280 undeveloped lots, a few of which are probably unsuitable for building due to slope or soil conditions (J. Dean, Executive Secretary, Cobbly Nob Property Owners Association, personal communication with M. Schweitzer, ORNL, July 23, 1997).

In contrast with the rapid growth in Sevier County, the number of housing units in Cocke County grew by only 8.9% during the 1980s. This is about half the statewide growth rate of 16.6% for the same period. Cosby had 576 housing units in 1990, about 70% of them single-family structures. Cosby's housing growth rate is unavailable.

Housing in Cocke County, with a 1990 median value of $44,878, is considerably less expensive than in Sevier County, where the 1990 median value was $72,183 (Table 29). Monthly rents are similar in the two counties, with Cocke County having a median rent of $320 compared with $347 in Sevier County (U.S. Bureau of the Census 1991). Multifamily rental complexes are relatively scarce and, as a result, rents are beginning to rise in Sevier County; rents of $400 to $500 a month are becoming increasingly common. Rental housing is especially hard to find for those families with low incomes and seasonal employment. Currently, Sevier County has about 15 apartment complexes, but vacancies typically do not last more than a week, and some complexes go years without a vacancy. Rent-subsidized housing also fails to meet the high demand, even though Ridgewood Village in Pigeon Forge recently made available 100 rent-subsidized apartments and a 50-unit senior housing complex was recently completed in Sevierville. Despite these new developments, there is still a shortage of apartments and low- to moderate-income housing in Sevier County (J. Wagner, City Planner, Sevierville, Tennessee, Planning Office, personal communication with M. Schweitzer, ORNL, October 9, 1996).

Table 30 lists the types and numbers of vacant housing units in Sevier and Cocke Counties. In Sevier County, approximately half the vacant units are held for seasonal, recreational, or occasional use. Cocke County also has a sizable number of housing units in this category (about one-fourth of all vacancies), but the largest number of vacant units in Cocke County fall into the "other" category, which includes abandoned and dilapidated units.

The demand for new houses is overwhelming home builders in Sevier County; as a result, they have to refer or turn away more business than in the past. Part of the county's rapid growth is a result of demand for overnight rentals. Many of these new homes are being built outside the cities of Gatlinburg, Pigeon Forge, and Sevierville. According to the Sevier County Electric System, 644 more housing units were added outside these cities than within their city limits in 1993 (*The Mountain Press*, July 21, 1994).

### 3.6.4 Public Services

#### 3.6.4.1 Education

The Sevier County school system comprises 14 elementary/middle schools, three high schools, one vocational center, one special learning center, and an adult high school. All Sevier County public schools are accredited by the Southern Association of Colleges and Schools, a standard more rigorous than state standards (*Everything You Always Wanted to Know about Sevier County* 1994). The schools are not zoned, so students may attend their school of choice; but bus service is only provided to and from the school closest to a student's residence.

There are two public schools in the Pittman Center area: Gatlinburg-Pittman High School, which serves grades 9–12, and Pittman Center Elementary School, which serves grades K–8. Gatlinburg-Pittman has an enrollment of 673 students and Pittman Center Elementary enrolls 222 (D. Waskoviak, Sevier County School System, personal communication with M. Schweitzer, ORNL, May 9, 1995). Over the past 10 years, enrollment at both schools has increased by about 45% (C. Elder, Director of Vocational Education, Sevier County School System, personal communication with M. Schweitzer, ORNL, May 9, 1995). Current student-teacher ratios at Pittman Center Elementary are 20:1 for K–3, 21:1 for grades 4–6, and 28:1 for grades 7–8—all of

**Table 29. Housing in the area of Foothills Parkway Section 8B**

| Place | Total units | | | Singe-family structures | | Median values ($) | |
|---|---|---|---|---|---|---|---|
| | 1980 | 1990 | Percent change 1980–90 | 1980 | 1990 | 1980 | 1990 |
| Sevier County | 16,604 | 24,166 | 45.5 | 13,405 | 17,067 | 67,658 | 72,183 |
| Gatlinburg | 2,044 | 2,923 | 43.0 | 1,380 | 1,932 | 50,800 | 88,700 |
| Pigeon Forge | 807 | 1,371 | 69.9 | NA | 929 | 41,200 | 66,600 |
| Pittman Center | NA | 291 | NA | NA | 228 | NA | 80,000 |
| **Cocke County** | 11,277 | 12,282 | 8.9 | 8,264 | 8,274 | 46,523 | 44,878 |
| Cosby | NA | 576 | NA | NA | 501 | NA | 43,401 |

NA = not available.
*Source:* U.S. Bureau of the Census (1991).

**Table 30. Housing vacancy in the area of Foothills Parkway Section 8B**

| Place | Total vacant units | For rent | For sale only | Rented or sold, not occupied | Seasonal, recreational, or occasional use | Other vacant |
|---|---|---|---|---|---|---|
| Sevier County | 4,646 | 936 | 376 | 240 | 2,270 | 824 |
| Gatlinburg | 1,439 | 386 | 73 | 33 | 844 | 103 |
| Pigeon Forge | 176 | 22 | 16 | 19 | 73 | 46 |
| Pittman Center | 85 | 4 | 2 | 1 | 62 | 16 |
| Cocke County | 1,091 | 255 | 115 | 172 | 242 | 307 |
| Cosby | NA | NA | NA | NA | NA | NA |

NA = not available.
*Source:* U.S. Bureau of the Census (1991).

which are better than the ratios required by the state (C. Henry, Principal, Pittman Center Elementary School, personal communication with M. Schweitzer, ORNL, May 9, 1995). At Gatlinburg-Pittman, the ratio of students to teachers is 18:1, which is much better than the state standard for high schools (K. Cantrell, Guidance Counselor, Gatlinburg Pittman High School, personal communication with M. Schweitzer, ORNL, May 9, 1995). At Gatlinburg-Pittman, a free-standing building containing two classrooms was built during the 1994–95 academic year, and another such building—housing a band room and an art room—was completed during the 1995–96 school year. Construction of a school theater at the high school is tentatively scheduled to begin in spring 1998 (M. Harmon, Director of Maintenance, Sevier County School System, personal communication with M. Schweitzer, ORNL, May 10, 1995, October 9, 1996, and July 23, 1997). In late 1994, local officials in Pittman Center called for construction of a new elementary school in a different location, since the existing school is in a flood hazard area (*The Mountain Press*, January 1, 1995). Since then, the county has purchased a 15-acre parcel of land on the southeast side of Pittman Center Road (SR 416), immediately south of the Foothills Parkway ROW, as a site for a future elementary school (J. Coykendall, Chairman, Pittman Center Planning Commission, personal communication with M. Schweitzer, ORNL, July 22, 1997). Private schooling is available in Sevier County in the form of a day and boarding school for grades 6–12; a day school for pre-school age, kindergarten, and primary grade children; and two schools for day students in grades K–12. A state and federally funded adult high school is available for literacy training, general equivalency diploma training, and regular high school classes for adults (*Everything You Always Wanted to Know about Sevier County* 1994).

The Cocke County public school system has nine elementary schools, two high schools, and one vocational school. Cosby has two public schools. Cosby School is located in the northernmost portion of Cosby and serves grades K–12. It has an enrollment of 902 students and provides student bus service. Smoky Mountain Elementary School, located in the southern part of Cosby, serves grades K–8 and enrolls 142 students. Its bus service extends within an approximate 16-km (10-miles) radius of the intersection of U.S. 321 (SR 73) and SR 32. Both Cosby schools have special education programs for gifted children and those with learning disabilities. Combined enrollment at the two Cosby schools has remained constant since 1986, but the number of students has increased slightly at Cosby School and declined at Smoky Mountain Elementary. Recently, Cosby School added three portable buildings containing six classrooms; these additions were largely necessitated by the school's push to reduce student-teacher ratios. Currently, the ratio of students to teachers at both schools in the Cosby area is 17:1 for K–3 and approximately 25:1 for grades 4–8. At Cosby School, the ratio also is about 25:1 for grades 9–12. These ratios, especially for the early grades, are substantially better than those required by the state. The Cocke County School Board has recommended separating Cosby School's elementary and high school students and housing the two different age groups in separate schools, but the county commission has not yet appropriated the necessary funds for this (F. James, Attendant Supervisor, Cocke County School System, personal communication with M. Schweitzer, ORNL, May 9 and 10, 1995 and October 9, 1996).

### 3.6.4.2 Water

Water service in Sevier County is provided by four utility districts and the three largest cities—Gatlinburg, Pigeon Forge, and Sevierville. Each of the cities serves its own residents and, in some cases, customers located adjacent to its borders. Gatlinburg provides about 2900 water hookups,

primarily using water drawn from the west fork of the Little Pigeon River. The city's average daily water usage is about 0.0438 $m^3/s$ [(1 million gallons per day (MGD)] in the winter and about 0.1 $m^3/s$ (2.5 MGD) in the summer. The city's water treatment plant has a rated peak capacity of 0.09 $m^3/s$ (2 MGD) and the city can buy up to another 0.0438 $m^3/s$ (1 MGD) from Pigeon Forge, provided the water is available (D. McFalls, Assistant Superintendent of Public Works, Gatlinburg, Tennessee, personal communication with M. Schweitzer, ORNL, May 8, 1995). Pigeon Forge provides more than 2300 hookups, primarily using water from Waldens Creek, a tributary of the Little Pigeon River. The city's customers consume an average of approximately 0.07 $m^3/s$ (1.5 MGD) in the winter and 0.1 $m^3/s$ (2.5 MGD) in the summer. The peak demand, which generally is experienced in the height of the summer tourist season, is approximately 0.15 $m^3/s$ (3.5 MGD). The city's treatment plant is rated at 0.11 $m^3/s$ (2.6 MGD) and, in addition, up to 0.0438 $m^3/s$ (1 MGD) is purchased, as needed and available, from Sevierville (R. King, Chief Water Plant Operator, Pigeon Forge, Tennessee, personal communication with M. Schweitzer, ORNL, May 9, 1995). Sevierville has approximately 5100 hookups, providing water from the Middle Prong of the Little Pigeon River (J. Bettis, Senior Accounting Clerk, Sevierville Water System, personal communication with M. Schweitzer, ORNL, October 9, 1996). Average daily use is roughly 0.07 $m^3/s$ (1.6 MGD) in the winter and 0.11 $m^3/s$ (2.6 MGD) during the summer months. Peak summer demand is approximately 0.13 $m^3/s$ (3 MGD), including water sold to Pigeon Forge. While Sevierville's water treatment plant has a rated capacity of 0.18 $m^3/s$ (4 MGD), the city is only allowed to pump 0.13 $m^3/s$ (3 MGD) from the Little Pigeon River because of water quality concerns. Once this peak capacity of 0.13 $m^3/s$ (3 MGD) is reached, Sevierville will have to start cutting back on the amount of water sold to Pigeon Forge during critical periods (T. McCarter, Operator, Sevierville Water Plant, personal communication with M. Schweitzer, ORNL, May 8, 1995).

During the peak tourist season, both Gatlinburg and Pigeon Forge have insufficient water processing capabilities, and Sevierville is rapidly approaching its capacity. As noted earlier, Gatlinburg buys water from Pigeon Forge during the summer months, and Pigeon Forge buys water from Sevierville. However, Sevierville faces the near-term possibility of being unable to provide all the water needed by its customers. To eliminate this water shortage, Pigeon Forge, Gatlinburg, Sevierville, and the Sevier County government—acting under the auspices of a countywide water board—undertook the construction of a pumping station and a raw water line from Douglas Lake to a treatment plant in Pigeon Forge, a distance of roughly 24 km (15 miles). From there, treated water will be distributed to the member governments. The largest financial contribution will be made by Pigeon Forge, followed closely by Gatlinburg. The shares contributed by Sevierville and the county will be much smaller. Voting strength on the board is directly proportional to the amount of money committed. Pittman Center will participate as a non-voting member (*The Mountain Press*, January 12, 1995). When completed, the raw water line from Douglas Lake is expected to supply approximately 0.26 $m^3/s$ (6 MGD) (R. King, Chief Water Plant Operator, Pigeon Forge, Tennessee, personal communication with M. Schweitzer, ORNL, May 9, 1995). The pumping station at Douglas Lake and necessary expansions to the Pigeon Forge water treatment plant were completed in June 1997. The current target date for completing the raw waterline and beginning to draw water from the lake is the summer of 1998 (G. McGill, Project Manager, McGill Associates, personal communication with M. Schweitzer, ORNL, July 22, 1997). The city of Sevierville also has considered the possibility of buying 1 MGD from the Knoxville Utilities Board, but this option is not being actively pursued at the present time

(P. Layman, General Manager, Sevierville Water System, personal communication with M. Schweitzer, ORNL, October 9, 1996).

The Webb Creek Utility District provides water to virtually all structures in the Cobbly Nob area east of Pittman Center. The same utility district also serves a few parcels in Pittman Center, but most of the community gets water from private wells and—largely due to cost considerations—there are no plans for the Webb Creek Utility District to provide water to the rest of Pittman Center (J. Coykendall, personal communication with M. Schweitzer, ORNL, October 8, 1996). Recent testing indicated that about half of the wells in Pittman Center were contaminated with fecal e-coli bacteria coming from failed septic systems. Because of this, Pittman Center has expressed interest in trying to renegotiate an existing contract signed with Gatlinburg in 1978 that would pipe potable water to the town using state and matching Gatlinburg city funds. The proposed water line would extend from Gatlinburg across the Greenbriar Bridge on U.S. 321 to provide service to all of Pittman Center (T. Ledford, Acting City Administrator, Pittman Center, Tennessee, personal communication with P. L. Sau, ORNL, August 5, 1994). No recent effort has been made to pursue this option, largely due to Gatlinburg's current lack of surplus water during the peak tourist season (J. Coykendall, Chairman, Pittman Center Planning Commission, personal communication with M. Schweitzer, ORNL, July 22, 1997). Even if Pittman Center does not get water from Gatlinburg under the terms of the 1978 contract, it is very likely that the town will get piped water in the next 5 to 20 years as part of a countywide water system (J. Coykendall, Chairman, Pittman Center Planning Commission, personal communication with M. Schweitzer, ORNL, January 11, 1995).

In Cocke County, the Newport public water system serves the entire city and Cosby. The system provides 6500 hookups, 3000 of them inside the Newport city limits and the remainder in surrounding areas of Cocke County (L. Allen, Water Manager, Newport, Tennessee Utilities Board, personal communication with P. L. Sau, ORNL, August 12, 1994). Newport also supplies water for the Webb Creek Utility District. Water lines follow SR 32 south to Cosby, and then go east along U.S. 321 into the Cobbly Nob resort and to a few parcels on the eastern edge of Pittman Center (J. Valentine, Webb Creek Utility District, personal communication with P. L. Sau, ORNL, August 5, 1994). The average daily demand for city water is 0.17 $m^3/s$ (3.9 MGD) and the peak demand is approximately 0.22 $m^3/s$ (5 MGD); the rated capacity of the city's treatment facility is 0.25 $m^3/s$ (5.8 MGD). The utilities board is considering upgrading the system and is attempting to get state funds for this purpose, but there are no firm plans to make improvements at this time (L. Atkins, Superintendent of Newport Water Plant, personal communication with M. Schweitzer, ORNL, May 8, 1995 and July 22, 1997).

### 3.6.4.3 Sewers

In addition to seeking public water service from Gatlinburg, Pittman Center is considering alternatives to its current dependence on individual septic systems for wastewater disposal. Most of the older septic systems in Pittman Center were built without adequate distances between water wells and septic tanks, and the predominant soil type is not suitable for effective septic field operation. This accounts for the high rate of septic system failure and well contamination described in Sect. 3.6.4.2. Because the problem is likely to get worse in the future (D. Morris, Pittman Center Alderman, personal communication with P. L. Sau, ORNL, August 5, 1994) and because any sewer line extension would be very expensive, the town is considering alternative

waste treatment ideas, including wetlands treatment coupled with spraying treated water on slopes, community pumped septic systems, and mound treatment (A. Anderson, East Tennessee Community Design Center, personal communication with T. R. Young, ORNL, August 13, and 15, 1994). However, no design or feasibility studies have been performed for any of these options (J. Coykendall, Chairman, Pittman Center Planning Commission, personal communication with M. Schweitzer, ORNL, July 22, 1997). Centralized sewer service, which would allow substantially greater density of urban development in the Pittman Center area, is not likely to be available in the foreseeable future (J. Coykendall, Chairman, Pittman Center Planning Commission, personal communication with M. Schweitzer, ORNL, January 11, 1995).

Gatlinburg currently treats an average of 0.105 $m^3/s$ (2.4 MGD) of wastewater, but its peak demand during a recent 12-month period was 0.22 $m^3/s$ (5 MGD). This was associated with flood conditions, and much of the volume was due to infiltration into the city's sewer lines. The city's wastewater treatment plant is capable of adequately treating 0.13 $m^3/s$ (3 MGD). There are no current plans to increase that capacity, but ongoing improvements to the city's sewer lines will reduce infiltration and hence peak flow. Pigeon Forge presently treats 0.09 $m^3/s$ (2 MGD) and has a peak capacity of 0.18 $m^3/s$ (4 MGD). Like Gatlinburg, the peak volume reached by the city is approximately 0.22 $m^3/s$ (5 MGD). The city has no current plans to increase its treatment plant capacity, but it will probably consider such improvements in the next few years (M. Cross, Project Manager, Professional Services Group, personal communication with M. Schweitzer, ORNL, May 8, 1995).

Newport has a wastewater treatment plant with a maximum capacity of 0.19 $m^3/s$ (4.35 MGD). Current average daily use is only 0.105 $m^3/s$ (2.4 MGD). The Cosby area does not have sewer service and relies on septic systems. Newport would be the most likely source of any future sewer service for Cosby (L. D. Brooks, Sewer Manager, Newport, Tennessee Utilities Board, personal communication with P. L. Sau, ORNL, August 12, 1994).

### 3.6.4.4 Solid Waste

Sevier County produces an average of 0.16 million kg (180 tons) of solid waste per day, which is deposited in a new 56-ha (140-acre) landfill that is expected to serve the county for 25 to 30 years. As a result of a new recycling program that received an achievement award from the Solid Waste Association of North America, the volume of waste deposited in the landfill has been reduced by 70%. This new program includes a co-composting plant adjacent to the Sevier County landfill that processes garbage and sewage and removes organic material. A demolition landfill accepts brush, tree stumps, and large blocks of concrete, and 11 oil recycling centers handle oil. Cardboard is baled, stored, and then shipped to Rock Ten Paper in Chattanooga, while scrap metal is sent to Ferris Metal to be recycled (*The Mountain Press*, July 20, 1994; *Everything You Always Wanted to Know about Sevier County* 1994).

Cocke County produces between 730 and 907 kg (75 and 100 tons) of solid waste per day, which it used to dump in a 10.4-ha (26-acre) landfill near Newport. However, that landfill was closed at the very beginning of 1997, and Cocke County's household wastes are now being hauled to a neighboring county while it attempts to develop a new landfill. The county recently acquired property adjacent to the old landfill to use for the disposal of dry wastes, which excludes household garbage. The county recently started recycling in all ten of its convenience centers, two

of which are in Cosby (C. McMann, Cocke County Landfill, personal communication with P. L. Sau, ORNL, August 12, 1994, and with M. Schweitzer, ORNL, October 9, 1996; D. Hensley, Cocke County Landfill, personal communication with M. Schweitzer, ORNL, January 24, 1997).

#### 3.6.4.5 Police and Fire Protection

Sevier County is served by five local law enforcement agencies: the Sevier County Sheriff's Department, which primarily serves outside incorporated communities, and the police departments of each of the four towns. All five agencies participate in drug prevention programs and assist the Fourth Judicial District Task Force. The Pittman Center Police Department has two full-time officers. The Sheriff's Department helps patrol Pittman Center, and the Gatlinburg Police Department provides additional officers to help with major accidents. Fire protection in Sevier County is provided by one professional and eight volunteer fire departments (*Everything You Always Wanted to Know about Sevier County* 1994). The volunteer departments rely on funding from auctions, fund-raising events, donations, and monies from county and city commissions. The Pittman Center Volunteer Fire Department serves the Pittman Center area. The GSMNP has formal mutual aid agreements with Gatlinburg and the other largest municipalities adjacent to the Park. In addition, park personnel have assisted Pittman Center in the past in dealing with motor vehicle accidents and responding to fires that have forest fire potential. According to park personnel, this type of informal assistance will continue to be provided in the future (C. Schell, Resource Management Specialist, Great Smoky Mountains National Park, personal communication with M. Schweitzer, ORNL, May 9, 1995).

The Cocke County Sheriff's Department serves all of Cocke County with 16 full-time officers (T. Moore, Sheriff, Cocke County, Tennessee, personal communication with M. Schweitzer, ORNL, September 19, 1994). Newport has its own municipal police department. Cocke County has five volunteer fire departments and a professional fire department that serves all of Cocke County. In addition, Newport has its own municipal fire department (E. Ramsey, Fire Department, Cocke County, Tennessee, personal communication with M. Schweitzer, ORNL, September 19, 1994).

### 3.6.5 Land Use

#### 3.6.5.1 Current Land Use

Cocke County covers 1152 $km^2$ (443 square miles). Sevier County is about one-third larger at 1555 $km^2$ (598 square miles). Figure 44 shows the relative size of these counties, as well as the location of key municipalities and roads. Table 31 shows the amount of each county that is devoted to various major land uses. Cocke County has a substantially larger portion of its total area in farms and other rural (non-federal) land uses than Sevier County. However, a much larger portion of Sevier County is federal land, due primarily to the presence of the GSMNP. Sevier County also is much more urbanized than Cocke County, due in large part to the tourism-related growth and development of recent decades. Cocke County has not developed land use plans or zoning ordinances for its unincorporated areas, but it enforces subdivision regulations where city ordinances are not in place. In Sevier County, a planning board was recently approved to develop regulations to govern the construction of private roads and the subdivision of land in

**Table 31. Land use in Cocke and Sevier Counties**

| | Cocke County | | Sevier County | |
|---|---|---|---|---|
| | Area ($mile^2$) | Percentage of county total | Area ($mile^2$) | Percentage of county total |
| Farmland | 131 | 29.6 | 116 | 19.4 |
| Other rural land (non-federal) | 228 | 51.5 | 210 | 35.1 |
| Federal land[a] | 70 | 15.8 | 194 | 32.5 |
| Urban land[b] | 5 | 1.1 | 73 | 12.2 |
| Water | 9 | 2.0 | 5 | 0.8 |
| Total | 443 | 100.0 | 598 | 100.0 |

[a]Nearly all federal land in Sevier County is part of the GSMNP, while federal land in Cocke County is divided primarily between the GSMNP and the Pisgah National Forest.

[b]The Cocke County land is designated as "urban," while the Sevier County land is designated as "commercial/industrial/urban" and may therefore be more inclusive.

*Source:* Vickers, personal communication with M. Schweitzer, ORNL, September 12, 1994.

unincorporated parts of the county (*The Mountain Press*, April 18, 1995). The largest municipalities in both counties—Pigeon Forge, Gatlinburg, Sevierville, and Newport—all have land use plans as well as zoning ordinances and subdivision regulations, and these towns generally extend their influence over local land use a limited distance beyond their city limits (J. Bryant, Tennessee Local Planning Assistance Office, Knoxville, Tennessee, personal communication with T. R. Young, ORNL, July 30, 1994; M. Robinson, Community Development Office, Newport, Tennessee, personal communication with M. Schweitzer, ORNL, July 28, 1994).

Land use plans and controls are in place for Pittman Center but not for Cosby. The most recent comprehensive land use plan for Pittman Center (*Land Use Plan: Pittman Center, Tennessee*) was submitted to the planning commission for approval in 1987. An update to the plan is expected by the end of 1997 and will probably incorporate many of the key ideas generated during the recently-completed "Futurescapes" program (Sect. 3.6.5.2) undertaken by the town in conjunction with the East Tennessee Community Design Center and the Tennessee Valley Authority (J. Coykendall, personal communication with M. Schweitzer, ORNL, October 8, 1996). Pittman Center has zoning and subdivision regulations, including provisions for planned unit developments—an unusually sophisticated mechanism for a town this small. An interesting feature of Pittman Center's zoning ordinance is that no land is designated for industrial uses (*Zoning Ordinance: Pittman Center, Tennessee* 1993) because of the lack of available land and adequate urban services to support industrial development and the desire to preserve the area's rural mountain character.

Currently, the primary land use in the Pittman Center area is low-density, single-family residential (*Land Use Map: Pittman Center, Tennessee* 1994). In the vicinity of the proposed Foothills Parkway interchange at Pittman Center Road (SR 416), there is a sizeable amount of undeveloped

land as well as some private residences and a few vacation rental units. The Pittman Center City Hall and Elementary School, which are designated as civic/commercial land uses, also are located near the proposed interchange. Between 1960 and 1994, nearly 1500 lots were created in the Pittman Center area through the subdivision of large parcels of land. As shown in Table 32, most of this land subdivision took place in the late 1960s and early 1970s. Slightly more than one-fourth of the 433 lots created in the 1960s were associated with the development of a trailer park. The early 1970s saw a substantial increase in land development, with the creation of nearly 1000 residential lots. More than half of these lots were in the Cobbly Nob area, where vacation rental homes were developed along with condominiums and year-round residences. Commercial development in the Pittman Center area primarily consists of vacation rental units, craft shops, and commercial recreation facilities like golf courses and campgrounds. All of these commercial ventures are located along the town's major roadways. The single largest commercial area in town is a resort and condominium complex, along with associated golf courses, located at the eastern end of town along U.S. 321. Other commercial land uses include a grocery and general store on U.S. 321, a campground and vacation rental units along Pittman Center Road, and numerous small crafts shops on Buckhorn Road (the western boundary of the city). All key roads mentioned in this section are shown in Fig. 45.

Current land use in the Cosby area is mostly low-density, single-family residential; a few commercial establishments are located along key roadways. Cosby experienced substantial subdivision of land in the late 1970s, when more than 500 lots were created. Two-thirds of these lots are associated with a campground/trailer park development. There are a few commercial establishments at the intersection of U.S. 321 and SR 32. An inn, a realty office, and a few crafts stores line SR 32 northward to I-40 and Newport.

Currently, the most important physical factors limiting development around Pittman Center are the lack of water and sewerage services, coupled with a rugged topography and periodic flooding that limit the carrying capacity of the land. Cosby has water lines available, but development is limited by the area's rugged terrain and lack of sewer service. In addition, Cosby is somewhat isolated from other areas of tourism-related commercial development.

#### 3.6.5.2 Land Use Projections

In 1993, Pittman Center was chosen for a demonstration project on accommodating development in environmentally sensitive areas. Pittman Center competed with other towns in East Tennessee to receive the services of design teams from the East Tennessee Community Design Center and Tennessee Valley Authority. Through the program—known as the Futurescapes Project—Pittman Center defined a set of goals that include preserving the community's mountain heritage and maintaining its environmental assets, and identified ways in which Pittman Center can achieve its goals and realize its vision. The Futurescapes Project was completed in late 1995 and is documented in a final report published by the East Tennessee Community Design Center (1995).

The Futurescapes design teams developed a consensus map designating specific areas of town for various types of development over the next 20 years (*Consensus Map: Pittman Center, Tennessee* 1994). The consensus map calls for the Pittman Center area to remain primarily residential—mostly low-density—with large corridors of open space interspersed throughout the town. The map designates a public land use area for a new elementary school and a small playground just south

**Table 32. Subdivision of land in and around Pittman Center and Cosby, 1960–1994**

| | Pittman Center area (including Cobbly Knob) | | Cosby and southwestern Cocke County | | |
|---|---|---|---|---|---|
| Year | Name of development | Number of lots | Year | Name of development | Number of lots |
| 1962 | Scenic Acres | 97 | | | |
| 1966 | The Holiday Out | 121 | | | |
| 1968 | Webb Creek #5 | 126 | | | |
| 1969 | Li'l Bit O'Heaven | 36 | | | |
| 1969 | Venture Out Gatlinburg | 53 | | | |
| **1960–69** | **Subtotal** | **433** | | | |
| 1970 | Li'l Bit O'Heaven | 66 | | | |
| 1971 | Outdoor Resorts | 396 | | | |
| 1972 | Broken Pine | 80 | | | |
| 1972 | Timberidge | 102 | | | |
| 1972 | Chestnut Ridge | 4 | | | |
| 1972 | Old Smoky Hy-Top | 54 | | | |
| 1972 | Pine Cove | 21 | ~1972 | Earl Hogue Subdivision | 39 |
| 1972 | Pittman Center Heights | 21 | ~1977 | Laurel Springs | 28 |
| 1973 | Old Hickory | 30 | ~1977 | Kamp-Rite Acres of Gatlinburg | 352 |
| 1973 | Chestnut Ridge #2 | 35 | ~1978 | Stonebrook Subdivision | 49 |
| 1973 | Foxwoods | 86 | ~1977–85 | Cosby Acres | 32 |
| 1973 | Chestnut Ridge | 98 | | | |
| **1970–79** | **Subtotal** | **993** | | | |
| 1980 | Frontier Log Village | 17 | | | |
| **1980–89** | **Subtotal** | **17** | | | |
| 1991 | Laurel Highlands | 22 | | | |
| **1990–94** | **Subtotal** | **22** | | | |
| **1960–94** | **Total** | **1465** | **1972–85** | **Total** | **500** |

*Source:* Tax Maps, Cocke and Sevier Counties, Tennessee (1994).

and east of Pittman Center Road (SR 416), immediately adjacent to the proposed Foothills Parkway interchange. All other land in the vicinity of the proposed interchange is designated for residential use (mostly low density) or as open space. No commercial enterprises are envisioned for that area and, in fact, local officials have advocated that the Foothills Parkway interchange be located at U.S. 321 to avoid stimulating commercial development along Pittman Center Road (J. Coykendall, Chairman, Pittman Center Planning Commission, personal communication with M. Schweitzer, ORNL, January 11, 1995). According to the consensus map and subsequent refinements developed during Futurescapes land use workshops, commercial land use will continue to be limited to a few areas along the community's major roadways. Land in the vicinity of existing commercial areas will be developed more intensively in the future. In addition, one new 80-ha (200-acre) parcel located near the intersection of U.S. 321 and Hills Creek Road will be developed as the commercial center of town. Hill Creek Road runs parallel to, and slightly west of, Pittman Center Road. The "village center," known as the Hills Creek area, is considered ideal for mixed use development which could include a visitors center, public facilities, retail space, rental cabins, and clustered housing (*The Futurescape of Pittman Center* 1995; A. Anderson, East Tennessee Community Design Center, personal communication with M. Schweitzer, ORNL, January 9, 1995). It is likely that the proposal to limit commercial development in Pittman Center will be challenged by some landowners, but this has not yet occurred (J. Coykendall, Chairman, Pittman Center Planning Commission, personal communication with M. Schweitzer, ORNL, October 8, 1996).

In addition to limiting the *amount* of commercial development, Pittman Center also has taken steps to prohibit certain things which it considers inappropriate for the community. A recently-passed ordinance prohibits ferris wheels, merry-go-rounds, go-carts, and similar amusement rides within the city. It also is illegal to keep venomous reptiles and wild or exotic animals. Other recent ordinances prohibit loud music and unscreened waste disposal facilities (*The Mountain Press*, December 23, 1995). No future land use plan has been developed for Cosby, but it is unlikely that the character of the area will change substantially in the next 10 years. Some additional commercial establishments might be added along U.S. 321 and SR 32, and a few new residential subdivisions might be developed. However, the slow pace at which land conversion has occurred in the past and the interest of many residents in avoiding high-intensity commercial development indicate that a dramatic shift in local land use is extremely unlikely.

### 3.6.6 Taxes

Sevier County and its incorporated towns have some of the lowest property tax rates in the state. Cocke County's equalized property tax rate is more than double that of Sevier County, and Newport's equalized tax rate is roughly three times that of Sevier County's municipalities because the additional property taxes levied by towns in Sevier County are very low (Table 33). In contrast, sales tax rates for the two counties are nearly the same. In Sevier County, the sales tax rate is a uniform 8.5 cents per dollar; sales tax rates in Cocke County are 0.25 cents higher. Both counties keep less than one-third of the sales tax revenues they collect. The bulk of these revenues (6 cents per dollar) go to the state treasury.

As shown in Table 34, Sevier County's total operating revenues are nearly 2.5 times those of Cocke County, and Sevier County receives more funds than Cocke County in each of the revenue categories shown. The difference between the two counties' revenues is greatest in terms of sales

**Table 33. Property tax rates in the area of Foothills Parkway, Section 8B, 1994**

| County<br>*City* | Actual tax rate[a] | Appraisal ratio (%) | Equalized tax rate[b] |
|---|---|---|---|
| Cocke | 2.52 | 100.00 | 2.52 |
| *Newport* | 4.71 | 100.00 | 4.71 |
| Sevier | 1.26 | 90.38 | 1.14 |
| *Gatlinburg* | 1.50 | 90.38 | 1.36 |
| *Pigeon Forge* | 1.43 | 90.38 | 1.29 |
| *Pittman Center* | 1.58 | 90.38 | 1.43 |
| *Sevierville* | 1.82 | 90.38 | 1.64 |

[a]Dollars per $100 of assessed value. For cities, property tax rate is *total* of city and county rates
[b]Equalized rate equals actual rate multiplied by the appraisal ratio.
*Source:* Vickers (1996).

tax, where Sevier County collects 6.5 times the amount that Cocke County does. Because of their substantial sales tax receipts—generated by the outlet malls, amusements, hotels, and other commercial facilities located within their boundaries—Sevier County and its major municipalities can afford to levy low property tax rates. However, the town of Pittman Center—which has very little commercial development—has much lower revenues, both in absolute terms and on a per capita basis, than both counties and all other towns listed in Table 34.

In 1992, the estimated value of all property in Sevier County was slightly less than $3 billion, nearly five times the value of all property in Cocke County. Approximately half the assessed value of Sevier County's property came from residential and farm land, with nearly the same value contributed by industrial and commercial property. In contrast, residential and agricultural land in Cocke County had more than twice the assessed value of its industrial and commercial properties. But within nearly all municipalities in both counties, industrial and commercial properties were worth more than residential and farm land. This was especially true in Pigeon Forge and Gatlinburg, where industrial and commercial properties accounted for approximately four-fifths and two-thirds, respectively, of the municipalities' total assessed property value. The major exception is Pittman Center, where there is little commercial activity and nearly three-fourths of the assessed property value was provided by residential and agricultural properties (Vickers 1996).

### 3.6.7 Economic Structure

Key economic indicators for Sevier and Cocke Counties and the state of Tennessee are shown in Table 35. In the winter months, unemployment in both counties tends to be substantially higher than the statewide average. During the summer, the Cocke County unemployment rate tends to remain higher than the state average, but unemployment in Sevier County drops to well below the state rate. Sevier County's per capita income is well above that of Cocke County, but both counties are below the average per capita income for the state as a whole. As of 1989, the latest year for which such figures are available, 25.3% of Cocke County residents had incomes below the poverty level, compared with 15.7% of Tennesseeans statewide and 13.2% of Sevier Countians.

**Table 34. Summary of operating revenues, by source, in the area of Foothills Parkway, Section 8B, fiscal year 1994**

| County / *City* | Property tax | | Sales tax | | Other sources[a] | | Total revenue | |
|---|---|---|---|---|---|---|---|---|
| | Revenue ($1000) | Percentage of total revenue | Revenue ($1000) | Percentage of total revenue | Revenue ($1000) | Percentage of total revenue | Revenue ($1000) | Percentage of total revenue |
| Cocke | 4,470 | 18.0 | 2,293 | 9.2 | 18,102 | 72.8 | 24,865 | 100.0 |
| *Newport* | 1,140 | 15.9 | 1,628 | 22.7 | 4,405 | 61.4 | 7,173 | 100.0 |
| Sevier | 11,545 | 19.7 | 14,911 | 25.4 | 32,232 | 54.9 | 58,688 | 100.0 |
| *Gatlinburg* | 654 | 3.9 | 3,285 | 19.4 | 12,974 | 76.7 | 16,918 | 100.0 |
| *Pigeon Forge* | 343 | 1.9 | 5,666 | 30.9 | 12,297 | 67.2 | 18,306 | 100.0 |
| *Pittman Center* | 30 | 12.9 | 51 | 21.9 | 152 | 65.2 | 233 | 100.0 |
| *Sevierville* | 714 | 9.8 | 3,634 | 49.7 | 2,958 | 40.5 | 7,306 | 100.0 |

[a]Other sources include state, federal, and other local contributions.
*Source:* Vickers (1996).

**Table 35. Key economic indicators for Cocke County, Sevier County, and Tennessee**

| Place | Labor force (Jan. 1994)[a] | Unemployment rate (%)[a] Jan. 1994 | Unemployment rate (%)[a] July 1994 | Per capita income (1992) | Percentage of persons with income below poverty level (1989) |
|---|---|---|---|---|---|
| Cocke Co. | 15,940 | 17.5 | 6.8 | $13,412 | 25.3 |
| Sevier Co. | 33,380 | 17.1 | 2.7 | $15,749 | 13.2 |
| Tennessee | 2,544,800 | 6.1 | 4.6 | $17,674 | 15.7 |

[a]By place of residence. Not seasonally adjusted.

*Source:* Tennessee Department of Employment Security (1994b and 1994c); County and City Data Book: 1994 (1994).

Employment in Sevier County is dominated by the retail trade and service industries, which account for over two-thirds of the county's jobs (Table 36). In contrast, these two sectors are much less important in Cocke County, where nearly two-fifths of the jobs are in the manufacturing sector. The importance of tourism to the Sevier County economy—indicated by the large number of retail and service jobs—is illustrated even more clearly in Table 37, which shows that over half of the jobs in Sevier County can be characterized as travel-generated. The absolute number of travel-generated jobs and the magnitude of travel-related expenditures in Sevier County are the third largest in the state, behind Davidson County (where Nashville is located) and Shelby County (where Memphis is). And on a jobs-per-capita basis, the impact of tourism on Sevier County is much greater than in either of those counties. In contrast to Sevier County, travel-generated jobs in Cocke County represent less than 5% of total employment. On a per-worker basis, the number of travel-generated jobs in Tennessee as a whole is slightly greater than in Cocke County.

The unemployment rate in Sevier County is subject to substantial fluctuation because of the county's reliance on tourism; the number of available jobs is highest during the summer and lowest in the winter. State and county officials are trying to diversify the economy by attracting industrial facilities and other enterprises that do not rely on the seasonal tourist trade. The county's second industrial park was recently filled, and the county is currently in the process of recruiting tenants for a third park. In addition to its economic diversification efforts, the county also is taking steps to lengthen the tourist season. Examples of these efforts are the annual Winter Fest celebration held in the county's three largest municipalities from November until February, the Christmas concerts and other holiday events recently instituted at Dollywood, the establishment of year-round music theaters throughout the county, the newly instituted annual Romance Fest in Gatlinburg, and the off-season promotion of the county's many factory outlets (R. DeBusk, Executive Director, Sevier County Economic Development Council, personal communication with M. Schweitzer, ORNL, December 16, 1994). The latest unemployment figures indicate that these efforts are having the desired effect; jobless rates for December 1994 and January through March 1995 were all lower than in the preceding years (*The Mountain Press*, January 31, 1995; March 5, 1995; May 1, 1995).

**Table 36. 1993 employment by sector (%)[a] in Cocke and Sevier Counties**

| | Cocke County | Sevier County |
|---|---|---|
| Retail trade | 20.9 | 35.2 |
| Services | 15.2 | 32.0 |
| Government | 13.9 | 10.6 |
| Manufacturing | 39.1 | 10.0 |
| Finance, insurance, and real estate | 2.5 | 4.8 |
| Construction | 2.5 | 4.7 |
| Other | 6.0 | 2.7 |
| Total | 100.1[b] | 100.0 |

[a]By place of work.
[b]Total does not equal 100.0% due to rounding error.
*Source:* Tennessee Department of Employment Security (1994a).

**Table 37. Economic impact of tourism in the area of Foothills Parkway, Section 8B, 1993**

| Place | Total travel expenditures ($) | Number of travel-generated jobs | Travel-generated jobs as % of total covered employment[a] |
|---|---|---|---|
| Cocke County | 22.48 million | 390 | 4.9 |
| Sevier County | 598.05 million | 12,470 | 51.9 |
| Tennessee | 6,779.15 million | 132,000 | 5.8 |

[a]Covered employment is by place of work and refers to jobs with employers that are covered by unemployment insurance; this includes nearly all employment in the counties and state.

*Source:* U.S. Travel Data Center (1994). Tennessee Department of Employment Security (1994a).

Like Sevier County, Cocke County suffers from high seasonal unemployment. However, Cocke County also has a year-round unemployment rate that is higher than the statewide average. To improve its local economy, Cocke County has an economic development commission that has been active since the early 1980s in recruiting new industry and maintaining existing businesses. In the last 5 years, the county has recruited a number of new industries and is in the process of bringing additional tenants to its new industrial park. In late 1994, a tourism council was established with the goal of attracting more visitors to Cocke County. The Council's efforts include promoting river rafting and other outdoor recreational activities and working with the state to improve the highway connecting Newport to Cosby. Future economic development efforts in Cocke County are likely to

focus on recruiting industry and attracting more tourists to the immediate area (J. Grooms, Newport-Cocke County Economic Development Commission, personal communication with M. Schweitzer, ORNL, May 9, 1995 and October 9, 1996).

Sevier County is continuing its massive building boom. Several tourist attractions and new motels are planned or under construction along the Highway 66 corridor between the I-40 interchange and downtown Sevierville. In addition, land preparation for a large new commercial development known as Governor's Crossing (eventually containing theaters, restaurants, a hotel, an outlets mall, and a water park) recently started on a site in the Sevierville area. Also, the Dollywood theme park has undergone two expansions since late 1994, and about half a dozen new music theaters have been opened or approved for future construction during the same time period (R. DeBusk, Executive Director, Sevier County, Economic Development Council, personal communication with M. Schweitzer, ORNL, October 9, 1996). But commercial construction is not the only booming industry. As mentioned in Sect. 3.6.3, the pace of residential construction is increasing in the county, especially in the unincorporated areas outside the major towns.

A recent report produced for the Futurescapes project (Eblen 1994) explores the question of future economic growth for Pittman Center. It predicts that Pittman Center will eventually "be caught up in the growth of the tourism industry" in Sevier County, but notes that the policies adopted by the town will greatly influence when and how Pittman Center is affected. Future economic growth in Pittman Center that is consistent with the community's expressed wishes could come from providing bed and breakfast facilities, short-term rental housing, vacation dwellings, and commercial recreation facilities for visitors who desire a less heavily developed environment than the one provided by Sevier County's larger municipalities.

Future growth in the Cosby area also is likely to be linked closely to tourism and outdoor recreation. Local officials in Gatlinburg and Cocke County are trying to get the state to widen U.S. 321 between Cosby and Gatlinburg, which could increase tourism in the Cosby area. Currently, the widening of U.S. 321 from Glades Road, on the east side of Gatlinburg, to Pittman Center Road is under design. The city of Gatlinburg is paying for this project but will probably ask the state to fund the actual construction. There is no state funding at this time to design the widening of U.S. 321 east of Pittman Center Road (J. Moore, Project Manager, Scheduling Section, Tennessee Department of Transportation, personal communication with M. Schweitzer, ORNL, July 22, 1997).

A group of local business people is considering the establishment of a welcome center in Cosby (J. Grooms, Newport-Cocke County Economic Development Commission, personal communication with M. Schweitzer, ORNL, May 9, 1995 and October 9, 1996). At the same time, there seems to be substantial local interest in ensuring that future economic development in the Cosby area does not degrade the existing quality of the community. Ecotourism and cluster development of the type sought by Pittman Center seems to be consistent with this goal and amenable to many current residents (I. McMahan, Jr., Director, Tourism Council of Newport and Cocke County, personal communication with M. Schweitzer, ORNL, October 10, 1996).

### 3.6.8 Social Structure

Because of the nature of the communities in the vicinity of Section 8B of the Foothills Parkway and the key issues facing them, this section focuses on local attitudes toward growth and development and on the forces affecting the direction of that development.

Overall, the growth in population and commerce that has occurred in Sevier County in recent decades has been well received locally, with government and business officials in Sevierville, Pigeon Forge, and Gatlinburg showing particular enthusiasm for development. In the unincorporated portion of the county, there has been some conflict between newcomers and longer-term residents over continued growth and the need for land use planning. In 1994, public discussion of the need for countywide planning pitted newer, pro-planning residents in subdivisions in northern Sevier County, near the Knox County line, against longtime residents in the eastern part of the county (*The Mountain Press*, July 6, 1994). Since then, the Sevier County Commission has voted—despite vocal opposition from some area residents and several local developers—to establish a countywide planning board, as noted in Sect. 3.6.5.1.

In Pittman Center, the use of planning and zoning to control future growth and development is well established and seems to be widely accepted by community residents. The town, which historically was sparsely settled and isolated from the rest of the county, was incorporated in 1974 (*Land Use Plan: Pittman Center, Tennessee* 1987), giving it more direct control over its future development than if it remained unincorporated or eventually was annexed by Gatlinburg. According to Pittman Center's "Vision Statement," the town aspires "To create and perpetuate a quality living environment and to encourage quality development that supports that end. To encourage development that supports a tourist-oriented economic base that relates to and magnifies our unique relation to and with the Great Smoky Mountains" (Pittman Center Planning Commission n.d.). Specific community goals, developed by local residents during the Futurescapes project, include preserving the community's mountain heritage, maintaining its water quality and other environmental assets, and building an economy based on nature-oriented "eco-tourism" and related enterprises, such as bed and breakfast establishments, crafts shops, and low impact recreational opportunities. Most Pittman Center residents seem to want to maintain the existing character of the community and avoid intense commercial development (Anderson 1994).

An immediate concern of the people living in Pittman Center is the high incidence of well contamination, which is motivating the town's current search for water supply and sewage treatment alternatives. The decisions made on these subjects could have a substantial impact on what is probably the biggest issue facing Pittman Center today: the shape of future development in the community. Currently, there are large amounts of vacant land in the town, much of it owned by non-residents (Anderson 1994). The presence of water and sewer lines, should these be made available, would allow substantially denser development than is now possible and would likely increase the development pressures felt by local residents. It is very likely that piped water will be available in Pittman Center within the next 5 to 20 years (Sect. 3.6.4.2). However, centralized sewer service—which would allow much greater development density than would piped water by itself—is not likely to be available in the foreseeable future (Sect. 3.6.4.3).

Even without centralized water and sewer services, Pittman Center's current zoning ordinance would allow greater density of land development than has occurred to date (Anderson 1994). And

changes in existing zoning laws, which could allow still more growth and alter existing land use patterns, are always possible if the make-up of the board of aldermen changes or if current members change their positions on development-related issues.

Pittman Center residents have expressed concern about the proposed Foothills Parkway interchange at Pittman Center Road because of its potential for stimulating commercial development in the area from the interchange south to U.S. 321 (Coykendall 1995). The community's desire to prevent commercial development along Pittman Center Road is reflected in its consensus land use map. During scoping for the EIS, the mayor and planning commission chairman issued a position paper suggesting that the western terminus of Section 8B be located at U.S. 321 rather than at Pittman Center Road, and that the Parkway from that point east to Cosby be built along the existing U.S. 321 corridor, to prevent further commercial development and associated impacts to the area's scenic quality. This would allow the existing Foothills Parkway ROW to be kept in its natural state and used for recreational purposes (Perryman and Coykendall 1993). The proposed realignment of the Foothills Parkway subsequently was endorsed by local citizens at Futurescapes transportation workshops (Anderson 1994).

Cosby is a more loosely integrated community than Pittman Center. While it is clearly recognized as a distinct place by its residents and those living in the surrounding area, it has no government, no land use controls, and no formal boundaries. A few years ago, some local residents attempted to incorporate Cosby as a municipality, but this effort was not successful. Cosby does not currently face the intense development pressures that exist in much of Sevier County, but it is the fastest-growing part of Cocke County and is likely to experience continuing growth and development related to recreation, tourism, and the inmigration of permanent residents. The precise magnitude and shape of that potential development is unclear, and Cosby does not currently have a land use plan to guide and control its growth.

### 3.6.9 Summary

During the construction period, the socioeconomic impact area would include most of Sevier and Cocke Counties. During Parkway operations, the impact area would be limited to southeastern Sevier County and the southwest corner of Cocke County, with Pittman Center and—to a lesser extent—Cosby experiencing the largest share of any impacts. The latest available population figures for the impact area show that Sevier County (population 58,184) is nearly twice as populous as Cocke County (population 30,801). Pittman Center had 478 residents, while Cosby had 1,220. Population and the local housing stock have grown much more rapidly in recent decades in Sevier County than in Cocke County. During the last few years, water has been in short supply in Sevier County during the peak tourist season, but the county and its municipalities are addressing this problem by constructing a raw water line from nearby Douglas Lake and increasing local water treatment capacity. Pittman Center has neither centralized water nor sewer service at present, while Cosby gets piped water from the city of Newport. Sevier County is more urbanized than Cocke County, but the largest municipalities in both counties have land use plans, zoning ordinances, and subdivision regulations. Land use plans and controls also are in place in Pittman Center, but not in Cosby. Employment in Sevier County is dominated by the retail trade and service industries, reflecting the substantial importance of tourism to the local economy, while manufacturing is much more important in Cocke County. Most Pittman Center residents seem to want to avoid intense commercial development and to maintain the community's existing

character. Cosby, while not experiencing the same powerful development pressures that face much of Sevier County, is still likely to experience continuing growth and development related to recreation, tourism, and the influx of new permanent residents.

## 3.7 EXISTING TRAFFIC CONDITIONS

The first step in performing the traffic analysis was to establish the existing traffic conditions on roadways and at intersections in the study area. ORNL began by collecting traffic volume and turning movement counts on highways and at intersections in the study area. Data was both collected in the field and acquired from the Tennessee Department of Transportation (TDOT), the NPS, previous Foothills Parkway traffic studies, and other sources. Traffic volume and turning movement counts were taken at key locations in the study area during the height of the summer and fall peak seasons in order to capture peak traffic conditions.

ORNL then performed a capacity analysis to determine the traffic conditions along each roadway and at each intersection in the study area. Traffic conditions were described using a measure called level of service (LOS), which indicates the general presence or lack of congestion and delay. The results of the analysis are then displayed. The predicted future traffic conditions for the various build alternatives and options are presented in Sect. 4.7.

### 3.7.1 Existing Traffic Patterns and Movements

Much of the information in this section is based on the Highway Capacity Manual produced by the National Research Council in 1994.

#### 3.7.1.1 Capacity Analysis

The concept of levels of service uses qualitative measures that characterize operational conditions within a traffic stream and their perception by motorists and passengers. The descriptions of individual levels of service characterize these conditions in terms of such factors as speed and travel time, delay, freedom to maneuver, traffic interruptions, and comfort and convenience.

Six levels of service are defined for each type of facility for which analysis procedures are available. They are given letter designations, from A to F, with LOS A representing the best operating conditions and LOS F the worst. Each LOS represents a range of traffic conditions. LOS A represents the highest quality of traffic service, with subsequent LOS categories representing incremental declines in such attributes as travel speed and maneuverability. LOS E corresponds to the maximum flow rate, or capacity, on the facility, while LOS F represents conditions where demand exceeds capacity (National Research Council 1994).

Although higher LOS conditions are more desirable, there is usually a trade-off between construction cost and LOS when designing highways. For most design or planning purposes, LOS C and D are typically used. However, acceptable and desirable LOS for highways is usually a decision made by political entities. In this study, we assume LOS A through C to be acceptable for GSMNP and Foothills Parkway roads. For roads outside the park, LOS A through D is considered acceptable.

Different highway facility types have differing operational goals and characteristics, and travelers have different expectations regarding traffic movement on them. Thus, the procedures for determining LOS for a highway facility, along with the qualitative characteristics of LOS, depend upon the type of facility being analyzed. Most of the roadways within the survey are currently rural two-lane highways, and some will soon be upgraded to rural multilane roads. Therefore, the capacity of each roadway, both for existing and future highway sections, is determined using the procedure appropriate for that facility type. All intersections in the study area are stop-sign controlled, and the corresponding capacity analysis procedures and LOS have been applied. The following paragraphs describe traffic conditions under the six LOS categories for the two types of highways analyzed in this study.

### 3.7.1.2 Level of Service for Rural Two-Lane Highways

**LOS A.** The highest quality of traffic service. Motorists are able to drive at their desired speed. Without strict enforcement, this can result in speeds approaching the maximum design speed and exceeding posted speed limits (which are usually lower). The passing frequency required to maintain desired speeds has not reached a demanding level, and almost no platoons[*] of three or more vehicles are observed. Drivers would be delayed (i.e., would not be able to travel at their desired speed) no more than 30 percent of the time by slow-moving vehicles.

**LOS B.** Passing demand needed to maintain desired speeds becomes significant and approximately equals the passing capacity at the lower boundary of LOS B. Drivers are delayed up to 45 percent of the time.

**LOS C.** Noticeable increases in platoon formation, platoon size, and frequency of passing impediments become noticeable. While traffic flow is stable, it is becoming susceptible to congestion due to turning and slow-moving traffic. Percent time delays can reach 60 percent.

**LOS D.** Passing becomes extremely difficult as passing demand becomes very high and passing capacity nears zero. Mean platoon sizes of 5 to 10 vehicles are common, and the percentage of time motorists are delayed reaches up to 75 percent.

**LOS E.** Percent delay time exceeds 75 percent. Passing is virtually impossible under LOS E, and platooning becomes intense when slower vehicles or other interruptions are encountered.

**LOS F.** This represents heavily congested flow with traffic demand exceeding capacity.

### 3.7.1.3 Level of Service for Rural Multilane Highways

**LOS A.** Traffic operates under free-flow conditions. Vehicle operation is virtually unaffected by the presence of other vehicles and is only affected by highway geometry and driver preferences. Maneuverability is good, and minor disruptions to flow are easily absorbed without a change in travel speed.

[*]Platoons are vehicles driving together on a highway section, either voluntarily or involuntarily due to signal control, geometrics, or other factors.

**LOS B.** This LOS is also indicative of free flow, although the presence of other vehicles begins to be noticeable. Average travel speeds are the same as for LOS A, but drivers have slightly less freedom to maneuver.

**LOS C.** The influence of traffic density becomes marked. The ability to maneuver within the traffic stream is now clearly affected by the presence of other vehicles, and average travel speeds begin to show some reduction for multilane highways with free-flow speeds over 50 mph. Minor disruptions may be expected to cause serious local deterioration in service, and queues* may form behind any significant traffic disruption.

**LOS D.** The ability to maneuver is severely restricted because of traffic congestion, and travel speed begins to be reduced by increasing volumes. For the majority of multilane highways with free-flow speeds between 45 and 60 mph, passenger car speeds at capacity generally range from 44 to 57 mph. Only minor disruptions can be absorbed without the formation of extensive queues and the deterioration to LOS E and F.

**LOS E.** This LOS represents near-capacity conditions and is quite unstable. Vehicles are operating with the minimum spacing at which uniform flow can be maintained. For the majority of multilane highways with free-flow speeds between 45 and 60 mph, passenger car speeds at capacity generally range from 42 to 55 mph but are highly variable and unpredictable within that range. As capacity is reached, disruptions cannot be damped or readily dissipated, and most disruptions will cause queues to form and service to deteriorate to LOS F.

**LOS F.** This represents forced or breakdown flow. Operations within queues are highly unstable, with vehicles experiencing brief periods of movement followed by stoppages. Average travel times with queues are generally less than 30 mph.

#### 3.7.1.4 Level of Service for Unsignalized Intersections

Levels of service for movements at unsignalized intersections are determined by the average total delay experienced by vehicles making that movement at the intersection. Total delay, measured in seconds per vehicle, is defined as the total elapsed time from when a vehicle first stops at the end of a queue until the vehicle departs from the stop line. The delay ranges corresponding to each LOS are provided in Table 38. Note that LOS is not applicable to movements that have a continuous right of way since these vehicles are not required to stop at an intersection.

Physical layouts and information on traffic control schemes (e.g., stop sign and/or yield sign control) related to the roadway section and four stop-sign-controlled "T" intersections have been collected. Capacity analyses have been performed for present traffic conditions on these roadway sections and intersections. These analyses are based on procedures suggested in Highway Capacity Manual (National Research Council 1994). The results are presented in the Tables 39–46.

The rural two-lane highway sections within the study area in general operated at acceptable levels of service. The worst LOS for roadways within the study area is D (flow approaching unstable

*Queues are lines of vehicles that are moving very slowly or have stopped, typically at traffic signs or signals or due to some interruption in traffic flow.

**Table 38. Level of service criteria for unsignalized intersections**

| Level of service | Average total delay (seconds per vehicle) |
|---|---|
| A | ≤5 |
| B | >5 and ≤10 |
| C | >10 and ≤20 |
| D | >20 and ≤30 |
| E | >30 and ≤45 |
| F | >45 |

flow conditions with moderate to heavy delays). However, traffic turning left from Foothills Parkway Section 8A onto U.S. 321 southbound is experiencing LOS E during the weekday peak periods and LOS F for weekend peak periods. The traffic demand on Section 8A is not high. The reason for the decrease in the capacity of the stop-sign-controlled Foothills Parkway approach is the high travel speed of the U.S. 321 traffic (about 45 mph). This increases the main traffic stream gap duration required for traffic from the Parkway to turn left onto U.S. 321.

Left-turn traffic from U.S. 321/SR 32 northbound to U.S. 321 currently experiences LOS E during the weekend peak periods.The two intersections along SR 416 (at U.S. 321 and at Webb Creek Road) currently operate under acceptable conditions at LOS D or better.

### 3.7.2 Traffic Data Collection and Acquisition

Traffic volume counts were collected at five locations in the Pittman Center and Cosby areas from June 29 to July 21, 1994 (Fig. 46). Traffic volume data for roads within and around the GSMNP were acquired from the NPS. The NPS data covered the period from June 1993 to June 1994 for four sites: (1) Sugarlands Visitor Center, (2) Oconaluftee, (3) Townsend Wye, and (4) Gatlinburg Spur. Volume data for Foothills Parkway Section 8A was also acquired from NPS.

Intersection traffic turning movement counts were taken at key intersections in the Cosby and Pittman Center areas during the peak color season in October 1994. These turning movement counts were taken during morning (11:00 A.M. to 12:00 P.M.) and afternoon (4:00 P.M. to 5:00 P.M.) peak hours during the weekday (10/25/94) and weekend (10/22/94, 10/29/94). Traffic turning movements were taken at four key sites (Fig. 46, sites 1–4).

Site 1. Intersection of U.S. 321/SR 32 with Foothills Parkway Section 8A in Cosby
Site 2. Intersection of U.S. 321 with U.S. 339/SR 32 in Cosby
Site 3. Intersection of U.S. 321 and SR 416 near Pittman Center
Site 4. Intersection of SR 416 with Webb Creek Road at Pittman Center

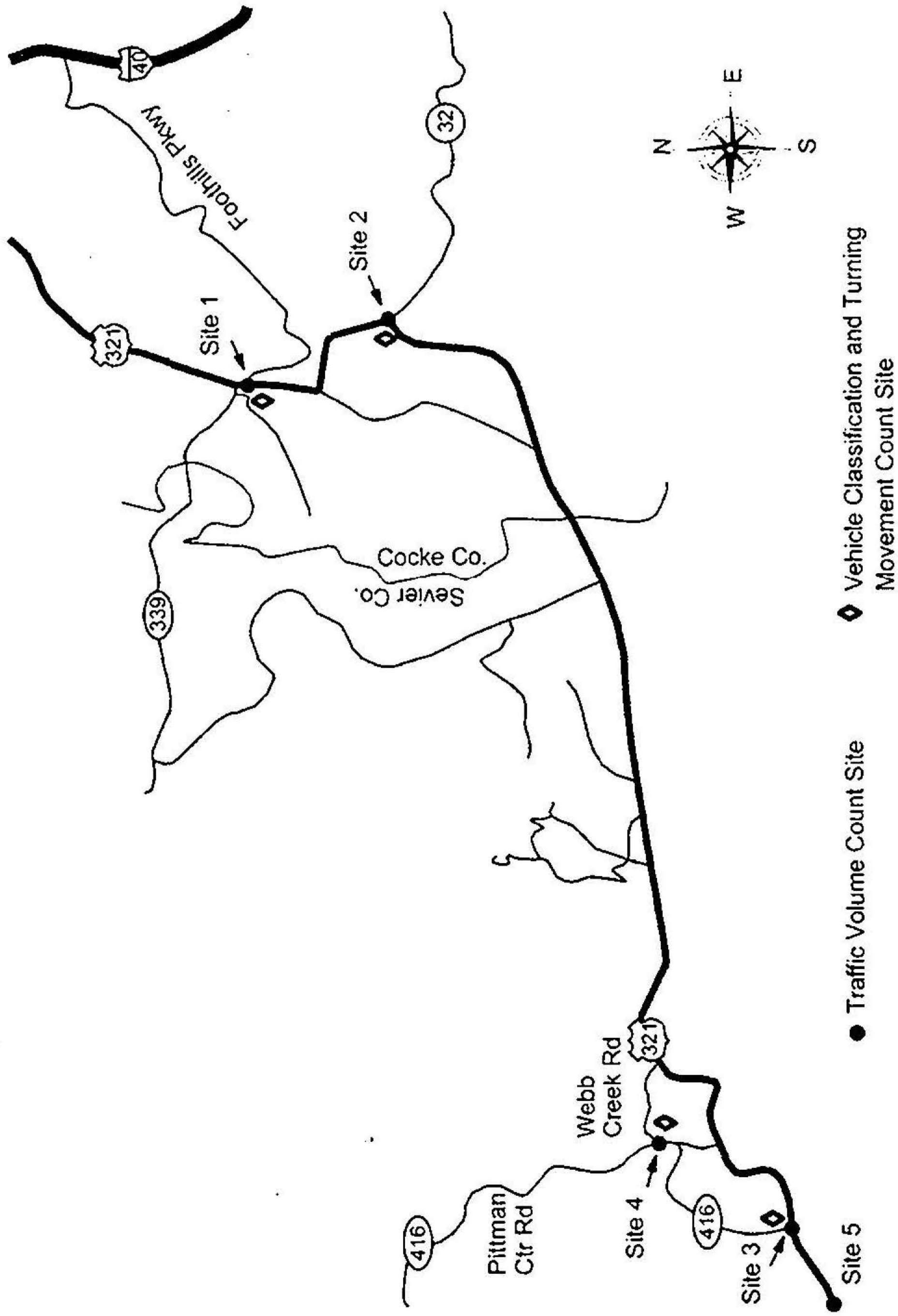



**Fig. 46. Area map for traffic volume counts and vehicle classification and turning movement counts.**

Based on these intersection traffic turning movement counts and the traffic volume data collected by the automatic traffic counters during the summer of 1994, the existing peak traffic conditions in the study area for both weekdays and weekends have been determined and are presented in Tables 39–46.

### 3.7.3 Traffic Noise Analysis

The first step in performing the traffic noise analysis was to establish the existing ambient noise levels at key receptor sites in the study area. This data was collected in the field and compared against noise level standards established by the Federal Highway Administration (FHWA). This section briefly discusses some of the properties of sound and factors that affect sound levels, describes metrics used to measure noise levels, presents the FHWA noise level standards, and discusses the results of the noise level collection effort in the context of those standards.

#### 3.7.3.1 Noise Regulation and Factors Affecting Noise Levels

FHWA has established allowable noise levels for several land use categories (Table 47). The FHWA noise abatement criteria require that the $L_{eq}$ noise level not exceed 67 dBA or that the $L_{10}$ noise level not exceed 70 dBA for Activity Category B. This category includes picnic areas, recreation areas, playgrounds, active sports areas, parks, residences, motels, and hotels. These FHWA guidelines relate to community noise levels and are not necessarily the same standards that would be applied to more pristine locations within national parks. However, the FHWA guidelines will be a reference to Section 8B and surrounding areas. In addition to the guidelines related to community noise levels, FHWA requires that the predicted noise levels resulting from roadway improvement not substantially exceed the existing noise levels.

**Factors influencing traffic noise levels.** Sound reduction over a certain distance is influenced by the kind of surface that lies between the source and the receptor. In general, reduction in the sound level from a vehicular "line source" is about 3 dBA per double distance over "hard" surfaces (e.g., concrete, asphalt, bodies of water) and is about 4.5 dBA per double distance over "soft" surfaces (e.g., grass, crops).

Walls, buildings, embankments for depressed roadways, berms, hills, or other terrain features between the source and receiver can serve as noise barriers and consequently will reduce the noise level at the receiver's location. A 5.0-dBA reduction in sound level can be achieved by using a noise barrier to merely break the line of sight between the receiver and the source. It should be noted that berms are better noise barriers than other materials such as timbers or concrete. An additional 3.0 dBA in sound reduction can be achieved by a berm compared with other barrier walls of different materials. For Section 8B, terrain features and cut/fill sections that might break the line of sight between noise sources and receptors would function much like berms. Such earthen obstructions are usually modeled as berms in the traffic noise analysis process so that future traffic noise levels can be accurately predicted.

For cases in which there is no clear line of sight between the receiver and source, and the tree height extends at least 15 ft above the line of sight, the noise level reduction from the dense growth of woods and other vegetation is about 5.0 dBA per 100 ft of such plantings. However, no more than a 10.0-dBA reduction in noise can be expected.

**Table 39. Existing weekday morning traffic conditions and levels of service at key intersections[a]**

| Intersection location | Approach | Total vehicles per hour | Directional information: Turning movement | Percent | Counts | Level of service | Traffic composition[b]: Motorcycle | Single-unit truck | Combination truck |
|---|---|---|---|---|---|---|---|---|---|
| U.S. 321 intersection w/Foothills Pkwy 8A (Site 1) | FH Pkwy 8A WB | 169 | Left turn | 86.36% | 146 | E | 0.00% | 0.00% | 0.00% |
| | | | Right turn | 13.64% | 23 | A | | | |
| | U.S. 321 SB | 445 | Through | 90.24% | 402 | | 0.00% | 4.88% | 4.27% |
| | | | Left turn | 9.76% | 43 | A | | | |
| | U.S. 321 NB | 596 | Through | 81.64% | 487 | | 0.00% | 6.28% | 3.38% |
| | | | Right turn | 18.36% | 109 | | | | |
| U.S. 321 convergence w/ SR 32 (Site 2) | U.S. 321 EB | 351 | Left turn | 86.19% | 303 | C | 0.00% | 4.42% | 4.42% |
| | | | Right turn | 13.81% | 48 | A | | | |
| | U.S. 321 SB | 211 | Through | 27.01% | 57 | | 0.00% | 4.60% | 4.02% |
| | | | Right turn | 72.99% | 154 | | | | |
| | SR 32 NB | 68 | Through | 69.57% | 47 | | 0.00% | 8.70% | 1.45% |
| | | | Left turn | 30.43% | 21 | A | | | |
| U.S. 321 intersection w/SR 416 (Site 3) | SR 416 SB | 74 | Left turn | 23.81% | 18 | D | 0.00% | 4.76% | 9.52% |
| | | | Right turn | 76.19% | 56 | A | | | |
| | U.S. 321 WB | 570 | Through | 98.00% | 559 | | 0.00% | 3.60% | 0.80% |
| | | | Right turn | 2.00% | 11 | | | | |
| | U.S. 321 EB | 325 | Through | 87.00% | 283 | | 0.00% | 2.50% | 2.50% |
| | | | Left turn | 13.00% | 42 | A | | | |
| SR 416 intersection w/Webb Creek Rd. (Site 4) | Webb Cr Rd WB | 29 | Left turn | 65.22% | 19 | A | 0.00% | 0.00% | 0.00% |
| | | | Right turn | 34.78% | 10 | A | | | |
| | SR 416 SB | 22 | Through | 66.67% | 15 | | 0.00% | 6.67% | 0.00% |
| | | | Left turn | 33.33% | 7 | A | | | |
| | SR 416 NB | 24 | Through | 54.17% | 13 | | 0.00% | 0.00% | 0.00% |
| | | | Right turn | 45.83% | 11 | | | | |

[a]Note that LOS is not calculated for through and right-turn movements at non-controlled approaches (i.e., those without traffic signs or signals) since these vehicles have the right of way at all times.

[b]Traffic composition of vehicles other than passenger cars, pickup trucks, vans, and SUVs.

**Table 40. Existing weekday evening traffic conditions and levels of services at key intersections[a]**

| Intersection location | Approach | Total vehicles per hour | Directional information: Turning movement | Percent | Counts | Level of service | Traffic composition[b]: Motorcycle | Single-unit truck | Combination truck |
|---|---|---|---|---|---|---|---|---|---|
| U.S. 321 intersection w/Foothills Pkwy 8A (Site 1) | FH Pkwy 8A WB | 125 | Left turn | 83.08% | 104 | E | 0.00% | 1.54% | 1.54% |
| | | | Right turn | 16.92% | 21 | A | | | |
| | U.S. 321 SB | 461 | Through | 97.02% | 447 | | 0.00% | 2.98% | 0.60% |
| | | | Left turn | 2.98% | 14 | A | | | |
| | U.S. 321 NB | 614 | Through | 88.12% | 541 | | 0.00% | 2.90% | 0.58% |
| | | | Right turn | 11.88% | 73 | | | | |
| U.S. 321 convergence w/ SR 32 (Site 2) | U.S. 321 EB | 465 | Left turn | 85.97% | 400 | C | 0.00% | 3.58% | 0.90% |
| | | | Right turn | 14.03% | 65 | A | | | |
| | U.S. 321 SB | 211 | Through | 26.67% | 56 | | 0.00% | 4.10% | 1.03% |
| | | | Right turn | 73.33% | 155 | | | | |
| | SR 32 NB | 48 | Through | 66.67% | 32 | | 0.00% | 2.38% | 2.38% |
| | | | Left turn | 33.33% | 16 | A | | | |
| U.S. 321 intersection w/SR 416 (Site 3) | SR 416 SB | 48 | Left turn | 21.05% | 10 | C | 0.00% | 0.00% | 5.26% |
| | | | Right turn | 78.95% | 38 | A | | | |
| | U.S. 321 WB | 552 | Through | 95.65% | 528 | | 0.48% | 4.83% | 0.48% |
| | | | Right turn | 4.35% | 24 | | | | |
| | U.S. 321 EB | 268 | Through | 91.53% | 245 | | 0.71% | 3.53% | 0.71% |
| | | | Left turn | 8.47% | 23 | A | | | |
| SR 416 intersection w/Webb Creek Rd. (Site 4) | Webb Cr Rd WB | 38 | Left turn | 52.78% | 20 | A | 0.00% | 0.00% | 0.00% |
| | | | Right turn | 47.22% | 18 | A | | | |
| | SR 416 SB | 22 | Through | 85.71% | 19 | | 0.00% | 0.00% | 0.00% |
| | | | Left turn | 14.29% | 3 | A | | | |
| | SR 416 NB | 31 | Through | 58.33% | 18 | | 0.00% | 2.08% | 0.00% |
| | | | Right turn | 41.67% | 13 | | | | |

[a]Note that LOS is not calculated for through and right-turn movements at non-controlled approaches (i.e., those without traffic signs or signals) since these vehicles have the right of way at all times.

[b]Traffic composition of vehicles other than passenger cars, pickup trucks, vans, and SUVs.

**Table 41. Existing weekend morning traffic conditions and levels of service for key intersections[a]**

| | | | Directional information | | | | Traffic composition[b] | | |
|---|---|---|---|---|---|---|---|---|---|
| Intersection location | Approach | Total vehicles per hour | Turning movement | Percent | Counts | Level of service | Motorcycle | Single-unit truck | Combin-ation truck |
| U.S. 321 intersection w/Foothills Pkwy 8A (Site 1) | FH Pkwy 8A WB | 286 | Left turn | 86.36% | 247 | F | 0.00% | 0.72% | 0.72% |
| | | | Right turn | 13.64% | 39 | B | | | |
| | U.S. 321 SB | 490 | Through | 90.24% | 442 | | 0.00% | 1.78% | 2.37% |
| | | | Left turn | 9.76% | 48 | A | | | |
| | U.S. 321 NB | 734 | Through | 81.64% | 599 | | 0.00% | 4.47% | 1.63% |
| | | | Right turn | 18.36% | 135 | | | | |
| U.S. 321 convergence w/SR 32 (Site 2) | U.S. 321 EB | 481 | Left turn | 86.19% | 415 | E | 0.47% | 7.04% | 1.88% |
| | | | Right turn | 13.81% | 66 | A | | | |
| | U.S. 321 SB | 480 | Through | 27.01% | 130 | | 0.00% | 1.50% | 2.01% |
| | | | Right turn | 72.99% | 350 | | | | |
| | SR 32 NB | 93 | Through | 69.57% | 65 | | 2.11% | 0.00% | 1.05% |
| | | | Left turn | 30.43% | 28 | A | | | |
| U.S. 321 intersection w/SR 416 (Site 3) | SR 416 SB | 80 | Left turn | 23.81% | 19 | D | 0.00% | 1.47% | 0.00% |
| | | | Right turn | 76.19% | 61 | B | | | |
| | U.S. 321 WB | 692 | Through | 98.00% | 678 | | 0.19% | 0.97% | 0.58% |
| | | | Right turn | 2.00% | 14 | | | | |
| | U.S. 321 EB | 413 | Through | 87.00% | 359 | | 1.94% | 1.94% | 0.00% |
| | | | Left turn | 13.00% | 54 | A | | | |
| SR 416 intersection w/Webb Creek Rd. (Site 4) | Webb Cr Rd WB | 18 | Left turn | 65.22% | 12 | A | 0.00% | 0.00% | 0.00% |
| | | | Right turn | 34.78% | 6 | A | | | |
| | SR 416 SB | 17 | Through | 66.67% | 11 | | 0.00% | 0.00% | 0.00% |
| | | | Left turn | 33.33% | 6 | A | | | |
| | SR 416 NB | 20 | Through | 54.17% | 11 | | 0.00% | 6.25% | 0.00% |
| | | | Right turn | 45.83% | 9 | | | | |

[a]Note that LOS is not calculated for through and right-turn movements at non-controlled approaches (i.e., those without traffic signs or signals) since these vehicles have the right of way at all times.

[b]Traffic composition of vehicles other than passenger cars, pickup trucks, vans, and SUVs.

## Table 42. Existing weekend evening traffic conditions and levels of service for key intersections[a]

| Intersection location | Approach | Total vehicles per hour | Directional information: Turning movement | Percent | Counts | Level of service | Traffic composition[b]: Motorcycle | Single-unit truck | Combination truck |
|---|---|---|---|---|---|---|---|---|---|
| U.S. 321 intersection w/Foothills Pkwy 8A (Site 1) | FH Pkwy 8A WB | 175 | Left turn | 83.08% | 145 | F | 1.58% | 0.00% | 0.00% |
| | | | Right turn | 16.92% | 30 | A | | | |
| | U.S. 321 SB | 540 | Through | 97.02% | 524 | | 0.45% | 1.35% | 0.90% |
| | | | Left turn | 2.98% | 16 | A | | | |
| | U.S. 321 NB | 702 | Through | 88.12% | 619 | | 0.00% | 0.26% | 0.26% |
| | | | Right turn | 11.88% | 83 | | | | |
| U.S. 321 convergence w/ SR 32 (Site 2) | U.S. 321 EB | 560 | Left turn | 85.97% | 481 | E | 0.00% | 1.68% | 0.00% |
| | | | Right turn | 14.03% | 79 | A | | | |
| | U.S. 321 SB | 400 | Through | 26.67% | 107 | | 0.37% | 1.10% | 0.73% |
| | | | Right turn | 73.33% | 293 | | | | |
| | SR 32 NB | 62 | Through | 66.67% | 41 | | 0.00% | 1.02% | 2.04% |
| | | | Left turn | 33.33% | 21 | A | | | |
| U.S. 321 intersection w/SR 416 (Site 3) | SR 416 SB | 93 | Left turn | 21.05% | 20 | D | 0.00% | 2.63% | 0.00% |
| | | | Right turn | 78.95% | 73 | B | | | |
| | U.S. 321 WB | 738 | Through | 95.65% | 706 | | 0.00% | 1.69% | 0.28% |
| | | | Right turn | 4.35% | 32 | | | | |
| | U.S. 321 EB | 381 | Through | 91.53% | 349 | | 0.00% | 0.40% | 0.40% |
| | | | Left turn | 8.47% | 32 | A | | | |
| SR 416 intersection w/Webb Creek Rd. (Site 4) | Webb Cr Rd WB | 29 | Left turn | 52.78% | 15 | A | 0.00% | 0.00% | 0.00% |
| | | | Right turn | 47.22% | 14 | A | | | |
| | SR 416 SB | 30 | Through | 85.71% | 26 | | 0.00% | 7.69% | 0.00% |
| | | | Left turn | 14.29% | 4 | A | | | |
| | SR 416 NB | 31 | Through | 58.33% | 18 | | 0.00% | 0.00% | 0.00% |
| | | | Right turn | 41.67% | 13 | | | | |

[a]Note that LOS is not calculated for through and right-turn movements at non-controlled approaches (i.e., those without traffic signs or signals) since these vehicles have the right of way at all times.

[b]Traffic composition of vehicles other than passenger cars, pickup trucks, vans, and SUVs.

**Table 43. Existing two-lane rural highway weekday morning traffic conditions and levels of service**

| Road section name | Range | Traffic volume | Directional split | | Percentage of trucks | Level of service |
|---|---|---|---|---|---|---|
| U.S. 321 (Site 1) | From intersection with Foothills Parkway Section 8A to convergence with SR 32 | 737 | NB | 66% | 9% | C |
| | | | SB | 34% | | |
| U.S. 321 (Site 2) | From U.S. 321 convergence with SR 32 to intersection with SR 416 | 694 | EB | 62% | 7% | C |
| | | | WB | 38% | | |
| SR 416 (Site 3) | From intersection with U.S. 321 to intersection with Webb Creek Road | 87 | NB | 33% | 7% | A |
| | | | SB. | 67% | | |
| U.S. 321 (Site 4) | From intersection with SR 416 to outside of Gatlinburg | 983 | EB | 46% | 5% | D |
| | | | WB | 54% | | |

**Table 44. Existing two-lane rural highway weekday evening traffic conditions and levels of service**

| Road section name | Range | Traffic volume | Directional split | | Percentage of trucks | Level of service |
|---|---|---|---|---|---|---|
| U.S. 321 (Site 1) | From intersection with Foothills Parkway Section 8A to convergence with SR 32 | 807 | NB | 70% | 4% | D |
| | | | SB | 30% | | |
| U.S. 321 (Site 2) | From U.S. 321 convergence with SR 32 to intersection with SR 416 | 722 | EB | 70% | 5% | C |
| | | | WB | 30% | | |
| SR 416 (Site 3) | From intersection with U.S. 321 to intersection with Webb Creek Road | 70 | NB | 32% | 4% | A |
| | | | SB | 68% | | |
| U.S. 321 (Site 4) | From intersection with SR 416 to outside of Gatlinburg | 1,111 | EB | 52% | 4% | D |
| | | | WB | 48% | | |

**Table 45. Existing two-lane rural highway weekend morning traffic conditions and levels of service**

| Road section name | Range | Traffic volume | Directional split | | Percentage of trucks | Level of service |
|---|---|---|---|---|---|---|
| U.S. 321 (Site 1) | From intersection with Foothills Parkway Section 8A to convergence with SR 32 | 1,215 | NB | 60% | 5% | D |
| | | | SB | 40% | | |
| U.S. 321 (Site 2) | From U.S. 321 convergence with SR 32 to intersection with SR 416 | 909 | EB | 62% | 5% | D |
| | | | WB | 38% | | |
| SR 416 (Site 3) | From intersection with U.S. 321 to intersection with Webb Creek Road | 74 | NB | 32% | 4% | A |
| | | | SB | 68% | | |
| U.S. 321 (Site 4) | From intersection with SR 416 to outside of Gatlinburg | 1,196 | EB | 44% | 2% | D |
| | | | WB | 56% | | |

**Table 46. Existing two-lane rural highway weekend evening traffic conditions and levels of service**

| Road section name | Range | Traffic volume | Directional split | | Percentage of trucks | Level of service |
|---|---|---|---|---|---|---|
| U.S. 321 (Site 1) | From intersection with Foothills Parkway Section 8A to convergence with SR 32 | 1,161 | NB | 63% | 1% | D |
| | | | SB | 37% | | |
| U.S. 321 (Site 2) | From U.S. 321 convergence with SR 32 to intersection with SR 416 | 960 | EB | 65% | 2% | D |
| | | | WB | 35% | | |
| SR 416 (Site 3) | From intersection with U.S. 321 to intersection with Webb Creek Road | 117 | NB | 35% | 1% | A |
| | | | SB | 65% | | |
| U.S. 321 (Site 4) | From intersection with SR 416 to outside of Gatlinburg | 1,217 | EB | 47% | 1% | D |
| | | | WB | 53% | | |

**Table 47. Federal Highway Administration noise standards**

| Land use category | Design noise level ($L_{eq}$) | Design noise level ($L_{10}$) | Description of land use category |
|---|---|---|---|
| A | 57 dBA (exterior) | 60 dBA (exterior) | Tracts of land in which serenity and quiet are of extraordinary significance and serve an important public need, and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose. Such areas could include amphitheaters, particular parks or portions of parks, or open spaces that are dedicated or recognized by appropriate local officials for activities requiring special qualities of serenity and quiet. |
| B | 67 dBA (exterior) | 70 dBA (exterior) | Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals, picnic areas, recreation areas, playgrounds, active sports areas, and parks. |
| C | 72 dBA (exterior) | 75 dBA (exterior) | Developed lands, properties, or activities not included in categories A and B. |
| D | ---- | ---- | For requirements on undeveloped lands, see FHPM 7-7-3(3). |
| E | 52 dBA (interior) | 55 dBA (interior) | Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals, and auditoriums. |

Atmospheric effects such as precipitation, wind fluctuations, wind gradients with altitude, temperature, temperature gradients with altitude, and relative humidity also affect sound transmission. These factors can result in as much as a 10-dBA difference in sound level.

**$L_{10}$ and $L_{eq}$ noise level measurements.** Two noise level measures are commonly used in traffic-related noise studies: $L_{10}$ and $L_{eq}$. $L_{10}$ is the $10^{th}$ percentage point or the $90^{th}$ percentile of the sound pressure level probability distribution function. In other words, $L_{10}$ is the noise level that is exceeded 10 percent of the time at a specific location. The equivalent noise level, $L_{eq}$, is the average noise level expressed in decibels. In field data collection, $L_{eq}$ may be approximated as the logarithmic sum of a series of discrete noise level samples. In general, the $L_{eq}$ noise level reading is about 3 dBA lower than the $L_{10}$ reading for the same sound source over a period of time.

The $L_{10}$ noise level is not additive. The $L_{eq}$ noise level is additive, but it is not linearly proportional to the traffic volume. In general, doubling the traffic volume will only add 3 dBA to the original $L_{eq}$ noise level. For combining two $L_{eq}$ sound levels, the "decibel addition" rules given in Table 48 can be used for noise levels known or desired to an accuracy of ± 1 dBA. Based on the addition rules, if the difference between the measured ambient noise level and the projected future traffic noise is between 4 and 9 dBA, only 1 dBA needs to be added to the projected future traffic noise. If the difference is 10 dBA or more, the currently measured ambient noise can be ignored.

**Table 48. Decibel addition rules**

| When two decibel values differ by | Add the following amount to the higher value |
|---|---|
| 0 or 1 dBA | 3 dBA |
| 2 or 3 dBA | 2 dBA |
| 4 to 9 dBA | 1 dBA |
| 10 dBA or More | 0 dBA |

**Effects of noise on people**. Because noise and increases in noise are bothersome to people, it is necessary that this study address some of the effects of noise on people. For the purposes of this study, highway noise effects can be categorized into three groups: (1) activity interference, (2) general annoyance, and (3) hearing loss. The most obvious and direct activity interference produced by noise is the effect on verbal communication. Tables 49 and 50 show some of the resulting activity interference produced by various noise levels.

**Table 49. A-scale noise levels that will permit acceptable speech communication or voice levels and listener distances**

| | Voice level[a], dBA | | | |
|---|---|---|---|---|
| Distance (ft)[b] | Low | Normal | Raised | Very loud |
| 1.0 | 66 | 72 | 78 | 84 |
| 2.0 | 60 | 66 | 72 | 78 |
| 3.3 | 56 | 62 | 68 | 74 |
| 3.9 | 54 | 60 | 66 | 72 |
| 4.9 | 52 | 58 | 64 | 70 |
| 5.9 | 50 | 56 | 62 | 68 |
| 11.8 | 44 | 50 | 56 | 62 |

[a]Based on men's voices, standing face-to-face outdoors.

[b]Distances in reference information are given in meters, but have been changed to feet in this table to be more readily understood.

**Table 50. Quality of telephone usage in the presence of steady-state interfering noise**

| Noise level (dBA) | Telephone usage |
|---|---|
| 30–50 | Satisfactory |
| 50–65 | Slightly difficult |
| 65–75 | Difficult |
| Above 75 | Unsatisfactory |

General annoyance, a primarily subjective measurement, varies among individuals and is difficult to measure or predict. In terms of the time characteristics of noise, a smooth continuous flow of noise is generally more acceptable than abrupt or intermittent noise, although all of these noises may be unwanted. Related to traffic noise, this suggests that a steady flow of traffic and a steady-state continuous noise level are less objectionable to people than intermittent flow with time-varying noise levels.

The possibility of hearing damage is another concern people associate with increased noise levels. However, in the case of noise produced by highway traffic, this is an unwarranted concern. The Walsh-Healy Public Contracts Act of 1969 and the Occupational Safety and Health Act of 1970 (OSHA) have established a set of maximum permissible noise exposures for persons working in high noise environments. These maximum permissible noise exposures are given in Table 51.

**Table 51. Maximum permissible noise exposures for persons working in high noise environments**

| Duration (hours/day) | Sound level (dBA) |
|---|---|
| 8.0 | 90 |
| 6.0 | 92 |
| 4.0 | 95 |
| 3.0 | 97 |
| 2.0 | 100 |
| 1.5 | 102 |
| 1.0 | 105 |
| 0.5 | 110 |
| 0.25 or less | 115 |

Some may misinterpret this table to indicate that any noise level above 90 dBA will cause loss of hearing, regardless of exposure time. However, this table is intended to apply to industrial areas and workers, and it is intended to protect the hearing of people exposed on a daily basis to these noise levels and durations over a lifetime of employment. To experience continuous 90-dBA noise levels from highway traffic, one would have to stand approximately 3–6 m, or about 10–20 ft, from a highway lane carrying approximately 1,000 trucks per hour. To approach the OSHA exposure limits, one must then remain there beside the highway for 8 hours per day on a daily basis for many years. This is a rather unrealistic situation. There is a strong possibility that the OSHA table of values will be reduced by 5 dBA in future legislation in order to provide greater hearing protection for people exposed to noise. Even with this reduction, it is unlikely that residents near a highway are receiving hearing damage due to traffic noise.

#### 3.7.3.2 Ambient Noise Level Data Collection

Ambient noise level measurements were taken in the areas around Pittman Center and Cosby. Key receptor sites were identified using aerial photographs and topographic maps containing the Section 8B ROW. Identified key receptors included residences, rental properties, churches, schools, and other locations. A total of 41 sites were identified and confirmed as key receptors. A list of these sites and their measured ambient noise levels is provided in Appendix L. Maps illustrating the locations of key receptor sites are presented in Sect. 4.7.4 (Figs. 86–90).

#### 3.7.3.3 Ambient Noise Levels Within the Study Area

All of the measured sites within the study area, except for site 6 along U.S. 321, experienced ambient noise level measurements below the FHWA standard for residential areas (Leq of 67 dBA). In fact, about 71 percent of the sites experienced noise levels below 50 dBA. Along U.S. 321 and SR 416, highway traffic seemed to be the primary source of noise—although commercial/industrial activities appeared to be a contributing factor at one site. At most other locations, natural sound sources, such as running streams, insects, and birds, seemed to dominate noise levels.

## 3.8 AESTHETIC RESOURCES

### 3.8.1 Summary of Existing Conditions

The aesthetic resources affected by the proposed Foothills Parkway Section 8B involve viewing opportunities of the GSMNP, specific local viewsheds, scenery to the north, and interpretive opportunities (Fig. 47). Factors such as season, time of day, vegetation condition, and traffic affect the value of the potential viewing experience. Views of the GSMNP from this section on Webb Mountain would be better than other completed sections. This is due to the directness of the viewing opportunities, especially to the central ridge of the park to the south (Fig. 48) and of the foothills to the north from Webb Mountain. Even better are additional unobstructed views up and down a valley adjacent to the park which present a long series of succeeding side ridges (Fig. 48). Since the ridge generally runs east-west, early morning and late afternoon lighting enhances the appearance of ridge lines.

In general, Section 8B of the Foothills Parkway is completely wooded, topographically complex, and includes low ridges and mid-slopes of the Webb Mountain area paralleling the main spine of the GSMNP in an east-west direction (seen in Fig. 48). This area between Pittman Center and Cosby is principally wooded in thick deciduous forest broken up by occasional pine trees or pine stands. Some small valleys are the only cleared areas. These offer cultural and environmental interpretative opportunities along the parkway at Cosby, Rocky Flats, and Pittman Center.

The winding parkway would offer frequent but often short views of the GSMNP's high ridges 3 to 8 kilometers (2 to 5 miles) distant (Fig. 49). Foreground forests block most potential views. In addition, vegetation on roadside slopes would need to be maintained 50 meters (165 feet) or more away from the road to enable views of the park over tree tops. Without maintenance, all views eventually become blocked as a result of new vegetation growth.

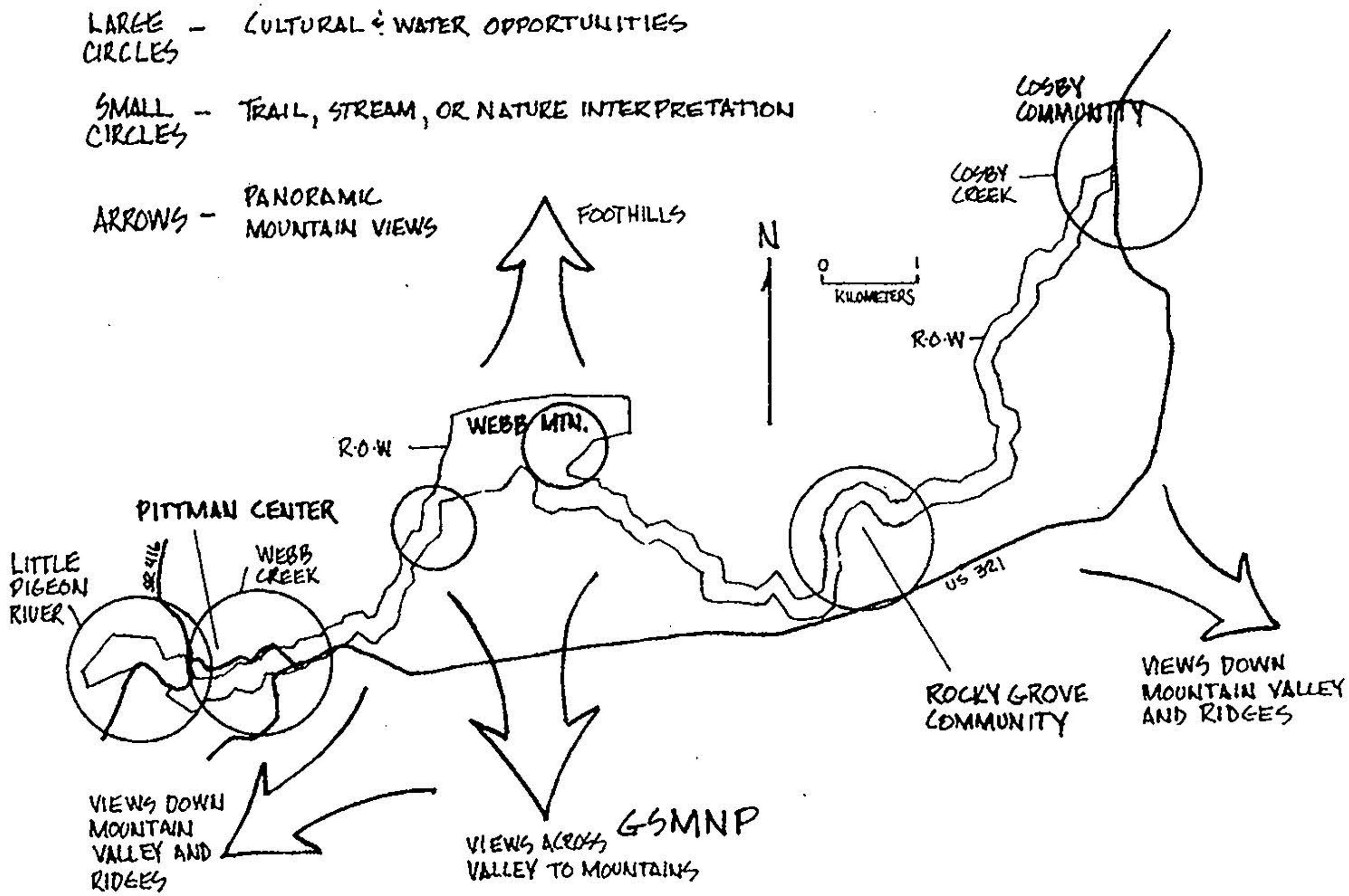
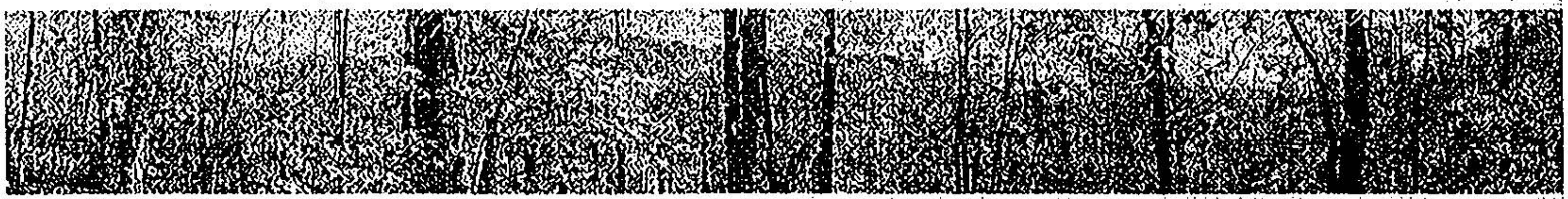
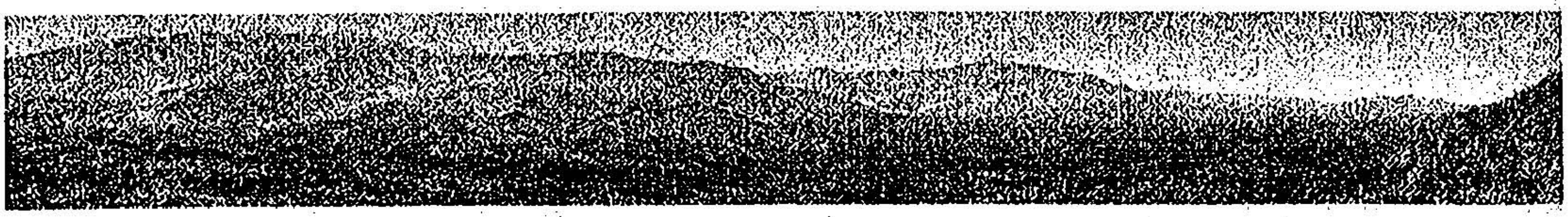



**Fig. 47. The principle aesthetic resources along the proposed parkway are views south (arrows) across a valley to the GSMNP and views east and west along the valley. Atop Webb Mountain, a view north reveals a broad panorama of foothills. Additional opportunities for human settlement history and nature interpretation exist at several locations (circles).**



View (180 degrees) south to GRSM through trees on Webb Mountain; location of proposed scenic overlook



Aerial View (180 degrees) south to Great Smoky Mountains National Park from treetop level above Webb Mountain

**Fig. 48. A 180 degree view of the GSMNP as seen from atop Webb Mountain where a scenic overlook could be developed.**

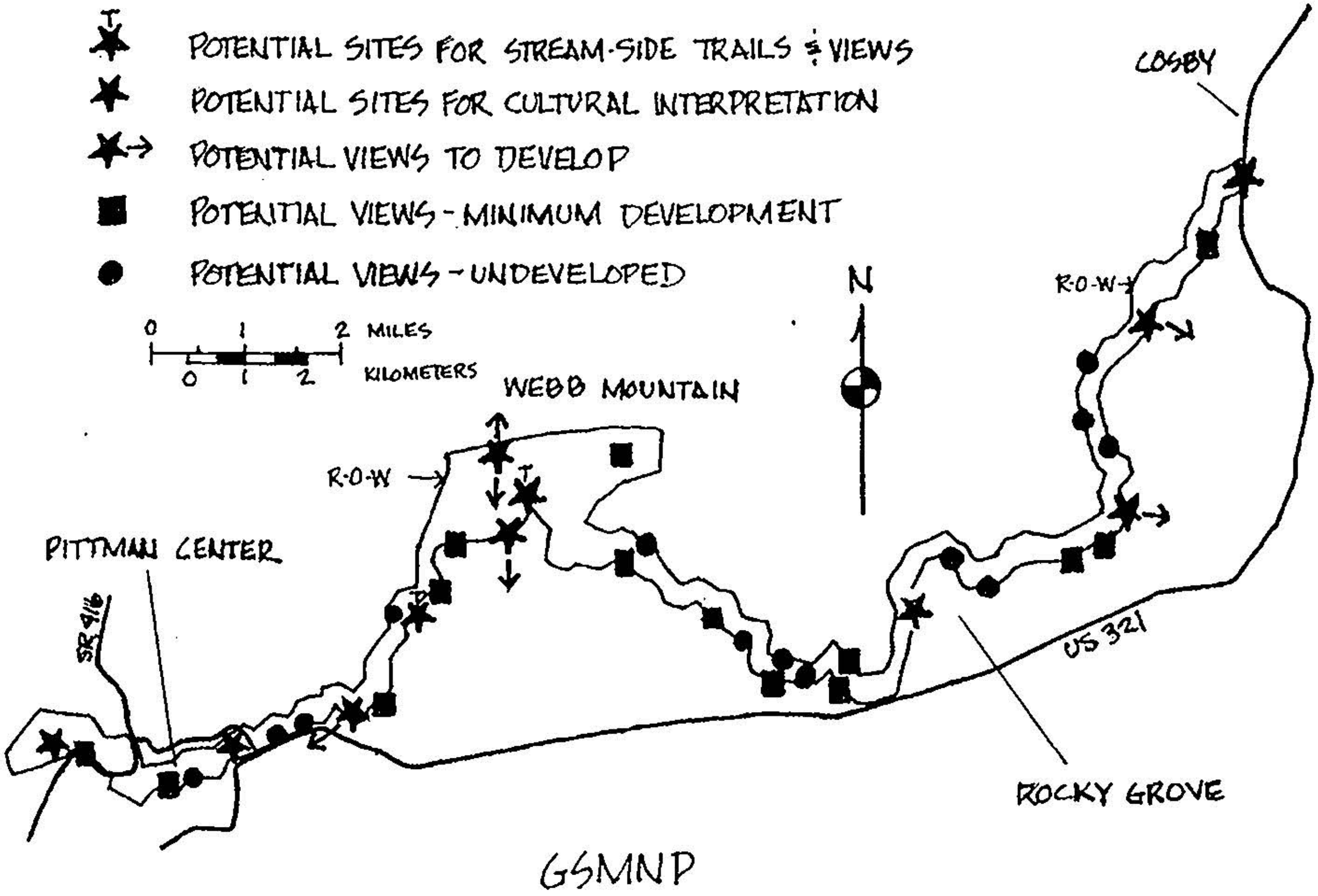



Fig. 49. Initial inventory of potential views and development sites along the proposed parkway. Thirty-eight sites were reduced to the best eleven (stars on map) to assess potential development effects.

Thirty-eight potential views of varying quality and focus were inventoried along the proposed alignment of the parkway (these sites are identified as dots, squares, and stars as shown on Fig. 49). These were subjected to review, aesthetic analysis (described in Sects. 3.8.4 and 4.8), and suitability for development/maintenance. Thirteen, identified as round dots, were eliminated from consideration as being too insignificant to develop. Fourteen, identified as squares, show some viewing opportunities for passive viewing without significant development. The remaining eleven sites, identified as stars, show the best development potential. "Star" sites were identified as those requiring the least amount of land grading while offering the best viewing opportunities. Two of these sites contain opportunities for quiet trail development, nature interpretation, or viewing. Three or four contain resources for human settlement interpretation. Five sites offer special opportunities for pull-over parking and scenic views. These eleven sites (stars) are treated in detail later in the text. The fourteen sites with some viewing opportunity (squares) will be mentioned from time to time as a potential resource to develop later. The remaining low potential sites (dots) will not be reviewed except as they relate to describing methodologies for aesthetic analyses and to acknowledge their initial consideration.

Besides the quality of scenic or interpretative viewing, site selection was also based on considerations of vegetation maintenance. This includes vegetation on cuts, fills, and where forests would need to be cleared to open views. Figure 50 provides an example of a developed viewing site to illustrate vegetation maintenance considerations. Figures 51A and 51B (pictures) show how conditions may appear.

Under good viewing conditions (i.e., limited or no haze), high ridges behind the nearest peaks can be seen from the ROW. These greatly enhance some views. However, the best views tend to look up or down the valley (easterly or westerly) between the ROW and the GSMNP. These views offer panoramas of many succeeding ridges that bring out the exceptional beauty of the area.

Most views of GSMNP are looking up from lower and mid elevations. Only the observation areas atop Webb Mountain would give a feeling of looking top-to-top at the Great Smoky Mountains. This is the most distant and panoramic view of the GSMNP from Section 8B. It is complemented by views to the north away from the park of rolling agricultural low lands mixed with wooded foothills in the far distance. Webb Mountain would offer the most dramatic view of any section of the parkway.

The western edge of the Section 8B ROW is in the area of Pittman Center, a small rural mountain community. Here, the aesthetic resources are small streams and the Little Pigeon River; small, fenced, bottomland pastures surrounded by forested low ridges; quiet paved roads; scattered houses of diverse ages and qualities; and the quaint, small, and historic Pittman Center (see Appendix N for more detail) nestled tightly in a narrow wooded valley. Rhododendron, mountain laurel, and dense hardwood forests provide the backdrop to this community. Ascending the initial slopes along the parkway, open areas including buildings and houses give way to completely forested settings. These open areas are not seen again until Rocky Grove (Fig. 52) and the town of Cosby at the easterly end of Section 8B. As one winds along the ROW, the forests change from bottomland hardwoods to upland hardwoods and, on steep exposed slopes, mixed stands of pines or hardwoods. Views of water and streams (all quite small) are scarce or hidden. This scenery would be interrupted by road cuts and fills that occasionally enable views of the Great Smoky Mountains, views of the intervening valley, and wooded foreground and midground slopes below the parkway.

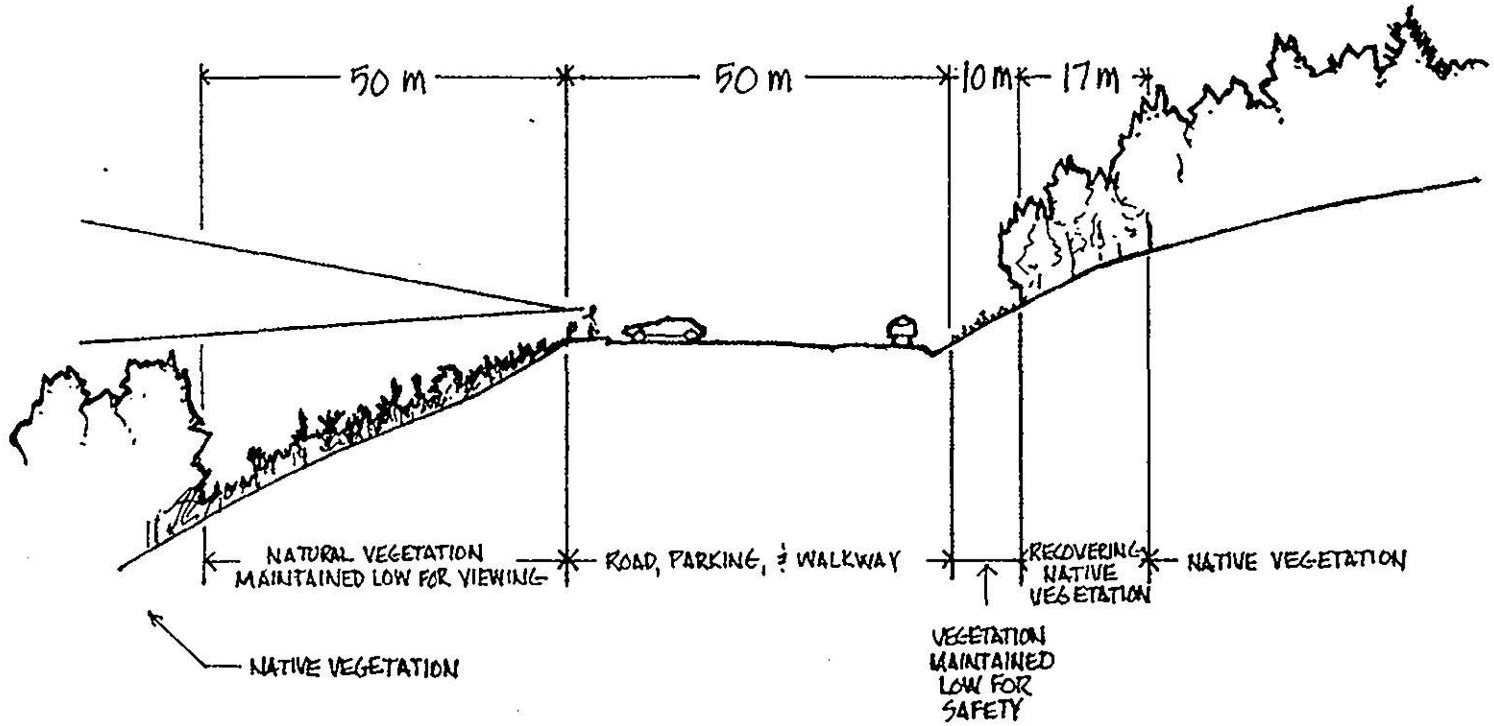



**Fig. 50. Simplified profile of a scenic pull-over illustrating the vegetation maintenance needed to maintain views and safety.**

Figs. 51A and 51B. Photographs show how a pull-over actually looks along another section of the parkway. Maintenance can be both costly and provide large patches of scrubby looking vegetation if clearings must be large for viewing.

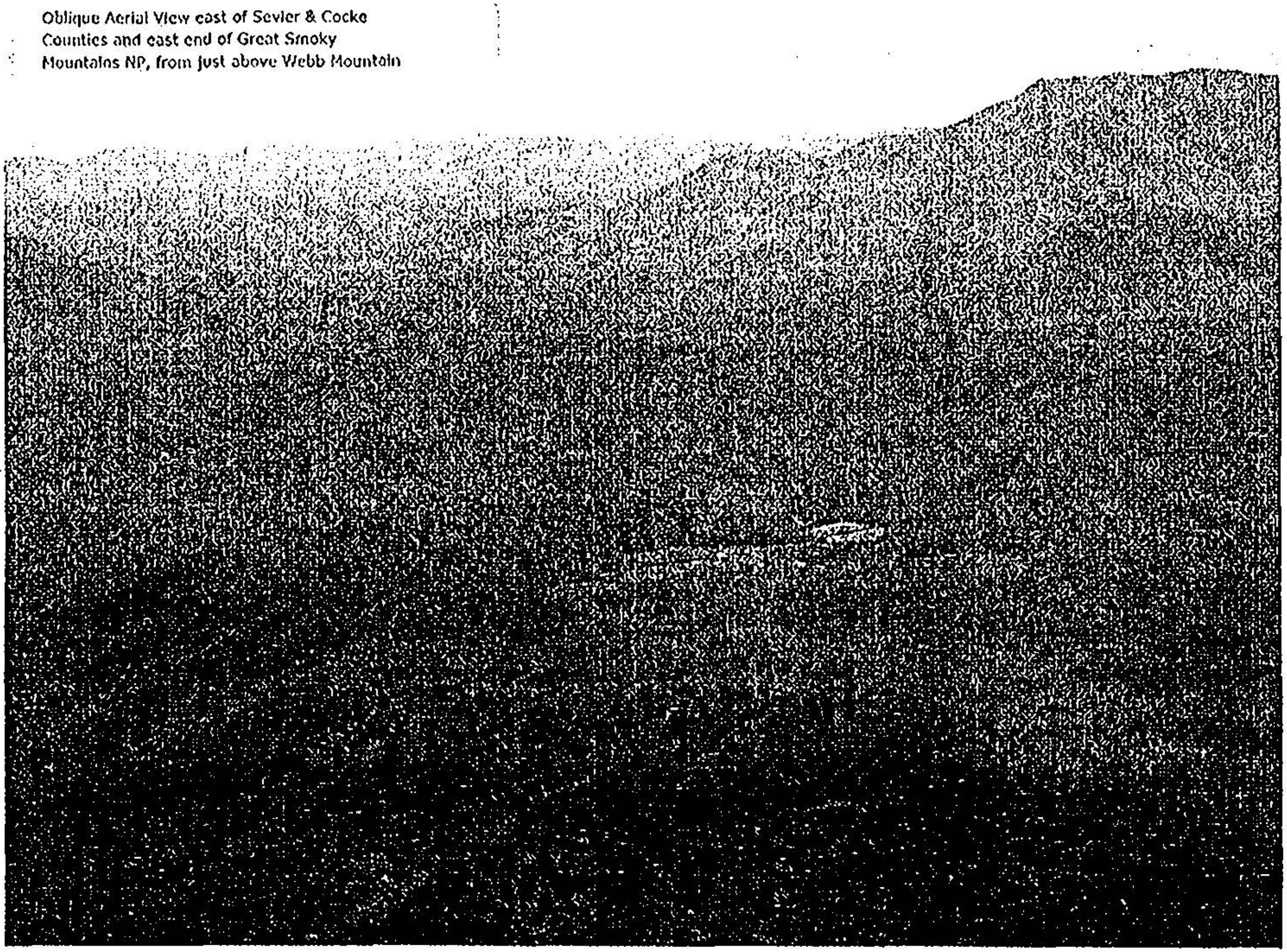



**Fig. 52. Isolated fields in the Rocky Grove area lie between Webb Mountain in the foreground and the main crest of the GSMNP in the upper right to upper left. These fields, accompanying stone walls, and other structures offer interpretative opportunities to travelers of the proposed parkway.**

At Cosby, the parkway connects with U.S. 321 and crosses Cosby Creek. This setting is rural although more open and developed than Pittman Center. Rural cultural resources are again present but less apparent in a much broader valley and slightly more commercial setting. Water resources (i.e., streams and rivers) play their largest aesthetic roles at the east and west ends of Section 8B. Although, there are a few areas along the ROW where close views of streams could be developed.

The intervening valley between the ROW and GSMNP contains U.S. 321, a relatively busy, straight, 2-lane highway, which is mostly hidden from view by trees from the ROW (Fig. 53). This is the motor viewing alternative to the ROW. The valley contains a golf course, camping parks, recreation homes, commercial businesses, and private homes, most generally close to the road and in a rural, forested setting. There are several locations where proposed cuts and fills on the parkway ROW would be seen from U.S. 321 and existing developments. Most of the mountain and parkway ROW viewing from U.S. 321 is blocked by trees along U.S. 321. There are no assurances these trees would remain as tourism develops.

Seasonal variation in vegetation is a significant aesthetic resource. Spring (April) brings abundant forest floor wildflowers and the greening of pastures and trees. As spring turns into summer, mountain laurel, rhododendron, and other flowering shrubs bring color to deeply shaded woods. By midsummer, people are attracted to the slightly cooler temperatures and cleaner smelling air of the mountains. The fall color (and cooler temperatures), however, is perhaps the main seasonal aesthetic event of the year. Along with the brilliant red and yellow colors of maples, sourwood, yellow poplar, and northern red oak, fall brings in many social and craft events.

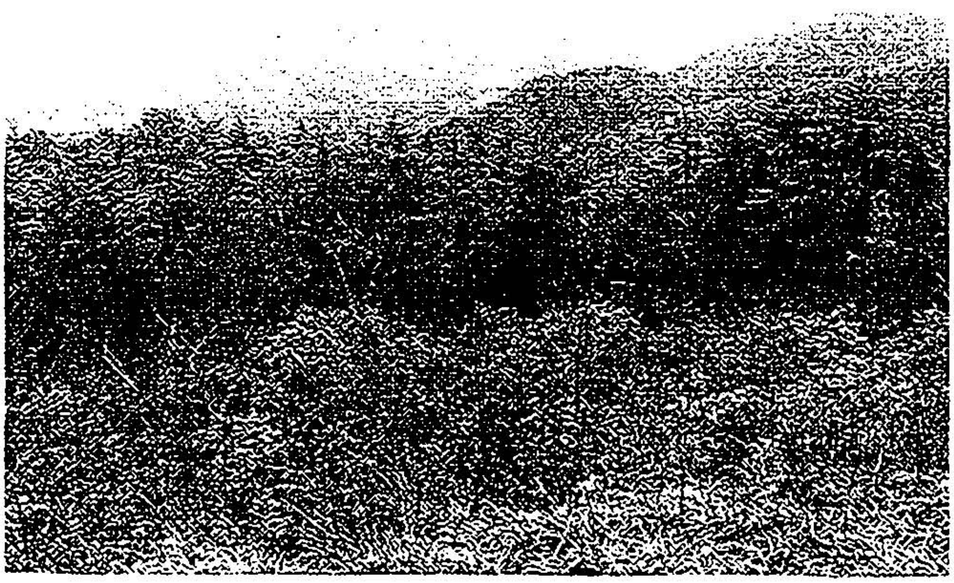
Sections of the existing built parkway ROW may be seen from a few limited vantage points along foot trails in the GSMNP. Generally, this viewing is from 5 to 8 km or (3 to 5 miles). On clearer days, the parkway may be seen as the only road in a mountainous wooded view.

### 3.8.1.1 Aesthetics of Cuts, Fills, and Associated Vegetation

Cuts and fills of the proposed parkway are an essential component of the aesthetic experience. All along Section 8B the color of exposed rock would vary between light brown, dark brown, gray, and patches of white. The gray would dominate only in segment 3 and be nearly absent in other segments. Exposed freshly cut gray rocks (slates and shales) provide the least negative contrast to native vegetation. These are also the hardest to revegetate. Contrast is increasingly greater with dark brown, light brown, and white rocks.

Typical fill slopes would be on a 1:2 (vertical:horizontal) incline. Cuts would typically be a 1:1 slope. Before stabilized with vegetation, both cut and fill slopes would provide negative aesthetic impact due to their contrasting color and texture to surrounding native vegetation. As these features age, natural regrowth of vegetation would occur. Less steep slopes revegetate faster and become natural looking more quickly. In 10 years, most cuts would be visually dominated by grasses, perennial herbs, and somewhat inconspicuous tree seedlings. By 20 years, sufficient native vegetation would take hold to begin visually blending with wooded surroundings. In 30 years, typical cuts and fills would be well vegetated with hardwoods and pines that blend with native surroundings (Fig. 54A and 54B). Steeper cuts would contain more pines and less hardwoods (Fig. 55). Beyond a 4:3 slope, bare rock is increasingly seen and pines become more scattered and stunted. Road cuts of shales and slates are the most aesthetically problematic and are likely to

Fig. 53. View of U.S. 321 near Cobbly Nob. Trees along this route block most views of both the GSMNP and the parkway ROW. Future development could alter this situation. Existing development includes resorts, camping, homes, and roadside services.



**Figs. 54A and 54B. Photographs of a road cut along an existing stretch of parkway shows how vegetation may appear in 30 years. Vegetation came back by natural seeding.**

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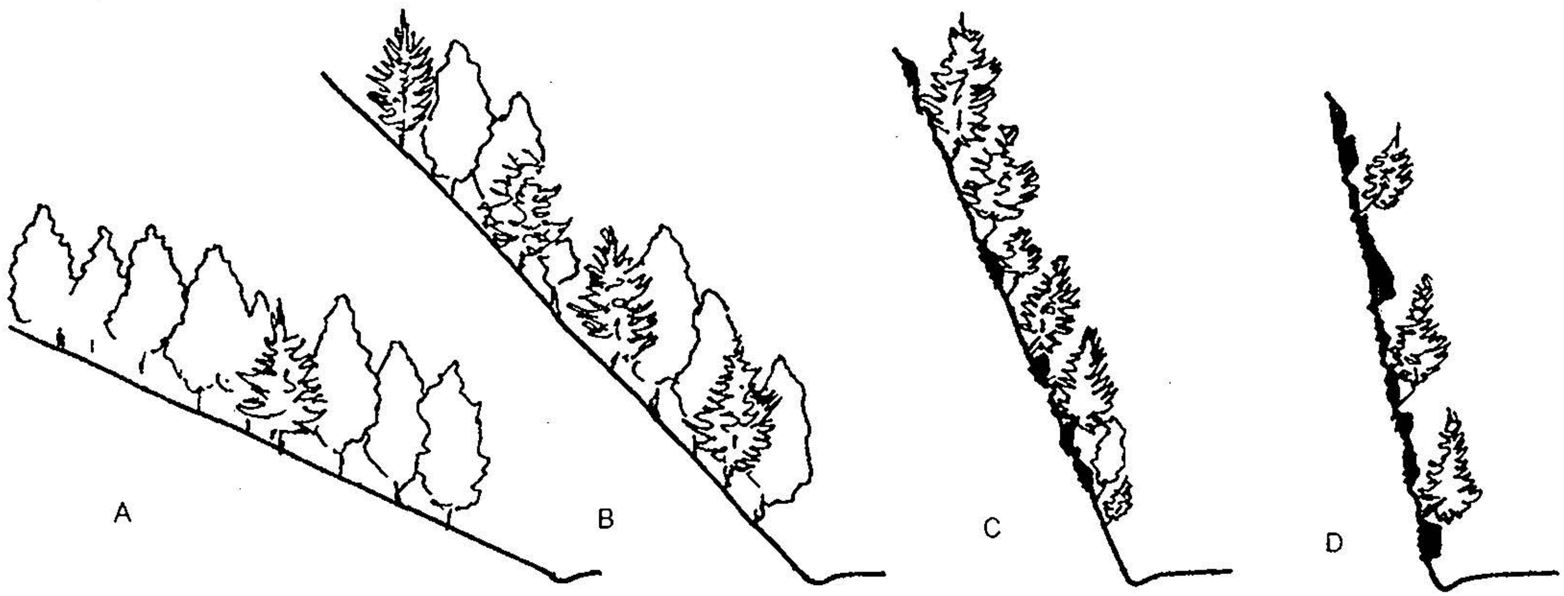


**Fig. 55. Based on similar sections of the parkway already constructed, the type of vegetation returning to cuts and fills will vary by steepness of slope. Steeper slopes will be occupied more by native pines as opposed to hardwoods. This figure illustrates what might occur after 20 to 30 years.**

occur occasionally on the higher parts of Section 8B. This bedrock is difficult to stabilize and revegetate even on more gentle slopes, often remains bare indefinitely and rarely is attractive to view. On road fills and slopes where vegetation is constantly cut back for panoramic viewing, conditions would contrast with natural vegetation when viewed from a distance. The frequently cut vegetation would appear smoother in texture and lighter green in color. Close up, however, the cleared areas may look weedy and scrubby.

The development of vegetation on cuts and fills between initial parkway construction and 30 years later is of significant concern. In the first few years, cover would be grasses, native mixes of perennials, and seedlings of a few native trees. These would increasingly be replaced by shrubs, small trees, briars, and patches of grasses and perennials. Exotic pest plants such as honeysuckle, multiflora rose, johnsongrass, privet, and thistle may require control. Within 15 to 20 years, a few larger native trees would be present. On better soil and gentler slopes, an even canopy of trees would be growing. At this time, some cuts and fills would be blending into the scenery quite well but they would still be identifiable by the casual observer (Fig. 56). The vegetation recovery process can be accelerated by planting aggressive, native, pioneer species such as Virginia pine and maple.

### 3.8.2 Introduction

The Foothills Parkway provides the recreation- and leisure-oriented motorist opportunities to discover the beauty and charm of the Smoky Mountains and the rural Tennessee landscape. Scenic mountain vistas, seasonal foliage displays, woodlands, sparkling streams, quiet pastoral scenes, fences and rock walls, and colorful wildflowers are part of this landscape. The objectives are similar to those of the Blue Ridge Parkway designed and built over an approximate 50-year period from the 1930s to the 1980s.

### 3.8.3 Approach to the Aesthetic Resource Evaluation

Because the experience of driving a scenic parkway consists of sequentially perceived views of varying aesthetic quality, the existing Section 8B environment was evaluated for its potential to provide opportunities for scenic viewing, either from the future roadway or from its scenic turnouts. Studies of the southern portion of the Blue Ridge Parkway provided guidance for assessing preferences for potential scenic views from Section 8B (see Appendix M). Scenes with water elements are likely to be most preferred, followed by views that offer multiple, receding mountain ridges, and third, scenes focused on rural valleys. The least likely preferred vistas are ones obstructed in part by trees and other vegetation and also scenes whose field of view is dominated by largely low, single-ridged mountains.

Parkway designers would combine these views (along with other resource opportunities and constraints) to structure the overall alignment of Section 8B. Designers would consider the relative aesthetic quality of the potential views from this section within the broader context of views from other parkway sections to create varied and rhythmic scenic experiences that—ideally—*in toto* reveal the essential aesthetic character of the Great Smoky Mountains and the rural Tennessee landscape.

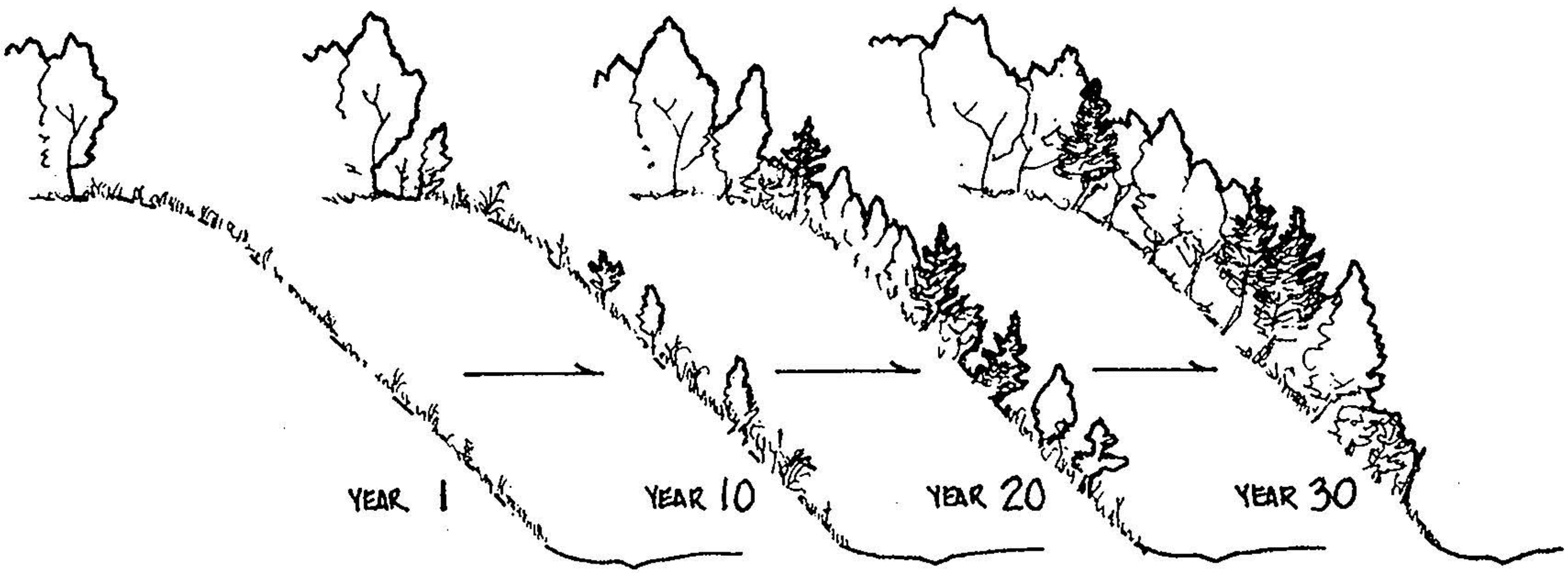


**Fig. 56. Illustration of road cut vegetation recovery on a 1:1 slope over time on Webb Mountain. The first 10 years is dominated by a grassy stage which gradually evolves into a full forest stage by about 30 years. Rate of recovery will vary by steepness of slope, aspect, soil condition, and elevation.**

A worksheet was created specifically for application on Section 8B of the proposed Foothills Parkway (see Fig. 57). It utilizes Hammit's findings under the heading "quality of view" in slightly modified form for worksheet purposes (Hammit 1988). The findings of others (Noe 1988; Wellman et al. 1988) regarding the conditions of viewing, as opposed to the view itself, are also presented on the worksheet. The basis for the quality of viewing conditions is segregated into critical components on the worksheet [i.e., presentation of the view (i.e., focus) and special experience opportunities at each viewing location such as sounds, lighting, and temperature]. These components together form some immediate conditions around the viewer (foreground conditions) which help shape the aesthetic experience. This experience is tempered strongly by the opportunity to view. Time for viewing, the openness of the view, and the ability to stop and take good pictures all influence the opportunity to view.

On the worksheet, evaluation boxes to the left carry the least weight and those to the right, the most. In each box a response is chosen (working from left to right), and the outcome is then integrated into the next box in the evaluation process. The result at the right is an estimated aesthetic experience rating of 1 to 5, with 1 being outstanding and 5 being boring or negative. These ratings help compare the different views along Section 8B in a systematic way. They also help when considering the sequence of views and aesthetic experiences traveling in either direction on the proposed parkway. This helps to prioritize and manage the different viewing opportunities for specific purposes and values.

The limitations with such worksheets are that the unique combination of circumstances surrounding a viewing experience is not always easily categorized. Classifying special experience opportunities best exemplifies this limitation. Aspects of several different ratings in this box can apply at a single viewing site. In such a case, one must estimate a rating. This leaves room for different opinions. Any aesthetic evaluation would have such limitations even though extensive effort is taken to systematize the procedure. Consequently, results should be considered estimates. The benefit of this approach is that the rules of evaluation are defined and referenced.

The evaluations are based on conceptual road plans developed by the FHWA and the NPS, topographic maps, field (on-site) examinations, and use of worksheets developed specifically for this evaluation. Worksheets were employed later in the process to address the quality of views from points along the proposed parkway alignment which offer some significant view. A slightly different methodology is used to assess groups of views of the proposed parkway. The difference is that views from the parkway estimate the level of positive experience in viewing, while views of the parkway estimate levels of negative experience in terms of undesirable contrasts between the construction effects and the surrounding landscape.

# Aesthetic Experience Worksheet
# Foothills Parkway Section 8B
# *** Views From the Parkway Section ***

## *View 'A', Little Pigeon River, 1-400 to 1-680*

**Quality of View (pick one)**

Very Best – Water scenes with long views of series of receding mountain ridges and valleys
Best – Long views of receding mountain ridges or water scenes but not both; close views of wooded mountain streams
*Better** – Long but partially blocked views of mountain ridges or water scenes; more midground ridges than long view
Good – Midground views of opposing ridges; rustic valleys, little to no long views
Fair – Midground to foreground views of opposing ridges, close views of roads, traffic; development may be present

**Presentation of View (pick one)**

Best – View along outside of moderate road curve with long line of sight on road; view for 6+ seconds at speed limit
*Better** – View along outside of moderate/sharp road curve with moderate line of sight on road, view 4–6 seconds at speed limit
Good – View along straight roadside with long to moderate line of sight on road; view 3–4 seconds at speed limit
Fair – Along tight curves and short lines of sight on road; view less than 3 seconds at speed limit

**Foreground Condition (pick one)**

| Special Experience Opportunity | Presentation of View: Best | *Better* | Good | Fair |
|---|---|---|---|---|
| I | 1 | 1 | 1 | 2 |
| *II* | 1 | 2* | 2 | 2 |
| III | 2 | 3 | 3 | 3 |
| IV | 3 | 3 | 3 | 4 |
| V | 4 | 4 | 4 | 4 |

**Aesthetic Experience (pick one)**

| Viewing Condition | Quality of View: Very Best | Best | *Better* | Good | Fair |
|---|---|---|---|---|---|
| vg | 1 | 1 | 2* | 3 | 3 |
| g | 1 | 1 | 2 | 3 | 4 |
| m | 2 | 2 | 3 | 4 | 5 |
| f | 3 | 3 | 4 | 4 | 5 |
| p | 3 | 3 | 4 | 5 | 5 |

1 = outstanding; 2 = very good; 3 = positive; 4 = somewhat neutral; 5 = negative

**Special Experience Opportunity (pick one)**

I. Fall color; spring blooms; water sounds; cool in summer; very special lighting effects
*II.** Morning or evening back/side lighting; mists; winter ice/frosts; deep woods; cool wet smells
III. Wildlife viewing (birds, deer, etc.); special geology; cool woods smell; big trees; unusual vegetation; noticeable ecological processes
IV. Mostly normal mountain vegetation; little unusual lighting effects or sensory experiences expected
V. Blinding sun; heavy fog; bad smells; bad traffic situation; noisy; strong winds; dead and dying vegetation; hot in summer; trash in view

**Viewing Condition (pick one)**

| Opportunity to View | Foreground Condition: 1 | *2* | 3 | 4 |
|---|---|---|---|---|
| *A* | vg | *vg** | m | f |
| B | vg | g | f | f |
| C | g | m | f | p |
| D | g | m | f | p |
| E | m | f | p | p |

vg = very good; g = good; m = moderate; p = poor

**Opportunity of View (pick one)**

*A.** Horizontal view angle >180°; vertical view angle >20°; pull over present
B. Horizontal view angle 90–180°; vertical view angle 15–20°; pull over present
C. Horizontal view angle 45–90°; vertical angle 10–15°; pull over available; larger viewing angles with no pull over available
D. Horizontal view angle 30–45°; no pull over available
E. Horizontal view angle <30°; no pull over

Choices are marked with an asterisk.

**Fig. 57. Sample aesthetic evaluation worksheet.**

Foreground, midground, and farground*, as defined by Orr are useful terms in describing views (Orr 1973). This is because the expression of form, line, color, and texture in scenes changes with distance. These are the basic building blocks in scenic analysis. Consider, for example, how one might describe a tree 50 m away versus a clump of trees 2 km distant. Textures and forms change dramatically. When something new is introduced into a scene, such as a new road, it is seen differently at various distances in terms of contrasts (e.g., color, texture, line, form). It is therefore important to describe the distance terms and how perception generally changes with them.

### 3.8.4 Description of Key Aesthetic Development Sites

The description of affected aesthetic resources can be conveniently divided into the same segments of the ROW as in other parts of this report. Figure 58 shows 38 individual aesthetic sites along the parkway and which of 7 segments they fall into.

Segment 1 is the furthest west and includes cleared fields, barns, houses, the Little Pigeon River at close view, and scant views of the GSMNP (Fig. 58). Segment 2 contains the transition from lowland to upland conditions with opportunity for both lowland, near water views, and low-to-mid elevation views of the GSMNP to the south and southwest. The third segment contains views of the GSMNP from higher elevations as well as opportunities for quiet walkways and environmental interpretation. Segment 4 involves a winding slow descent along the top of a subridge to Webb Mountain. Many views along this segment are difficult to develop because of the winding parkway ROW and forests blocking views. Few interpretive opportunities, beyond environmental topics, are available for interpretation along this segment. Segment 5 provides the descent into, and climb out of, the Rocky Flats valley with few panoramic views but interesting views of old stone walls and farmsteads. Segment 6, along a low ridge, offers views of the GSMNP to the southeast where many succeeding ridges provide excellent panoramas. Most views are difficult to develop because of steep and complex topography. Segment 7 descends into Cosby Creek valley where there are opportunities for historical, stream-side, and environmental interpretation.

Thirty-eight aesthetic resource sites are identified on the map of Fig. 58. According to the methodology described early, most sites were evaluated for aesthetic qualities. Thirteen sites with a rating of 4 or 5 (low aesthetic quality) are identified with dots and were eliminated from further consideration. The final eleven sites were retained for detailed analysis and description. These are identified with stars in Fig. 58. Fourteen other sites have some potential for limited development but are considered lower priority (squares in Fig. 58). All sites are listed in Table 52.

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*__Foreground__ extends from the eye of the viewer to approximately 0.8 km (about 0.5 miles) away. It is often strongly defined by the texture of tree trunks, road surfaces, rock surfaces, forest floor, building siding, and tree leaves. It is also often affected by line and color. Form may be defined by such elements as houses (angular form), boulders (rounded to angular forms), and large tree trunks.

__Midground__ extends from 0.8 km to about 3 km (about 2 miles). The details of leaf shapes, tree trunk textures, and rock surface textures are lost and taken over by the texture of tree crowns, geologic forms (ridge tops), and differences between stands of trees (e.g., clumps of conifers in hardwood forests) and perceived by differences in colors and general textures of forests. The fine texture of young forest canopies can be differentiated from the rougher looking, large rounded crowns of trees in older forests.

__Farground__ extends beyond 3 km. The texture of tree stands fades into wooded and non-wooded differences. Colors became muted by the haze of distance unless special back lighting occurs. Forms or shapes of mountain ridges and valleys dominate the view.

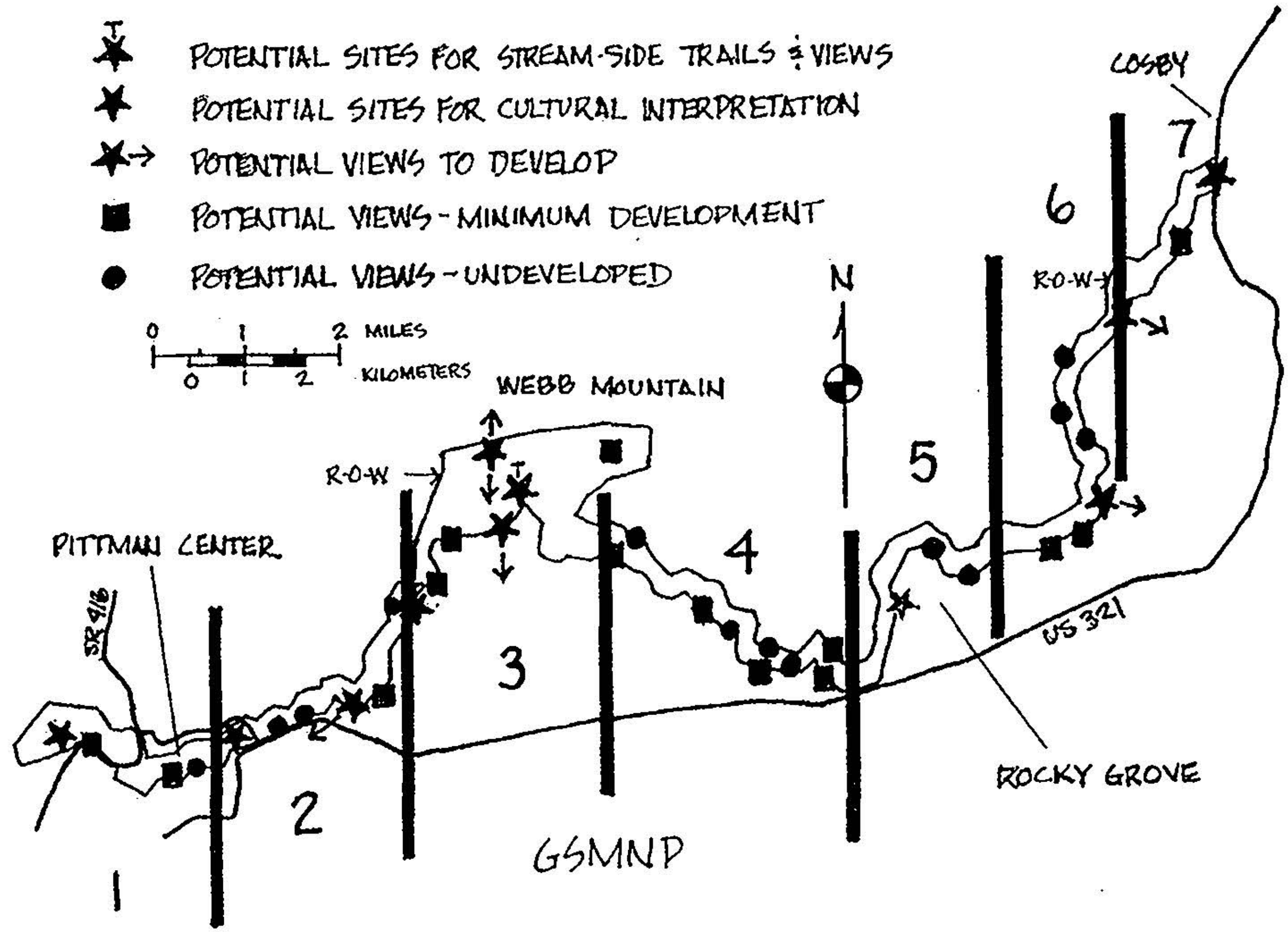


Fig. 58. The aesthetic resources of Section 8B are divided into these 7 segments.

**Table 52. The location and identification of views and interpretative sites along Section 8B of the proposed Foothills Parkway. These sites were identified after consideration of development constraints, opportunities, and maintenance requirements.**

| Symbol as appears on Fig. 58 | Segment number | Roadway station | Rating and view identification | | Description |
|---|---|---|---|---|---|
| Star | 1 | 1-400 to 1-680 | 1-2 | 1A | West terminus at Little Pigeon River |
| Square | 1 | 1-400 | 2 | 1A1 | North ramp alternative assumed; combine with 1A |
| Square | 1 | 2-170 | 3 | 1B | View of tunnel assumed, steep cuts avoided |
| Dot | 1 | 2-170 | 4 | 1C | Tunis Branch lateral views of small valley, small cleared fields, thinned forests |
| Star | 2 | 2-380 to 2-970 | 2 | 2A | Webb Creek valley view of water, hayfields, and some rural houses |
| Dot | 2 | 2-870 | 4 | 2A1 | Alternative terminus access not assumed |
| Dot | 2 | 3-400 | 4 | 2B | View south at alternative terminus site |
| Star | 2 | 4-580 to 4-700 | 3 | 2C | Good westerly view of GSMNP with tree clearing |
| Square | 2 | 4-940 to 5-200 | 2 | 2D | Narrow view south toward Timothy Creek, clearing at issue |
| Dot | 2 | 6-000 | 5 | 2E | Close view of wooded valley to southwest |
| Square | 3 | 6-300 to 6-400 | 2 | 3A | Narrow view south on curve toward Lower Mill Dam Creek |
| Star | 3 | 6-500 to 7-200 | | 3A1 | Stream-side interpretative trail opportunity |
| Square | 3 | 7-810 | 3 | 3B | Short view down Warden Branch (southeast) to GSMNP |
| Star | 3 | 8-120 to 9-170 | 1 | 3C | Composite views south from lower parking lot and Parkway |
| Star | 3 | 8-700 | 2 | 3C1 | Trail to scenic view south of GSMNP |
| Star | 3 | Upper parking | 1 | 3D | Upper Webb Mountain parking panorama |
| Square | 3 | Parking access road | 2 | 3E | North view to English Mountain on sharp curve |
| Square | 4 | 10-450 | 3 | 4A | South view from Blackgum Gap, 2+ ha of tree clearing |
| Dot | 4 | 10-450 | 4 | 4B | North view from Blackgum Gap, limited sight distance |

**Table 52. Continued**

| Symbol as appears on Fig. 58 | Segment number | Roadway station | Rating and view identification | | Description |
|---|---|---|---|---|---|
| Square | 4 | 11-500 to 11-950 | 1 | 4C | Southwest view from Table Ridge, 1+ ha of tree clearing |
| Dot | 4 | 12-370 | 4 | 4D | Branam Hollow view east, very narrow |
| Dot | 4 | 12-670 | 4 | 4E | Pine Cove view northeast, close view only |
| Square | 4 | 12-670 | 3 | 4F | View south up Texas Creek to GSMNP, clearing needed |
| Dot | 4 | 12-760 | 4 | 4G | Close view north of evergreens, very plain scenery |
| Square | 4 | 13-250 to 13-450 | 3 | 4H | 2nd best of squares, view south-southeast with pull-over space |
| Square | 4 | 13-700 | 2 | 4I | View southeast, pull-over, extensive forest clearing required |
| Star | 5 | 15-050 to 15-600 | 3 | 5A | Valley alternative for aesthetics, stream, old stone walls, small fields, and several houses |
| Dot | 5 | 16-400 | 4 | 5B | Shults Grove Church, very closed in but stream near |
| Dot | 5 | 17-000 | 4 | 5C | Rocky Grove view south but closed in by near ridge |
| Square | 6 | 17-860 | 3 | 6A | View south to GSMNP but very near development |
| Square | 6 | 18-300 | 3 | 6B | View southeast toward Buckeye Creek, too steep for pull-over development |
| Star | 6 | 18-800 | 4 | 6C | View east spectacular if developed, but narrow view |
| Dot | 6 | 19-410 | 4 | 6D | View northeast out Sandy Hollow, view quality marginal |
| Dot | 6 | 19-900 | 4 | 6E | West view down valley into near opposing ridge |
| Dot | 6 | 20-500 | 5 | 6F | View down Chavis Creek, short view to opposing ridge |
| Star | 7 | 21-200 | 3 | 7A | East-southeast view up GSMNP ridge w/pull-over at Camp Creek |
| Square | 7 | 22-570 to 23-160 | 3 | 7B | East view from low elevation near terminus |

**Table 52. Continued**

| Symbol as appears on Fig. 58 | Segment number | Roadway station | Rating and view identification | | Description |
|---|---|---|---|---|---|
| Star | 7 | 23-800 | 3 | 7C | View of stream and rural development along Cosby Creek and community |

Figure 59 identifies only those areas selected for potential aesthetic development along the proposed parkway.

Table 52 demonstrates that significant visual resources exist along the proposed route of the parkway. It also indicates that some of these resources would exist without the development of pull-overs or parking lots. However, maintenance of some vegetation to keep views clear would be needed to retain these visual resources.

Eleven sites would offer especially improved aesthetic experiences if developed. These sites include several with close views, opportunities for interpretive development of culture or environment, or quiet walkways along streams or to panoramic viewing points. Some of the close viewing opportunities include flood plains, wetlands, houses, old rock walls, and archaeology. Table 53 lists only the sites selected for potential development and detailed analysis.

**Site 1A**

Site 1A is at the west terminus of Section 8B and lies within the floodplain of the Little Pigeon River. Small hay fields, cabins, and SR 416 occupy the location. Low wooded hills surround the valley and do not permit views of the GSMNP. Here, the parkway would emerge from a small gap onto a high bridge spanning one of the fields, Copeland Creek (a very small stream), and the Little Pigeon River. SR 416 would pass under the bridge (see Fig. 60). This picturesque location would require vegetation management along the Little Pigeon River to allow it to be visible to viewers. Since the area would be at a possible exit/entrance point for the parkway, more viewing may occur due to slower traffic. Enhancing the visibility of the river, cabins, and fields would be important.

Figure 60 illustrates the emergence of the parkway into the Little Pigeon River floodplain. The figure shows how important trees would be in screening road cuts where the parkway would emerge from the hills onto the overpass. Without these trees, the parkway would impress an engineered (non-natural) component in the view.

The area would be somewhat congested with the two bridges over the river and two existing roads as well as two intersections being somewhat close to one another at both ends of the short exit ramp (Fig. 61). Pull-over parking development on the parkway would not be safe on an overpass or near the intersection with the exit ramp. The only opportunity for stopping and interpretative development would be to locate a small parking area to the southwest of the intersection of the exit ramp and parkway. From such parking, trail development and small picnic facilities would be possible toward the parkway bridge (not the exit ramp) where it passes over the Little Pigeon River. About 0.5 to 0.75 hectares (1 to 2 acres) could be cleared or thinned to improve aesthetics in the area.

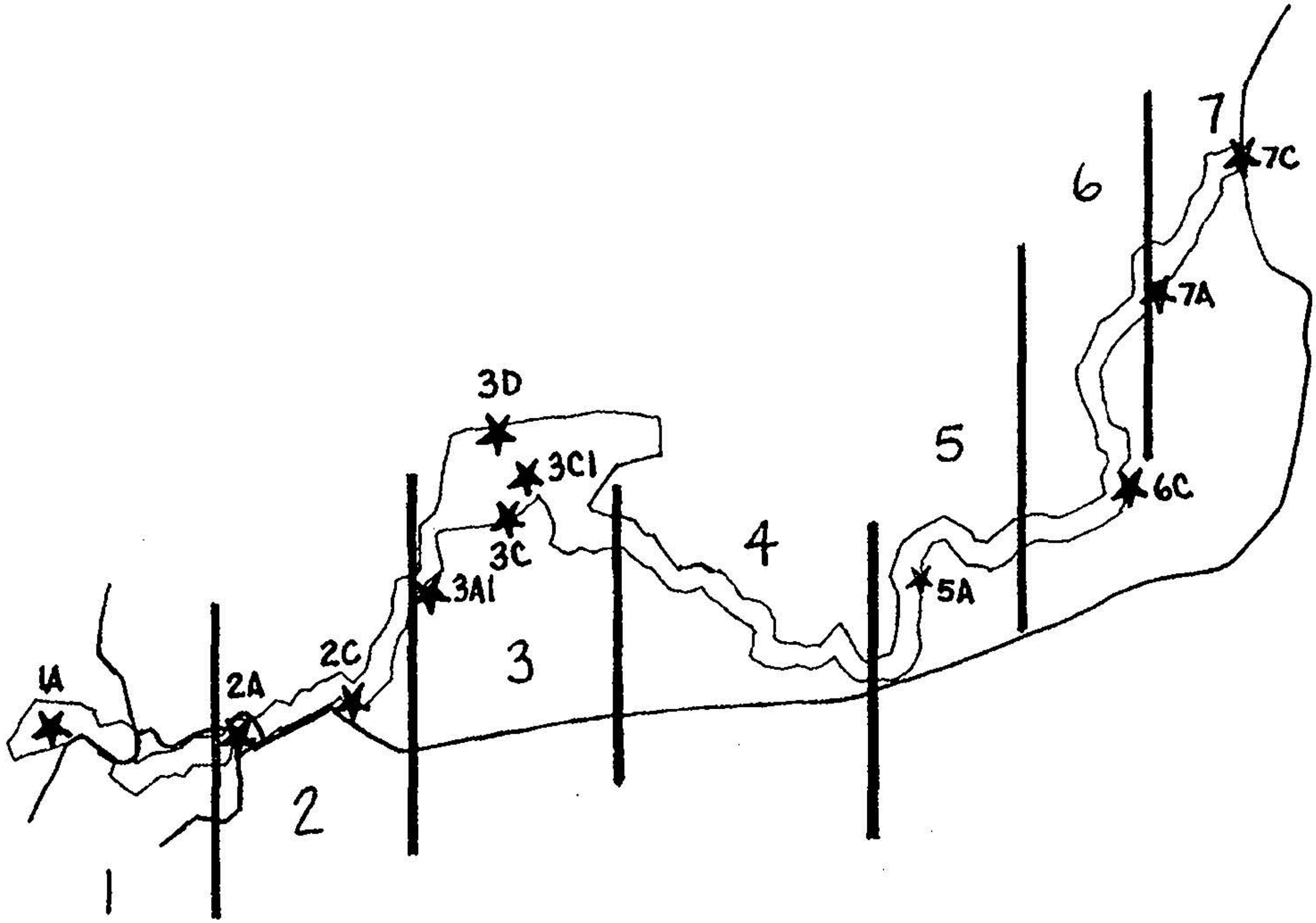


Fig. 59. The location and segment of sites for potential aesthetic development within the ROW of Section 8B.

**Table 53. Sites selected for potential development along Section 8B of the Foothills Parkway**

| Symbol as appears on Fig. 58 | Segment number | Roadway station | Rating and view identification | | Description |
|---|---|---|---|---|---|
| Star | 1 | 1-400 to 1-680 | 1-2 | 1A | West terminus at Little Pigeon River |
| Star | 2 | 2-380 to 2-970 | 2 | 2A | Webb Creek valley view of water, and Pittman Center features |
| Star | 2 | 4-580 to 4-700 | 3 | 2C | Good westerly view of GSMNP with tree clearing |
| Star | 3 | 6-500 to 7-200 | | 3A1 | Stream-side trail with interpretative opportunity |
| Star | 3 | 8-700 | 2 | 3C1 | Trail to scenic view south of GSMNP, stream nearby |
| Star | 3 | 8-120 to 9-170 | 1 | 3C | Composite views south from lower parking lot and parkway |
| Star | 3 | Upper parking | 1 | 3D | Upper Webb Mountain parking panorama |
| Star | 5 | 15-050 to 15-600 | 3 | 5A | Valley alternative for aesthetics, stream, old farming features |
| Star | 6 | 18-800 | 4 | 6C | View east spectacular if developed, but narrow view |
| Star | 7 | 21-200 | 3 | 7A | East-southeast view up GSMNP ridge w/pull-over at Camp Creek |
| Star | 7 | 23-800 | 3 | 7C | View of stream, Cosby Creek, and community |

Part of the aesthetic package at this location is the view from the parkway looking west as one travels west onto the overpass to view the Little Pigeon River floodplain.

Coming into the area just under tree-top level would not enable long distance viewing. However, this would focus greater attention to river and valley landscapes.

Some travelers who would access the parkway from U.S. 321 would have a slow, short drive along a narrow winding road that, along one stretch, is only feet from Webb Creek. Close-up viewing of this shaded, cool, damp, mountain stream is an excellent aesthetic experience. This short access road also passes through a portion of Pittman Center, an historic cultural center for the area.

**Site 2A**

At the location of site 2A, the parkway would cut across the small floodplain of Webb Creek. The parkway would run for some distance along the edge of a field with Webb Creek on the opposite

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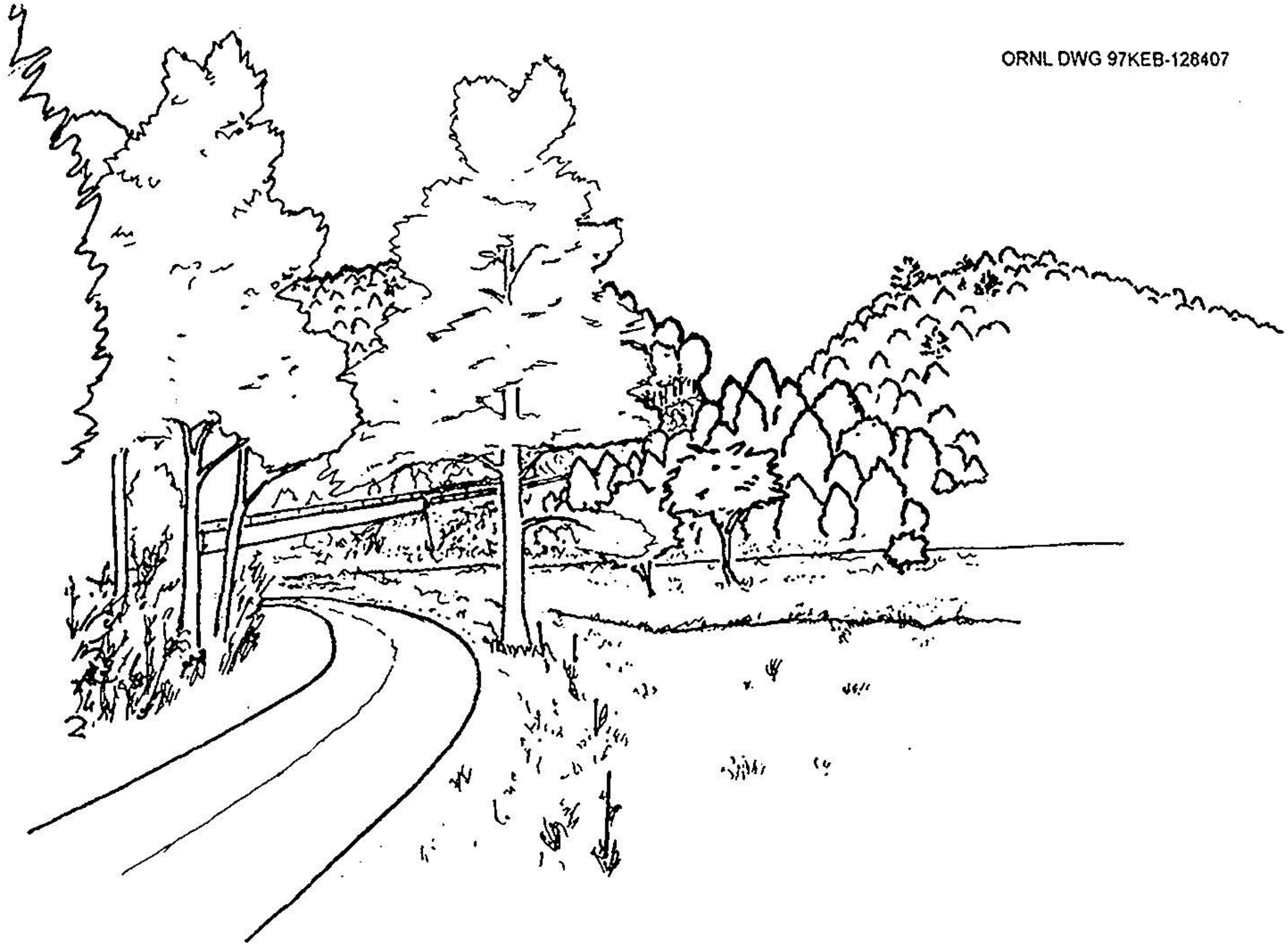

Fig. 60. This sketch shows how the parkway might emerge from low mountains into the open floodplain of the Little Pigeon River. The view is from state route 416 looking east, near site 1A.

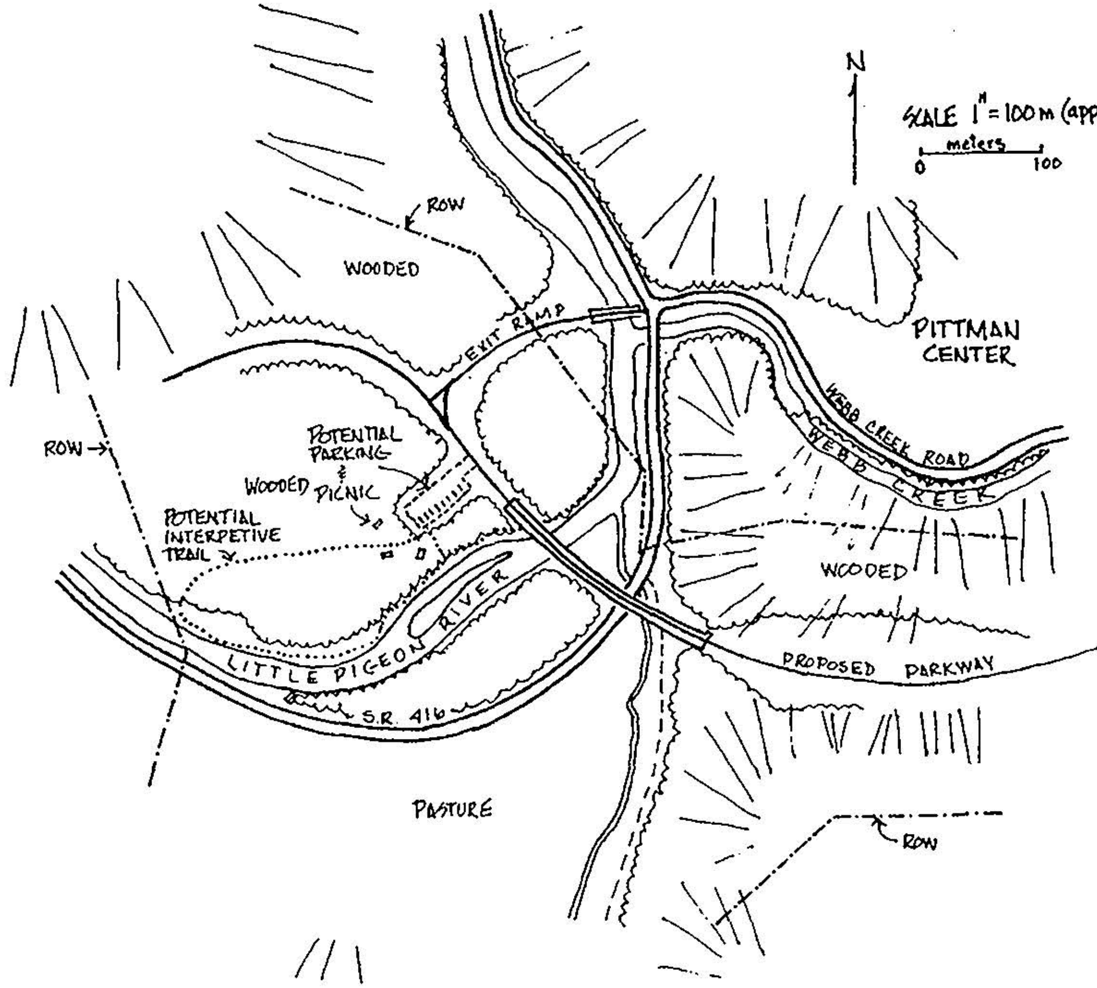


**Fig. 61. Sketch of the western terminus of Section 8B at site 1A where aesthetic developments would offer interpretive opportunity. Parking, picnic, trail, and interpretive opportunities could be located as shown. Some maintenance of wooded vegetation would be needed to improve views of the Little Pigeon River.**

side of the field (Figs. 62 and 63). Small open fields and the element of water would be important aesthetic elements to develop. Maintenance of stream-side vegetation to allow stream viewing would be necessary to improve the viewing experience. As with site 1A, the floodplain is surrounded by low wooded ridges which prevent viewing of the GSMNP. Pull-over opportunities exist in the floodplain and next to the fields for interpretive cultural stops on early 19th century settlement of the area and the history of nearby Pittman Center.

Where the parkway would descend into the Webb Creek floodplain from the east, a highly visible road cut on a steep slope would be imposed. The need would exist for retaining walls to minimize the exposure of these cuts along such a natural valley and stream. parkway travelers headed east across Webb Creek valley would be subjected to direct close views of the road cuts just mentioned. Plans would include retaining walls. Gray stone would be the most aesthetically desired material.

**Site 2C**
This site occurs at about 500 to 510 meters elevation in complex, steep terrain (winding parkway). It occurs between road station 4-580 and 4-700 on a short straight stretch of parkway between two turns curving in opposite directions. The section would probably be seen from U.S. 321 headed east. Approaching curves to the viewing stretch along the parkway make stopping for pull-overs somewhat hazardous so pull-over development is not recommended.

Enhancing the viewing opportunity to the west (an outstanding view) would require the clearing of trees. This could be as much as 75 meters out along a low ridge extending west from the parkway and about 50 meters wide (about 0.4 hectares or 1 acre). Along the rest of the stretch of this view, only nearby vegetation on road fills would need control. At the two ends of this stretch, additional trees could be removed to extend the length of view (see Fig. 64).

Only one parkway fill area would be seen from site 2C (see Fig. 64). Others to the west would be hidden from view by forest vegetation on ridges near the parkway. U.S. 321 may possibly be seen from site 2C, depending on the extent of vegetation clearing to view the GSMNP and the location of the viewer along the parkway.

**Site 3A1**
The site does not offer panoramic viewing of the GSMNP but is included for development to provide an interesting interpretive trail to a small, well shaded mountain stream (Sheep Pen Branch) (see Fig. 65). A lightly used hiking trail also passes across the site. Pull-over parking for 5 cars on an extended shoulder is possible near road station 7-100. The site could be developed as a quiet walkway involving nature interpretation and proximity to water.

**Site 3C**
Except for the panoramic view atop Webb Mountain (site 3D), site 3C offers the best viewing opportunity of the GSMNP. This site is the location of a proposed parking lot and would involve maintenance of vegetation to provide excellent viewing directly south. Figure 66 illustrates the view which includes a series of succeeding ridges most of which are visible even on hazy days. Views to the east are restricted by a nearby side ridge. Views to the west are less restricted and provide the best views.


**Fig. 62. An oblique aerial photograph of the site 2A area. Webb Creek appears in the center of the photo while U.S. 321 appears to the right.**

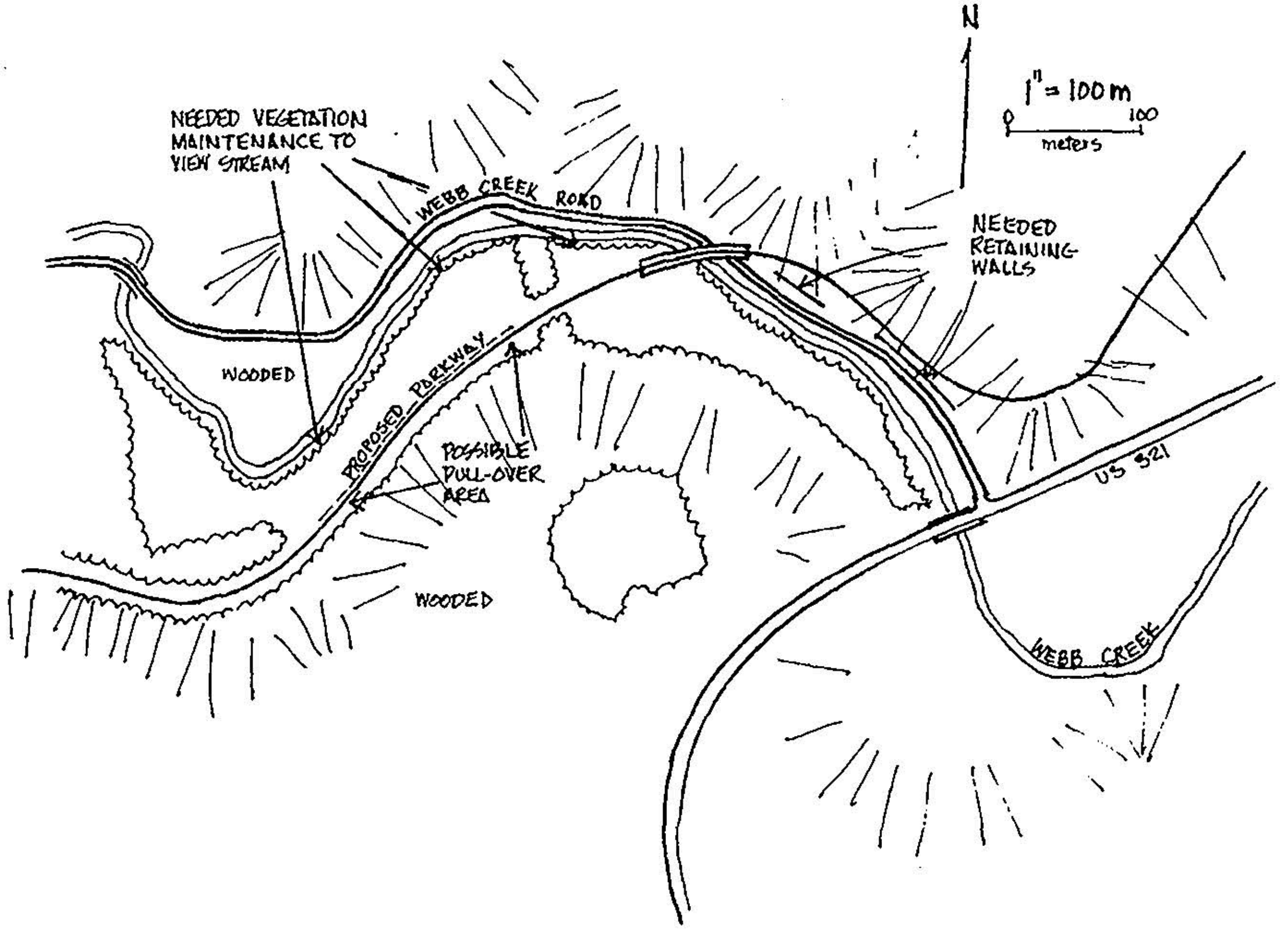


Fig. 63. Sketch of the proposed parkway passing through Webb Creek valley near U.S. 321 at site 2A. The main aesthetic features are the open fields, stream, and surrounding hillsides. Possible actions to improve aesthetics include retaining walls near U.S. 321, development of a pull-over, and some vegetation clearing and maintenance along parts of Webb Creek.

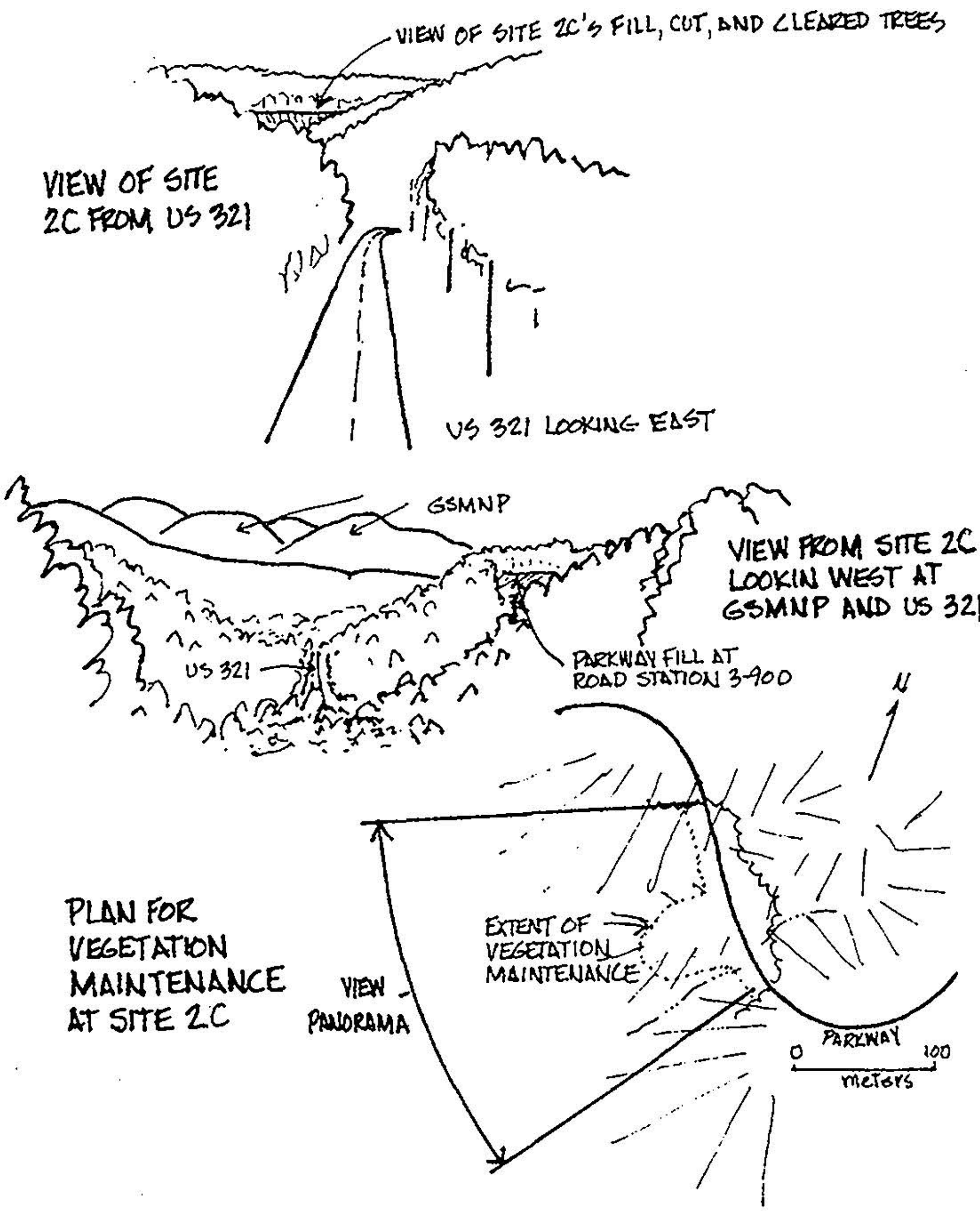


Fig. 64. Sketches of various aspects of site 2C.

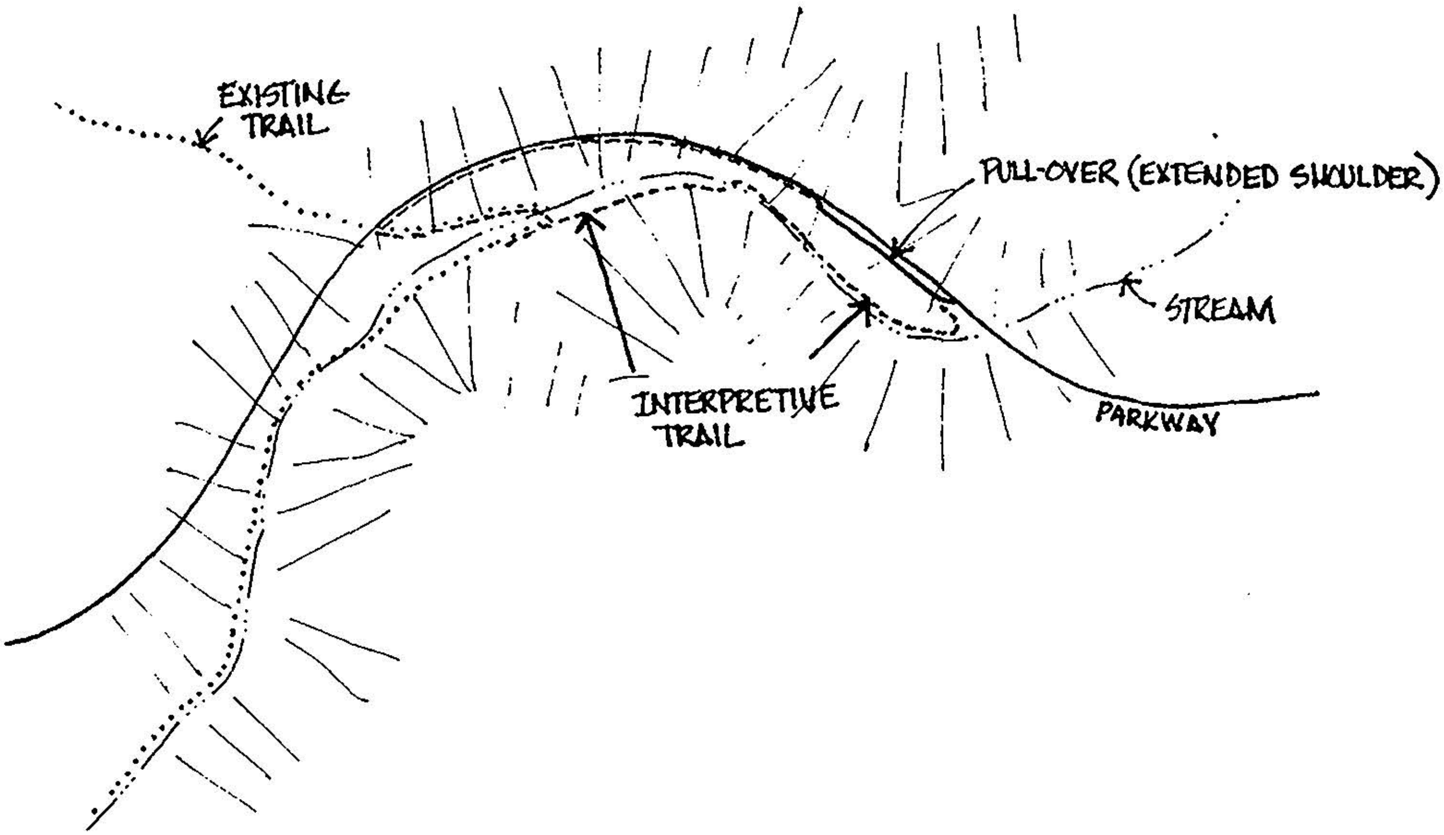


**Fig. 65. This quiet mountain stream walkway would provide interesting interpretive information about nature and some variation in activity for certain parkway travelers.** ***This site, site 3A1, may also act as a trail head for more ambitious hikers.***

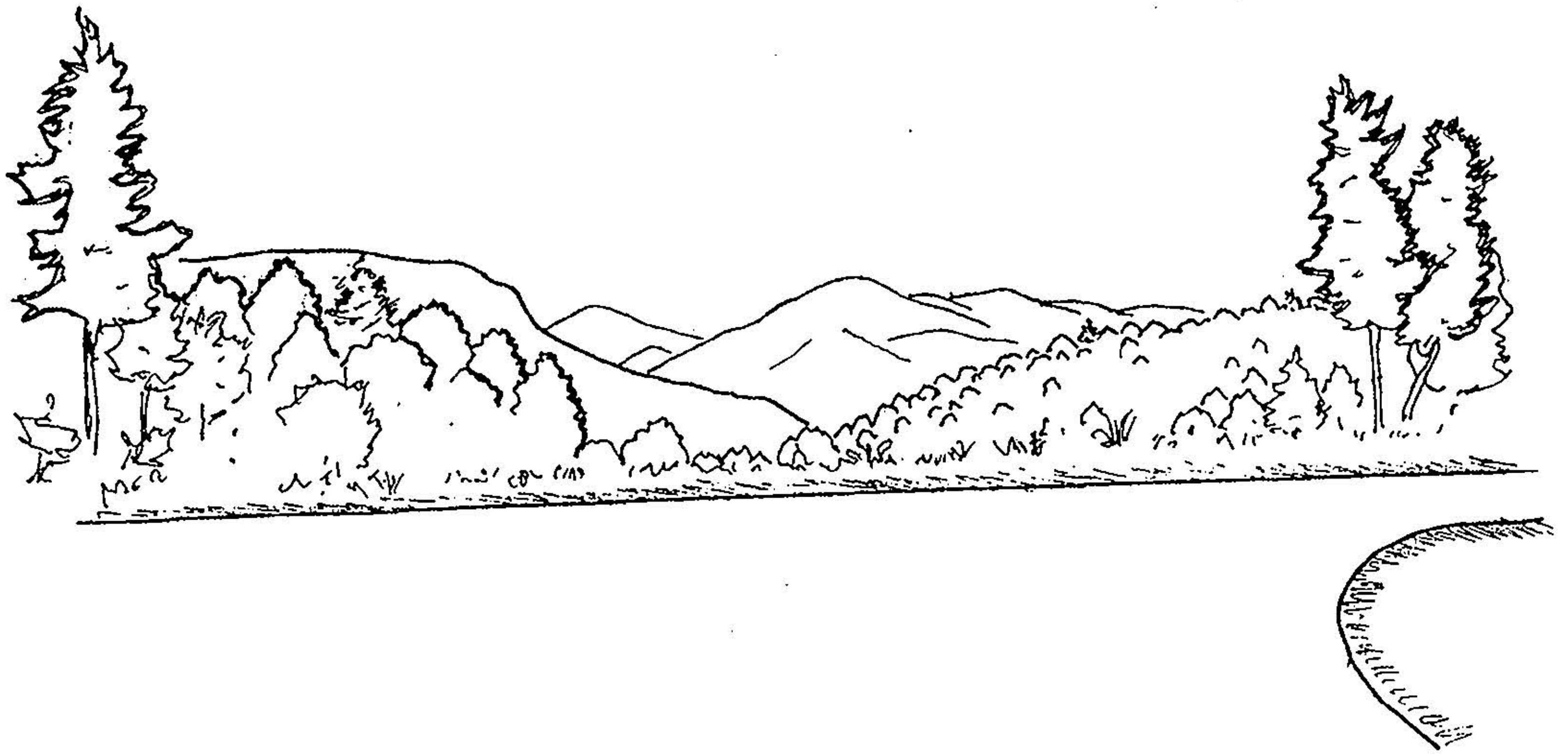

**Fig. 66. This sketch from the parking lot of site 3C shows the panoramic view of succeedingly more distant ridges of the GSMNP.**

In the vicinity of site 3C, there is a series of significant road cuts and fills that offer viewing opportunities to the east and west. Maintenance of vegetation at nearly every major cut along this site would be required. Approximately 2 to 2.5 hectares (5 to 6 acres) of vegetation would need to be maintained (see Fig. 67).

Site 3C is in the proximity of Cobbly Nob, a planned community of resort homes. Very little of the parkway would be seen from this housing development (Fig. 68) since topography and housing orientation focuses south, away from the parkway and toward the GSMNP.

**Site 3C1**
Site 3C1 is on a small ridge top to the east of the parking lot identified in site 3C. Investigation showed that an improved view of the GSMNP could be gained by climbing this ridge, a relatively easy, short climb. Figure 67 shows the location of this trail and the vegetation that would need to be periodically maintained for the best viewing. Since this view would be from a trail, only about half the trees in the identified zone for vegetation maintenance would have to be cut. Figure 69 illustrates the view from this location which is principally to the southwest. One can see the parking lot of site 3C in the lower right corner of the sketch.

***Site 3D***
This is the proposed site of the upper parking on top of Webb Mountain. It would offer panoramic views unmatched by any others of the parkway. Figure 70 illustrates the kinds of views to the east (top sketch), south (middle sketch), and west (bottom sketch), all of the GSMNP. In addition to this view is a spectacular view to the north of English Mountain, other foothills, and the developed valleys beyond. About 210 degrees of viewing is possible at this 850 meter (2800 ft) elevation. As much as 270 degrees of viewing is possible from the trail at the very peak of the mountain. Only to the west is the view blocked by vegetation.

The view in different directions would require moving around a loop parking lot just below the very peak of Webb Mountain. A short trail to the top would offer some excellent viewing to the west. Figure 71 illustrates a possible layout of the upper parking lot and areas where vegetation would need to be maintained for viewing. Retaining walls would reduce the extent of fill toe slopes, and would not affect the extent of maintained vegetation and the visibility of the mountain top from surrounding locations.

As Fig. 71 illustrates, the major variable in viewing is the extent to which trees are cleared and maintained so as not to obstruct views. In Fig. 71, there are several locations where vegetation is maintained out to 75 meters (250 ft) from the loop with most distances are closer to 50 meters (165 ft). Trees were assumed to be no more than 25 meters (82 ft) tall. Most trees are shorter, requiring less clearing than Fig. 71 shows. The worst case scenario would involve clearing and maintaining almost 4 hectares (nearly 10 acres) of vegetation.

The cleared area atop Webb Mountain as viewed from other locations such as U.S. 321, trails in the GSMNP, and Cobbly Nob would sometimes be visible, especially on clear days. Little should be seen from the Cobbly Nob development. There would be minimum exposure to U.S. 321 viewing. However, the cleared area atop Webb Mountain, along with the upper reaches of the parkway would be seen from selected trails in the GSMNP at a distance of 5 to 8 km (3 to 5 miles) or more on clear days (Fig. 72).

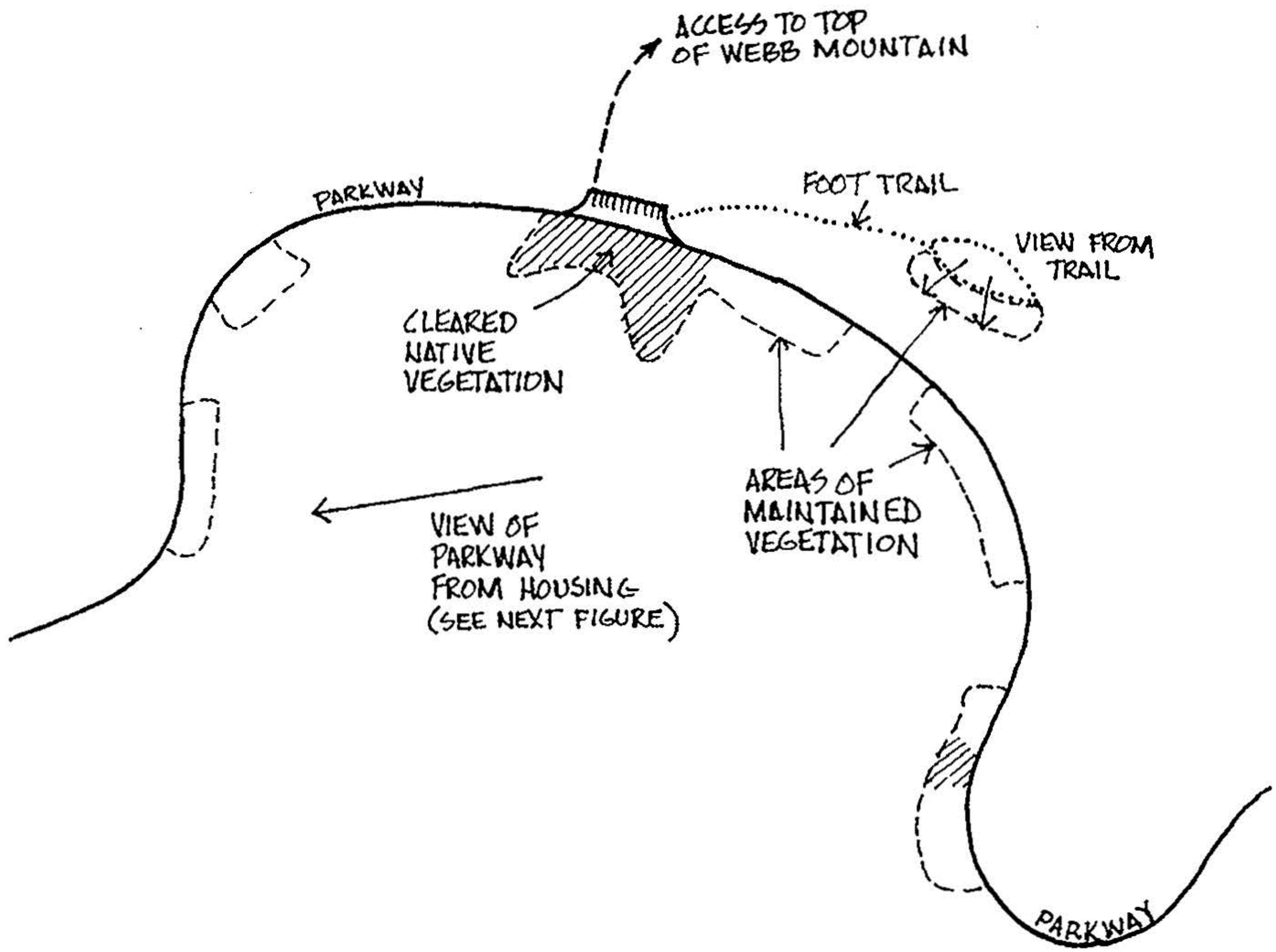


**Fig. 67. This sketch shows the extent of vegetation that will need to be maintained to capture the viewing resources of site 3C. Most clearing will extend no more than 30 meters (98 feet).**

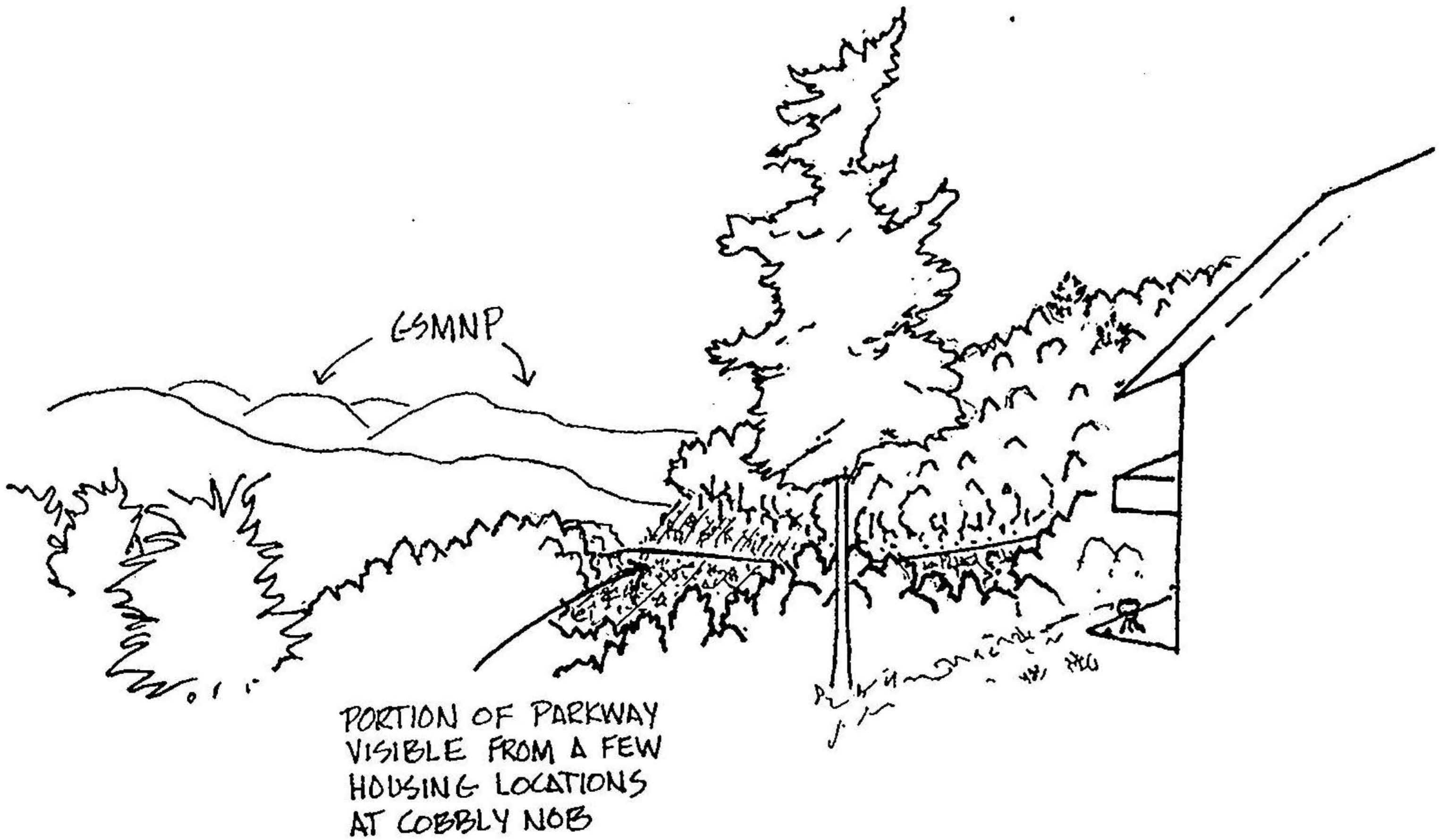


**Fig. 68. The most westerly portion of 3C may be seen from this housing development as illustrated.**

Fig. 69. A sketch of the expected view from 3C1 atop a ridge near the lower parking lot on Webb Mountain. This view could be accessed by trail and would require clearing of some trees.

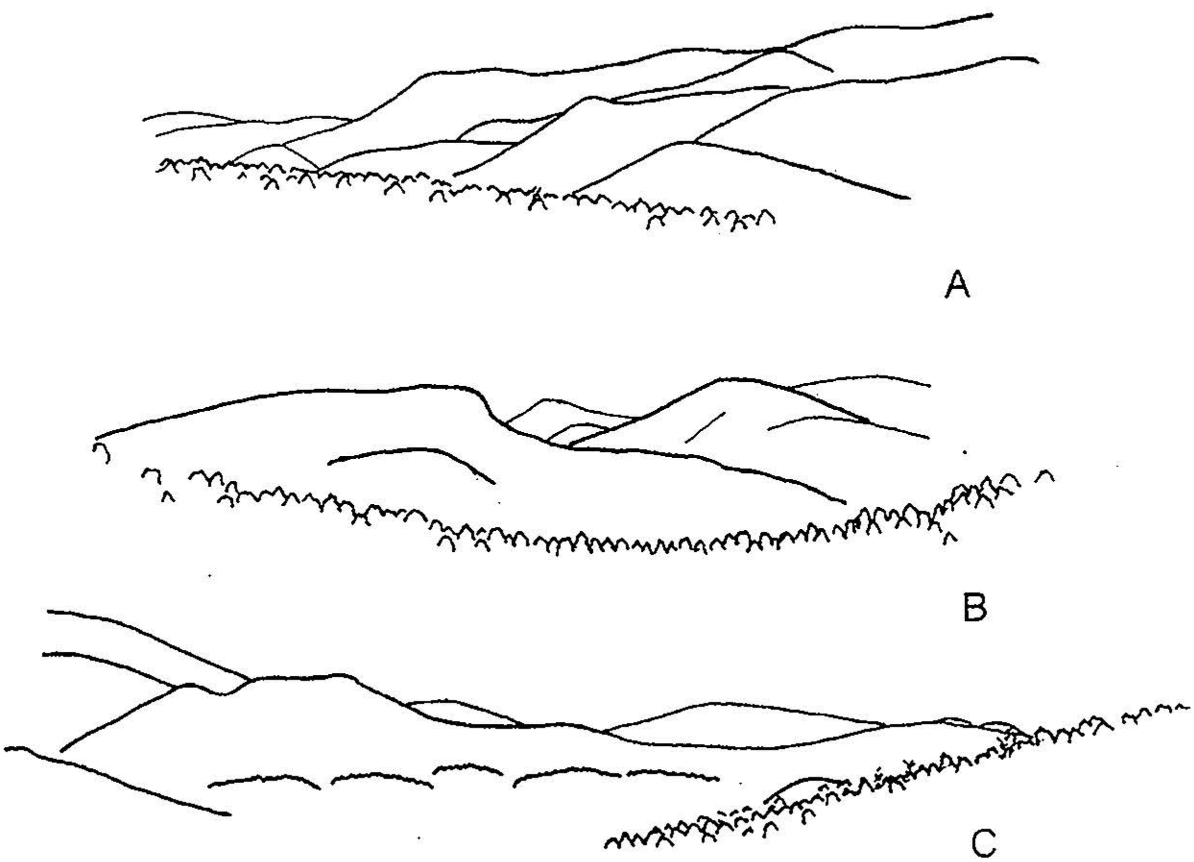


**Fig. 70. Illustrations of the kinds of views to the east (top sketch), south (middle sketch), and west (bottom sketch) of the GSMNP.**

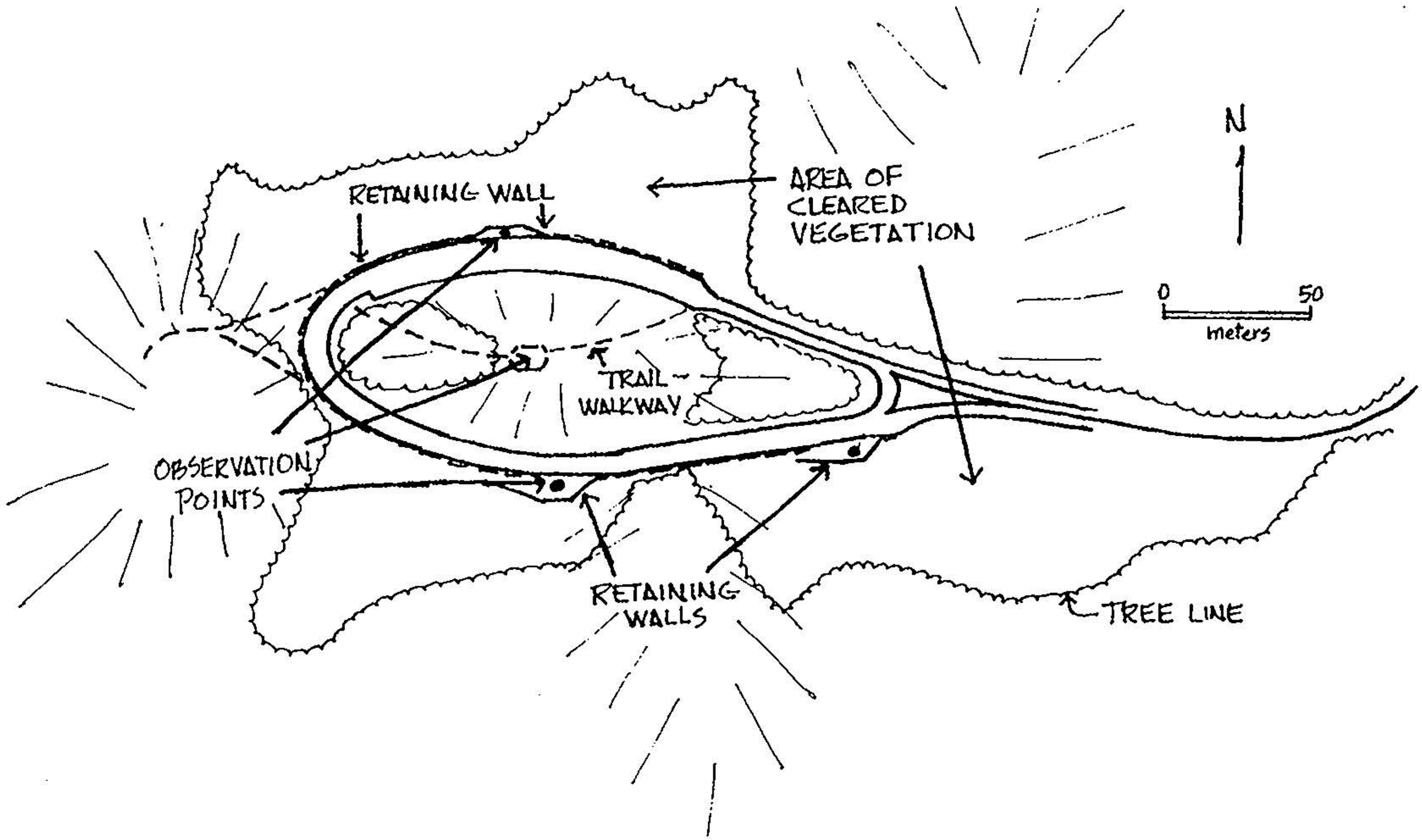


**Fig. 71. Plan sketch of the upper parking lot atop Webb Mountain. The illustration shows the possible extent of vegetation clearing to maintain panoramic views.**

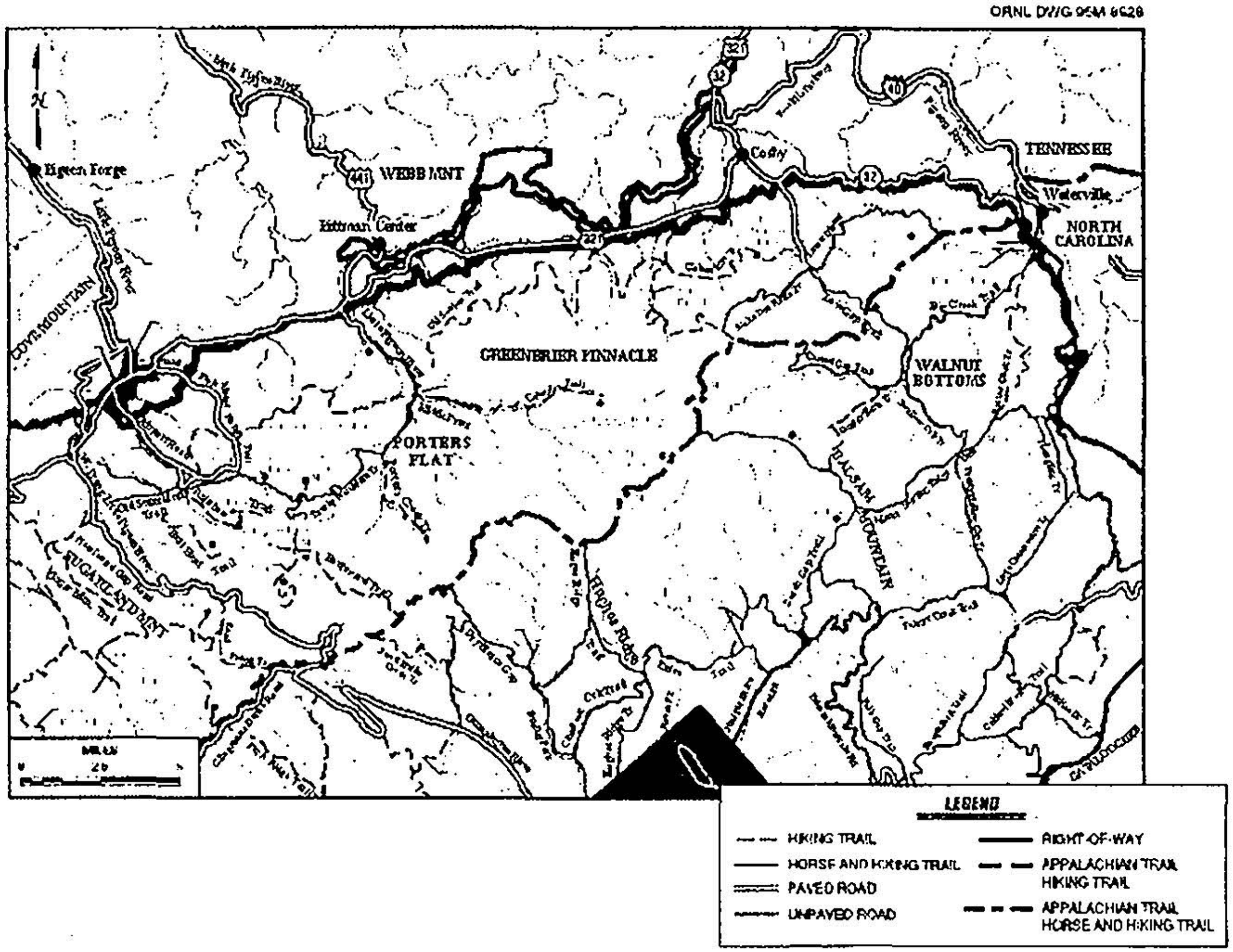


**Fig. 72. Foothills Parkway Section 8B right-of-way in relation to the Great Smoky Mountains National Park trails and other features.**

**Site 5A**
Site 5A is where the parkway descends into the valley of Rocky Flats. Of two alternative alignments, the valley floor alternative paralleling a stream is preferred due to the extensive unsightly road cuts necessary for the hillside alternative.

This site does not offer panoramic viewing but has good opportunity for development of interpretive resources. Proximity to a stream, a valley with historical development, and interesting rock fences comprise this mostly wooded valley. This short, relatively straight, level stretch of parkway would easily accommodate pull-over parking. Potential impacts to wetlands and slope stability may occur and should be considered prior to development (see Sects. 4.2, 4.3, and 4.4 for additional details). Trails are not suggested for this site. Rather, interpretive signs recognizing the historical significance of the area are suggested. Figure 73 depicts the general kind of development assumed for this site. About 0.25 hectares (0.6 acres) of additional forest clearing would be necessary for the pull-overs.

If site 5A is not conducive to such development upon closer inspection, site 5B may offer a suitable alternative with similar development objectives. It is located on the opposite side of Rocky Flats.

**Site 6C**
Site 6C occurs where the parkway, heading east, sharply turns north following the top of an intermediate ridge with an elevation of over 600 meters (1,970 ft). Wooded side ridges block most panoramic views.

This site spans a slight gap with a steep side slope and large road fill to the east. Being at the headwaters of Indian Creek, side ridges confine the panorama of the view, especially to the northeast. However, the focus of the view is a long easterly view of succeeding side ridges along the spine of the GSMNP and beyond. Because the view is so good and because the site is conducive to pull-over parking, it is identified as a developable site. A road and some private home development occurs downslope but would not be seen from the parkway.

Vegetation maintenance is again an issue. Most of the road fill would have to be maintained in short vegetation. This would extend downslope from the parkway as much as 50 meters (165 ft). On the south side of the road fill, additional vegetation would need to be cleared and maintained for about another 50 meters (165 ft). This clearing is important because some of it would be in the foreground view, directly ahead at eye level as opposed to being downslope. Figure 74 illustrates the location of the road fill, vegetation maintenance, and pull-over. Figure 75 is a sketch of what the view may look like. The total area of vegetation to be kept cleared and maintained is about 0.5 hectares (less than 1.5 acres).

**Site 7A**
Site 7A would offer spacious parking, a view to the south-southeast (toward Mt. Cammerer), and would be located along a fairly level and less winding portion of the parkway. The panorama of the view is limited to the east by another ridge. This site would be easier to develop than 6C and captures almost as much scenery of the GSMNP, including a series of succeeding ridges, but at closer range. The parking area could be separated from the parkway by a parking island and

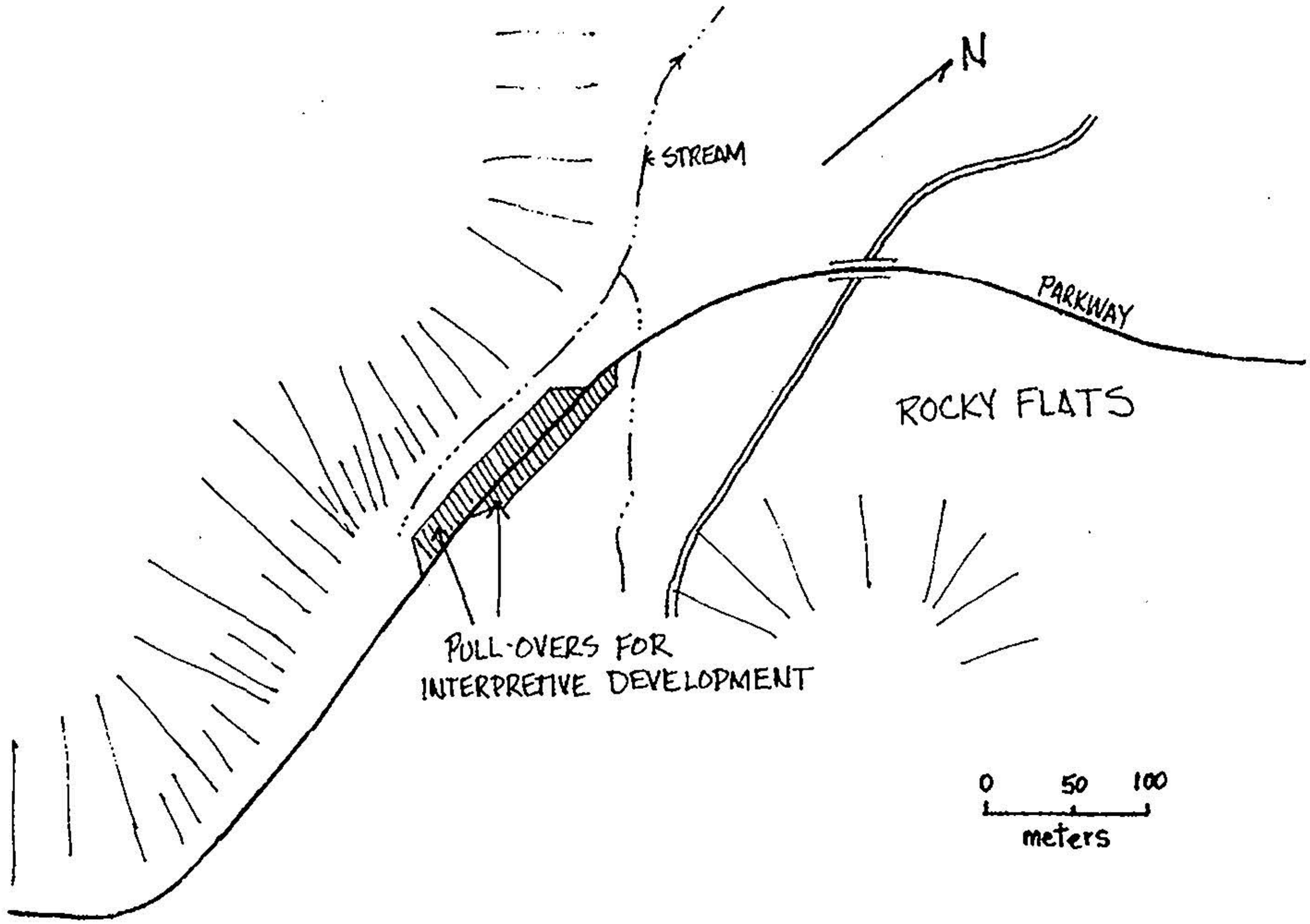


**Fig. 73. Sketch of site 5A at Rocky Flats (Rocky Grove) showing the location of pull-overs for interpretive development of cultural and environmental resources.**

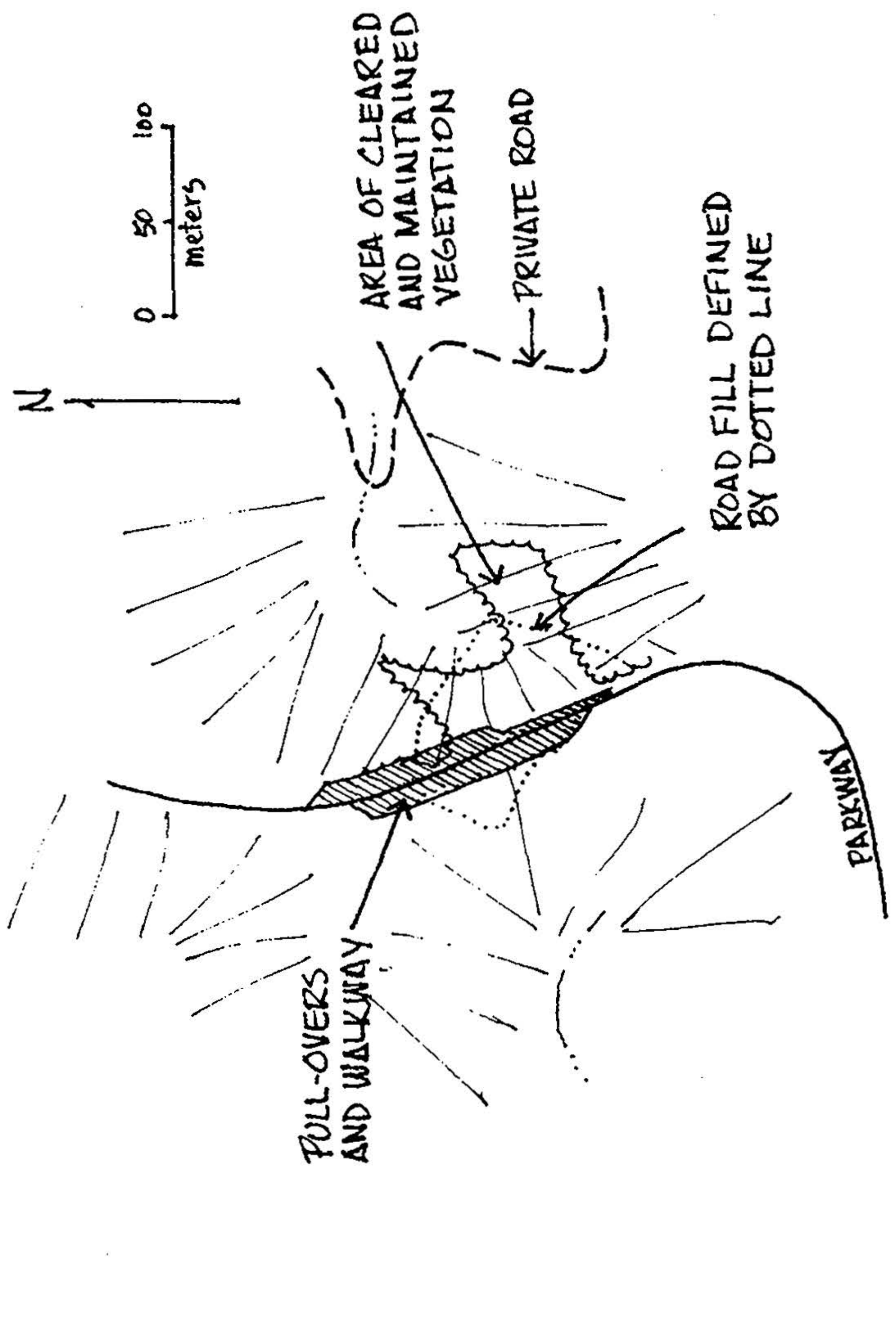


**Fig. 74. Sketch of possible development of site 6C.**

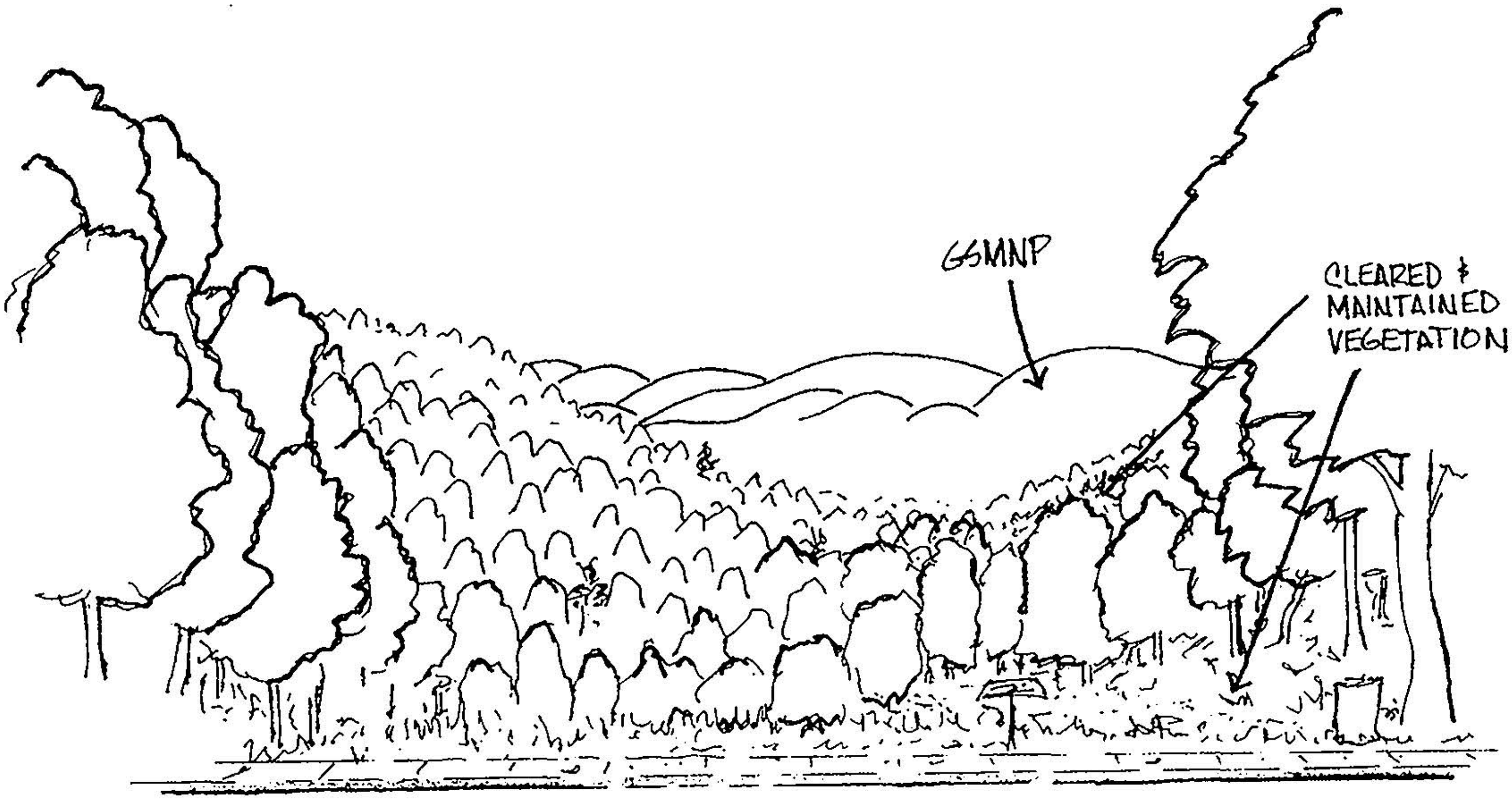


**Fig. 75. A sketch of what the view to the east of the GSMNP would look like from site 6C.** Note the foreground and midground vegetation clearing to the right of the sketch. Also note the long series of succeeding ridges in the center background.

involve pull in parking (Fig. 76). The amount of cleared vegetation to be maintained would be just over 1 hectare (about 2.6 acres).

**Site 7C**
Site 7C is the eastern terminus of parkway Section 8B. Here, 8B would connect with the completed Section A. This is in the Cosby Creek Valley bottom of Cosby which has historical churches, signs of agricultural settlement in the early 1800's, and Cosby Creek. Much of the surrounding area is in open fields and widely scattered development from early and mid twentieth century development. There are two alternatives for the exit ramp from the parkway to State Route 32. The southern alternative is shown in Fig. 77. The northern alternative would be to the northeast of the parkway bridge.

Potential aesthetic development of the site involves parking lot construction, trail development, and interpretative improvements to address local history. A map of the parkway highlighting stops, topography, and geology could also be included. The purpose of the siting of the parking lot and trail was to avoid future conflict with a possible realignment of the exit ramp and SR 32 (Fig. 77). Interpretive development to the north of the parkway would place activities too close to the nearby intersection.

The developed area would capture the cool, shaded condition along Cosby Creek. The valley view would be captured from the parkway at, and to the east of, the bridge crossing Cosby Creek. For this to be effective, trees may need to be thinned in the location of the hatched area on Fig. 77. Total forest affected may be about 0.8 hectares (about 2 acres).

### 3.8.5 Views of Section 8B

There is a major difference in the evaluation of views *from* the parkway and of views *of* the parkway. Generally, views from the parkway toward the GSMNP capture landscapes in their natural or existing element. Therefore, evaluations assessed the degree of positive experiences in the views. The methodology for doing so was presented earlier. Composite features (e.g., ridges, water, lighting effects, breadth of view) were used to define experiences based on surveys. In contrast, views of the parkway were assumed to be primarily negative. The methodology for assessing the degree of negative effects and possible actions for mitigation was devised by the United States Department of Agriculture Forest Service two decades ago. The methodology is based on identifying the degree of contrast introduced into a landscape by an action such as a road. In this methodology, distance (foreground, midground, and farground) and fundamental elements of a scene or characteristic landscape (form, line, color, and texture) are used to describe negative contrasts. This is the basis for evaluations of views of the proposed parkway. Views of the parkway were investigated from many positions. Resort housing sites were visited, commercial locations were checked, roadways (paved and unpaved) were inspected for views, and topographic maps were used to locate additional sites to check. Many sites were evaluated for the surrounding conditions of views in order to judge the degree of contrast imposed by the proposed pat is evaluated on a scale of 1 to 5, with 5 being the worst. This scale is explained in a footnote to the table.

There are several views of the proposed parkway extension that could be of concern. These views were evaluated using negative contrast. The locations are

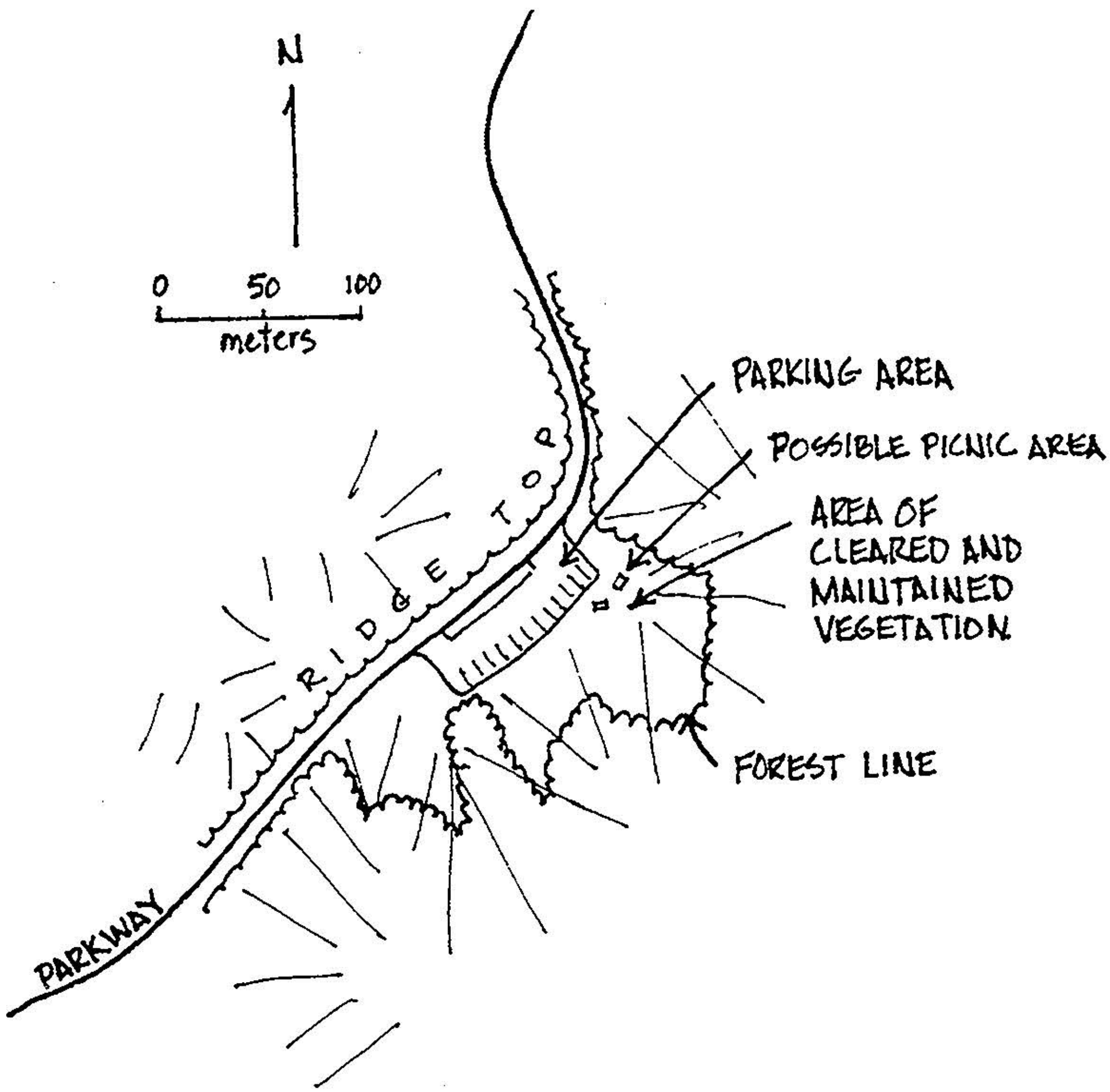


**Fig. 76. A plan sketch of site 7A showing vegetation clearing, parking arrangements, and direction of views.**

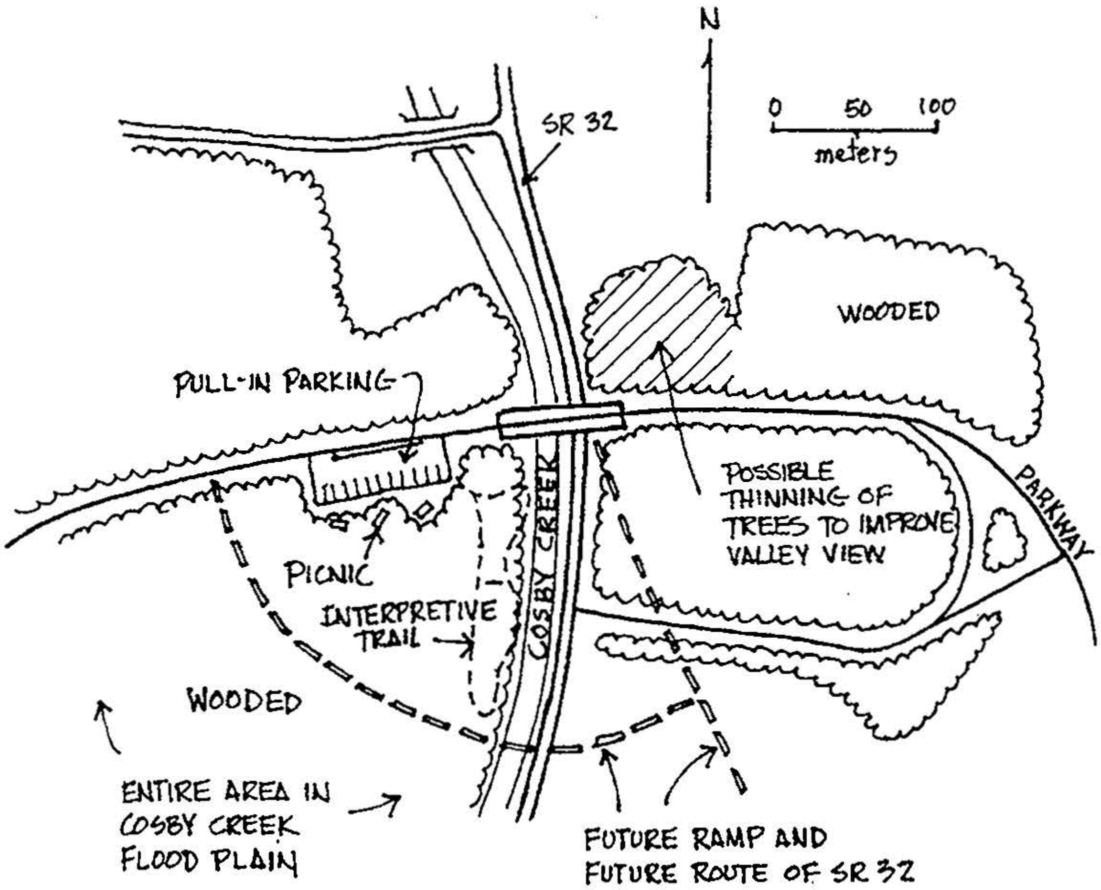


**Fig. 77. A plan sketch of the eastern terminus of Parkway Section 8B at Cosby Creek shows the potential of parking and interpretive development in the area.**

- Near Timothy Creek along U.S. 321, viewing the parkway at kilometer 4.8 (segment 2 near site 2C)
- Along U.S. 321 near Darky Branch and golf course, viewing segment 3 of the parkway
- A few houses in Deer Ridge Mountain Resort, viewing segment 3
- Along U.S. 321 near Texas Creek, viewing 12–100 to 13–300 (segment 4)
- Along U.S. 321 near Rocky Grove Church, viewing 14–500, and 14–800 (segment 5)
- Along U.S. 321 just west of the Sevier/Cocke County line, viewing around 17–000 (at the boundary between segment 5 and 6)
- At several locations along trails in the GSMNP (segment 3)

The most significant issue among these would be the view of the parkway cutting across near the top of Webb Mountain (segment 3). This area must receive special attention in minimizing some of the larger vertical exposures of cuts and fills. The next most important area is near Timothy Creek (segment 2). Retaining walls would be needed to minimize the exposure of larger fills in this area. The remaining areas would be of moderate concern, less from visitors traveling U.S. 321 than from local landowners having their views directly affected by road cuts and fills placed directly in and dominating their views. Some concerns about views of the proposed parkway are presented along with views from the parkway in Sect. 4.1.8.

In effect, there are three important kinds of views of the proposed parkway. The differences have to do with the distance from which one views the parkway: foreground, midground, and farground views. Each of these would occur in a somewhat different landscape setting for the viewer. These settings would affect the degree of undesirable contrast imposed by the proposed parkway cuts and fills.

The foreground views occur along some sections of U.S. 321, especially near the west end of Section 8B and along a short section of U.S. 321 near Rocky Grove. Some additional foreground views from residences would occur. In the foreground situations, other roads exist within the view, houses may be present, power lines are usually visible, and traffic noises are present. The degree of forest cover and amount of human disturbance/development is quite different as seen from some residences and compared to U.S. 321. Two subcategories in the foreground views are necessary for proper evaluation.

The midground views of the proposed parkway, besides those from the proposed parkway itself, are quite limited. Some glimpses from U.S. 321 and more direct views from residences occur. It is difficult to ascertain how the clearing of forests and grading of terrain for development would change views of Webb Mountain in the future. Although views would be opened by forest clearing, construction of buildings would again close views. Traffic along U.S. 321, as well as views of the GSMNP, tend to draw viewing away from Webb Mountain. A few recreational/tourist developments on the south side of U.S. 321 tend to have focused views toward Webb Mountain as a midground view. The contrasts of road cuts and fills against the forest cover of Webb Mountain would make the proposed parkway quite visible along segment 3. These views would be framed by foreground roads, traffic, and development.

Farground views are all from trails in the GSMNP. From these locations, the cuts and fills would be more distant but would provide a higher level of contrast by being in what appears to be a completely wooded and pristine view. Although images of the effect of the Robbinsville highway

cutting across a mountain slope some years ago may come to mind, the proposed parkway design standards are such that the actual visual impact should not be as great. This does not mean that the perceived impact would be any less.

Actions taken in the construction of the parkway (segment 3) to reduce visual contrasts would play a dominant role in the midground and fargound acceptability of views of the parkway.

From within the GSMNP, the Webb Mountain portions of the parkway would be visible during defoliate seasons from numerous places along the 518- to 762-m (1700- to 2500-ft) elevations of the Old Settlers Trail (Minnigh 1995; Great Smoky Mountains Natural History Association 1994). Slightly above where the trail crosses Darky Branch, one can see Pittman Center to the west; here the parkway would likely be visible. Most of the trails in the vicinity of Greenbrier Pinnacle are on the far side of the Pinnacle from the ROW and would therefore have no visual orientation or access toward the ROW (G. Minnigh, GSMNP/NPS, personal communication with C. Petrich, May 3, 1995). Portions of Section 8B would likely be visible some time during the year from at least 6 trails inside the GSMNP (Fig. 72).

Maddron Bald, atop the Maddron Bald Trail, also would offer clear views of Webb Mountain, SR 32, and toward the Rocky Flats area where the ROW descends from Big Ridge and then climbs toward Webb Mountain.

From Maddron Bald and from other high-elevation promontories in the western and northern end of the GSMNP, 360° views abound on clear days. The Deerfield Inn, near the Cobbly Nob residential development and just south of the ROW, is strikingly visible in profile, as are severe scars from construction of several nearby residences. One overlook is just south of Inadu Knob on the Appalachian Trail on the north flank of Mt. Guyot, the second highest peak in the Smokies. Again, 360° views allow the observer to see "everything," including much of the development in and around Gatlinburg and Pigeon Forge as well as the ROW.

The ROW would also be visible from numerous locations along U.S. 321, but exact viewpoints would depend on final alignments. Defoliate seasons would undoubtedly reveal much more of the final parkway, but again, final alignment would have to be known. At both termini of Section 8B, the ROW would be most visible, either along SR 416 or SR 32. On SR 416 and the associated interchange area, the parkway would be most visible near the Emerts Cove area of Pittman Center. The ROW also crosses Branham Road, but the vegetation there is quite dense and would likely screen much of the roadway from most viewing points. The ROW crosses Rocky Flats and Rocky Flats Road, where the ROW would be readily visible, but again the vegetation is dense. Where the ROW is located close to U.S. 321, the visibility would depend strongly on engineering and design implementation because of the steep topography and the dense vegetation that allows for ready screening. The Webb Mountain portions would likely be visible from numerous areas along U.S. 321.

## 3.9 CULTURAL RESOURCES ASSESSMENT

The cultural resource assessment of the Foothills Parkway Section 8B ROW completed by Thomason and Associates documented the architectural, historical, and cultural resources located

within the project area (Fig. 78; see Appendix N). The purpose of this effort was to identify all properties that may have architectural, historical, or cultural significance within the project area, in accordance with federal guidelines and regulations. The study identified those properties presently listed, or eligible for listing, on the National Register of Historic Places. The area traversed by Section 8B is composed of mostly mountainous terrain with three major exceptions: the community of Cosby in Cocke County, the area known as Rocky Flats in Sevier County, and the community of Pittman Center in Sevier County. These areas contain a variety of architectural, historical, and cultural resources that were the subject of this study.

The project area for the Section 8B ROW is approximately 305 m (1000 ft) wide except where it is enlarged for special uses. Given the potential visual, audible, and atmospheric impacts of this project, all properties located within 1.6 km (1 mile) of the ROW centerline were inventoried. Additional properties in the Cosby area were also inventoried where the potential visual impacts could possibly exceed 1.6 km (1 mile).

The file search and cultural resources inventory did not identify any properties actually within the Section 8B ROW of the Foothills Parkway as listed on the National Register of Historic Places. Neither were any properties within the Section 8B ROW identified as meeting National Register eligibility requirements. The file search and cultural resources inventory identified only one property within the project area presently listed on the National Register. The Tyson McCarter Place in Sevier County was listed on the National Register on March 16, 1976. This farmstead is composed of three outbuildings from the 19th century and is within the boundary of the GSMNP.

In 1994 the Southeast Archeological Center finished archeological investigations at three locations on the Foothills Parkway Section 8B (Leabo et al. 1996). One site is located in Cosby along Cosby Creek. This site was not believed to be eligible for inclusion on the National Register of Historic Places and no additional archeological testing was recommended. The second site is at Copeland Creek, south of Pittman Center. This site was considered potentially eligible for inclusion on the National Register of Historic Places. Given the variety of archeological components and the presence of undisturbed cultural deposits, additional archeological testing was recommended at the Copeland Creek site. This site provides an opportunity to examine cultural change over a large period of time. Further investigations can provide information concerning aboriginal occupants of the Tennessee and North Carolina area. The third site is located just southeast of Pittman Center along the Little Pigeon River. Some additional testing was recommended due to the likelihood of examining intact cultural deposits and the fact that multiple occupations took place at this site. Since the Little Pigeon River separates the Copeland Creek site from the Pittman Center site, further archeological investigations could determine whether the two sites were inhabited concurrently during one of apparently many prehistoric occupations.

### 3.9.1 Eligible National Register Properties

The following properties documented in the project area appear to meet eligibility requirements for listing on the National Register of Historic Places.

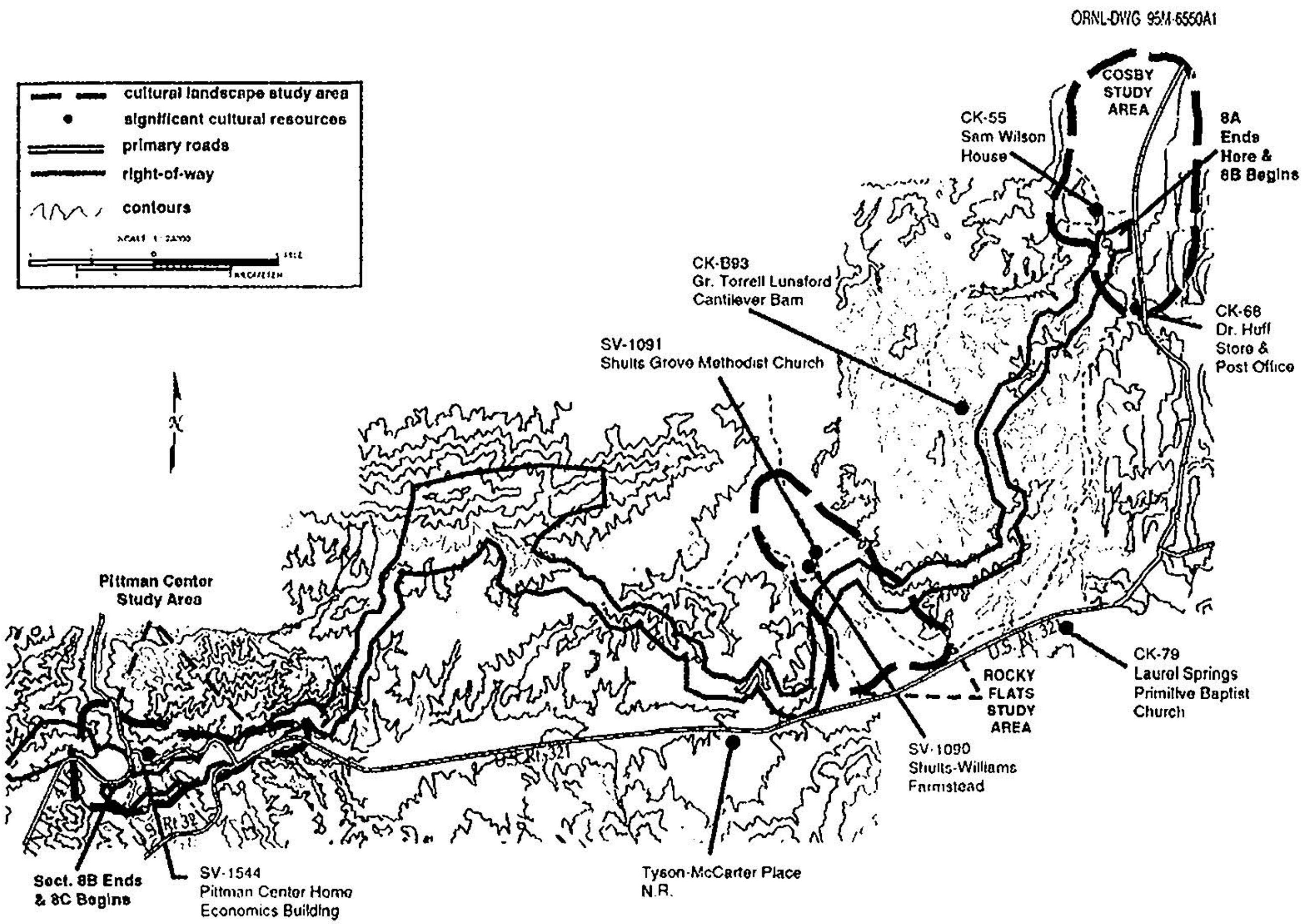


**Fig. 78. Architectural, historic, and cultural resources of Section 8B.**

### 3.9.1.1 Cocke County

**CK-55**—Sam Wilson House, Cosby vicinity: The Sam Wilson House is eligible for the National Register of Historic Places under Criterion C for architecture. The dwelling is representative of the I-house form common throughout the nineteenth and early twentieth centuries in rural East Tennessee. The Sam Wilson House is the largest and most elaborately detailed dwelling documented in Section 8B of the Foothills Parkway.

**CK-79**—Laurel Springs Primitive Baptist Church, Cosby vicinity: The Laurel Springs Primitive Baptist Church is eligible for the National Register of Historic Places under Criterion C for architecture. The well-preserved church is an example of the modest church buildings constructed in the rural, often isolated, areas of the mountainous regions of East Tennessee.

**CK-68**—Dr. John Huff store and post office, Cosby vicinity: The Dr. John Huff store and post office was a large general mercantile store that housed the only post office and Odd Fellows Hall in the upper Cosby area between ca. 1915 and ca. 1935 and is eligible for the National Register of Historic Places under Criterion C for architecture. Although abandoned and unused since the 1930s, the building is intact and retains almost all original features and integrity. The building is an example of an early twentieth century multi-use commercial facility of a type common in rural areas throughout the South.

**CK-B93**—G. Torrell Lunsford cantilever barn, Cosby vicinity: The G. Torrell Lunsford cantilever barn is eligible for the National Register of Historic Places under Criterion C for architecture. The well-maintained barn is a fine example of a type indigenous to the East Tennessee area, primarily Sevier, Blount, and Cocke Counties.

### 3.9.1.2 Sevier County

**SV-1090 & SV B1090**—Shults-Williams farmstead, Rocky Flats vicinity: The Shults-Williams farmstead is eligible for the National Register of Historic places under Criterion C for architecture. The farmstead is an example of the small yeoman farm in the foothills region in the late nineteenth and early twentieth centuries. This particular farm retains a wide variety of well-preserved outbuildings that are rare and indigenous to the foothills region of East Tennessee.

**SV-C1091**—Shults Grove Methodist Church, Rocky Flats vicinity: The Shults Grove Methodist Church is eligible for the National Register of Historic Places under criterion C for architecture. The well-maintained country church with modest Gothic Revival detailing is an excellent representative example of a type found throughout the foothills region of East Tennessee. Unaltered in appearance, the church is the best-preserved example of this style located in Sevier County.

**SV-1544**—Pittman Center Home Economics Building, Pittman Center vicinity: The Pittman Center Home Economics Building is eligible for the National Register of Historic Places under Criterion C for architecture and under Criterion A for social history. The restored structure is the only building remaining from the original Pittman Community Center that was established in 1921 by the Methodist Mission Board of New York. The facility had a great influence on the living conditions of the impoverished yeoman farmers of the mountainous region of Sevier County. The

Pittman Center Economics Building is the last remaining original structure of a once-vibrant village that was instrumental in the development of the foothills section of Sevier County. The building is an excellent example of the Craftsman-style educational facilities that were common from the early twentieth century, and since its restoration, has been well maintained in near original condition.

The consultant also identified seven sites along the Section 8B ROW consisting of the remnants of dwellings and farmsteads. None of these sites appears to possess sufficient architectural or archaeological significance to meet National Register criteria.

### 3.9.2 Cultural Landscapes

The Section 8B ROW descends and/or ascends through three valleys as it crosses Big Ridge and Webb Mountain: the Cosby area, Rocky Flats, and the valley at Pittman Center. These three valleys were extensively settled in the early nineteenth century by Anglo-Europeans who cleared the land and altered the original forested landscape. The existing rural landscapes are the physical and visual documentation of this history. As part of this project, these valleys were analyzed for their ability to convey a sense of time and place from this historical occupation. This analysis was conducted using guidelines issued by the National Park Service in its publication *National Register Bulletin 30, Guidelines for Evaluating and Documenting Rural Historic Landscapes.*

#### 3.9.2.1 The Cosby Valley

The Cosby Valley contains the community of Cosby and agricultural lands. Traditional crops in the valley include wheat, corn, and tobacco. Although much of the valley remains under cultivation, there have been extensive changes to the area in recent decades. In Cosby there are prominent non-contributing features, including dozens of post-1945 buildings, post-1945 chicken houses and associated buildings, widened roads, and a new bridge. Large transmission lines bisect the valley and extend for over a mile. Stone walls have been lost throughout much of the agricultural areas, probably because of larger field size and larger scale farming operations. As a result of the extent of these non-contributing features, the Cosby Valley does not contain significant natural or man-made features that collectively meet the criteria of a historic rural landscape.

#### 3.9.2.2 Pittman Center

Pittman Center is located in a small valley at the confluence of the Little Pigeon River and Webb Creek. This community was formed in the 1920s when it was settled as a Methodist mission, which constructed dozens of buildings along Webb Creek. To the west of the town center is a small valley adjacent to the Little Pigeon River that traditionally has been used for grain cultivation or livestock grazing. During the 1930s, Pittman Center was characterized by more than 20 school buildings and dwellings along the narrow valley of Webb Creek. The valleys to the west, south, and east contained small farmsteads with cultivated fields and pasture. Over the past several decades, almost all of the original mission buildings at Pittman Center have been razed. There no longer exists a significant collection of buildings and physical features retaining historic spatial relationships or organization at Pittman Center. The valleys adjacent to the town center do not contain any significant landscape features and have a mixture of pre- and post-1945 dwellings.

Because of the loss of original buildings and associated features, it is the consultant's opinion that Pittman Center does not contain significant natural or man-made features that collectively meet the criteria of a historic rural landscape.

### 3.9.2.3 Rocky Flats

Rocky Flats is the name given to a small valley separating Big Ridge and Webb Mountain between Cosby and Pittman Center. Several streams run through this valley, including Ogle Spring Branch and Matthew Creek. The area was settled in the nineteenth century and contained a series of small farmsteads at the turn of the century. Of the three study areas, Rocky Flats contains the largest number of historic properties and landscape features. A total of 13 properties were surveyed in Rocky Flats; physical features include cultivated fields and historic roadbeds. Rocky Flats also contains a network of stone walls that originally formed property and field boundaries. Despite the presence of these resources, it is the consultant's opinion that Rocky Flats no longer retains integrity to meet National Register criteria as a rural historic landscape. In addition to the historic properties, several dozen post-1945 buildings were noted in the valley. The present character of Rocky Flats is that of a erratic pattern of new housing development, older fields and pastures, and reclaimed woodlands. Although the stone walls offer glimpses of historic crop and field patterns, the overall appearance of the valley does not reflect a sense of time and place. None of the stone walls identified at Rocky Flats and other scattered locations within the project area was identified as possessing individual architectural or historical significance to meet National Register criteria.

# 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

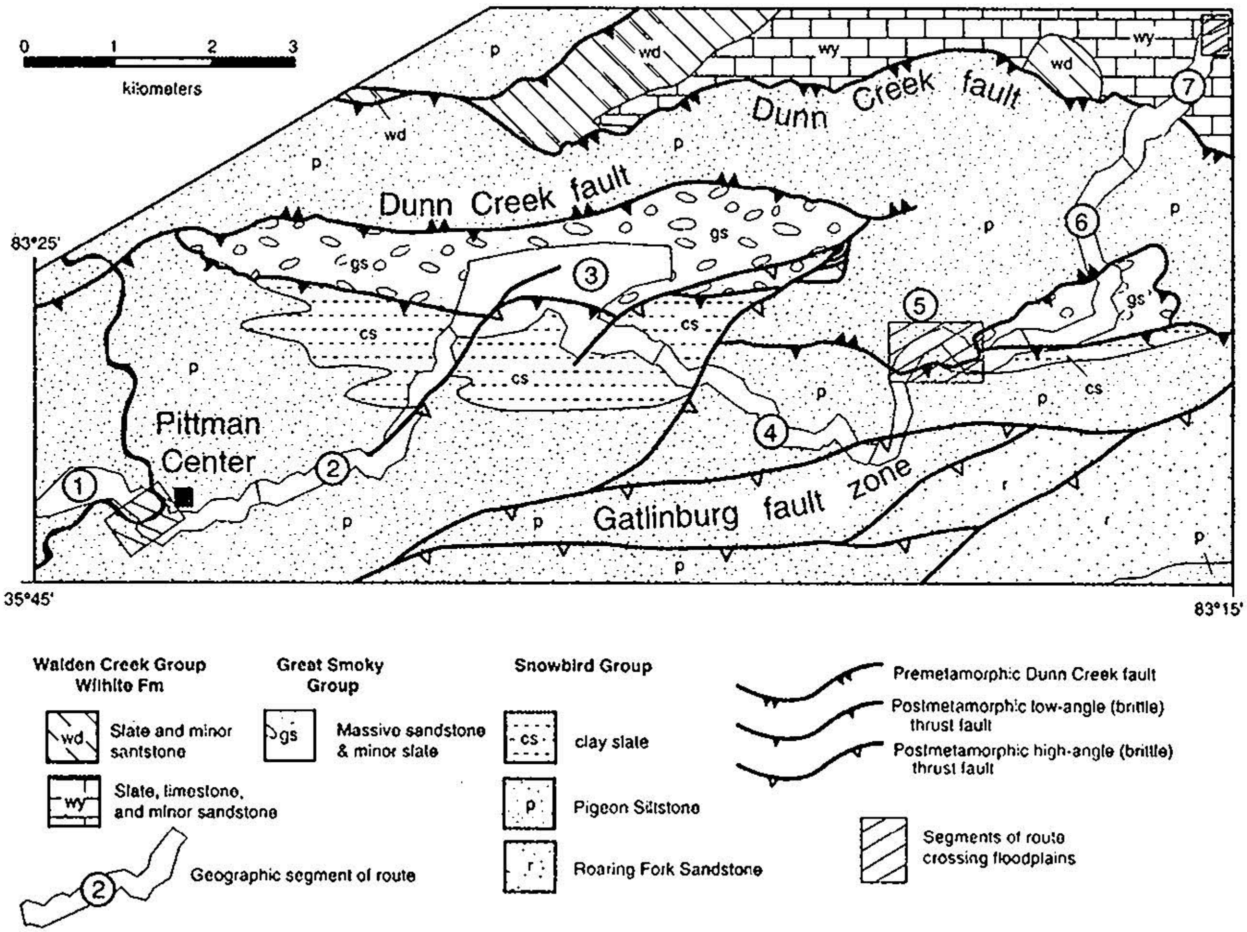


Figure 4.1-1: Simplified bedrock geologic map of the Webb Mountain area. Segmented 8B ROW is lightly shaded. Numbers indicate geographic segments

**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.

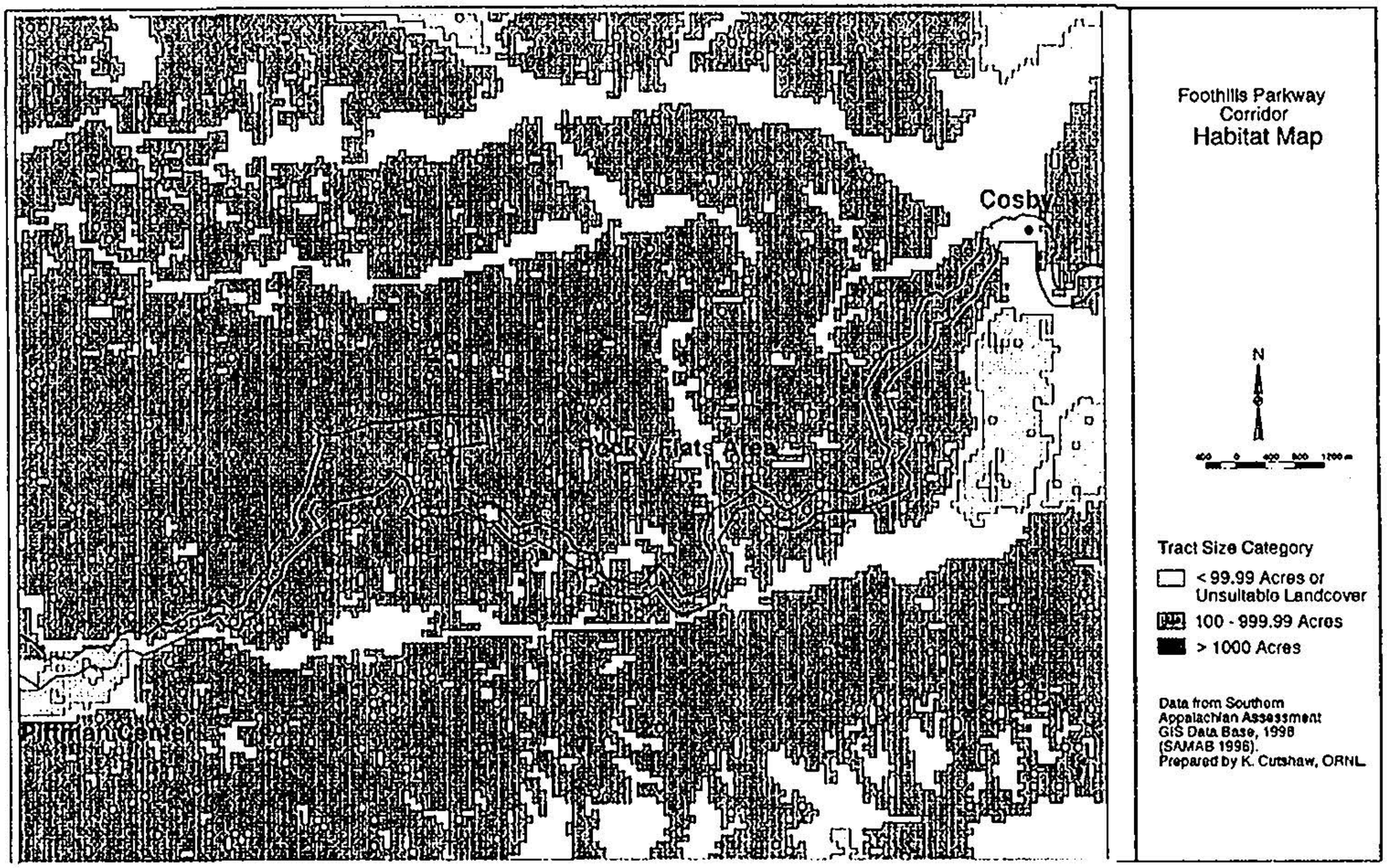


**Fig. 80. Habitat map in the approximately 130 mi$^2$ (335 km$^2$) region surrounding the right-of-way.**

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 μg/m³ (0.2 ppm) with a standard deviation of 59 μg/m³ (0.05 ppm) over the course of a year (October 1988 to October 1989). A natural background of 235 μg/m³, plus 3 standard deviations (412 μg/m³), 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 μg/m³, 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 μg/m³, 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 μg/m³ and 1493 μg/m³, 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 μg/m³, 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 $\mu g/m^3$, 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 $\mu g/m^3$, which is slightly less than the corresponding allowable PSD increment of 8 $\mu g/m^3$.

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 $\mu$m 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

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shares the rugged terrain, heavy vegetation, and undeveloped nature that characterizes the rest of this parkway segment. There also is some relatively flat, flood-free land within Pittman Center's municipal boundaries, much of it in close proximity to the Foothills Parkway ROW and Pittman Center Road, whose physical characteristics would make it relatively easy to convert to commercial or residential uses. Sections 4.6.1 through 4.6.9 present detailed discussions of prospective impacts in each socioeconomic subject area covered in Sect. 3.6 and brief treatments of environmental justice and cumulative impacts.

### 4.6.1 Population

**Construction period.** The NPS estimates that construction of Section 8B would require the same number of workers needed to build Section 8D, which is a peak work force of 69 persons (NPS 1995). These workers are likely to be subdivided into six work crews, organized by task. Since most of the crews would work intermittently over the life of the construction project, there would frequently be fewer than 69 workers on-site. If a local company were awarded the construction contract, the work force would be composed entirely of current residents of the study area. However, if a company located more than a 60–90 minute commute from the work site were selected, a number of workers would be expected to move to the project area from elsewhere. Again borrowing from NPS 1995, it is estimated that approximately 36 jobs (mostly foremen and highly skilled positions) would be filled by workers who would move to the local area from elsewhere. To be conservative, it is assumed that a nonlocal contractor would be chosen, and that the 36 inmoving workers would be accompanied by their families. Using the 1993 U.S. average household size of 2.63 (U.S. Bureau of the Census 1994), this means that a total of 95 persons could move to Sevier and Cocke counties during roadway construction. If all of these persons settled in Cocke County, it would represent an increase of only 0.3% over the 1994 population level. If all 95 new residents settled in Sevier County, a population increase of less than 0.2% would occur. In both cases (which represent the upper bounds of possible construction period growth), the effect on the host counties would be minimal.

Expenditures made by the workers and their employer during the construction period could create a number of "indirect jobs." Conservatively assuming a very high multiplier of 1.0 (meaning that one indirect job would be created for each construction job) and further assuming that all of these jobs would be generated locally, only 69 indirect jobs would be created in Sevier and Cocke counties. These indirect jobs, many of which would require relatively unskilled service workers, would be expected to be easily filled by existing residents and would be unlikely to cause any additional inmigration of workers.

**Operations period.** By the time Section 8B would be opened to traffic in 2005, population in the impact area is expected to exceed current levels, with Sevier County growing at a considerably faster pace than neighboring Cocke County (see Sect. 3.6.2.2). Beyond 2005, area tourism and population both are likely to grow, with or without the Foothills Parkway. But the demand for vacation accommodations and year-round housing in Pittman Center, Cosby, and the rural areas in between could be increased slightly by Section 8B operations because travelers using this segment would be exposed to areas that they would see while using surface roads. This would not alter established patterns of development, but it could speed up the rate at which such development occurs. The population growth—both seasonal and permanent—directly attributable to parkway operations in any given year would be expected to be minor if the western terminus of Section 8B

were located at or near U.S. 321 or if there were no western interchange at all. If the western interchange were located at Pittman Center Road, population growth in Pittman Center could increase at a slightly faster pace than with the other interchange options—especially if Section 8B were opened prior to completion of Section 8C. Under these circumstances, many travelers would be exposed to substantially more of Pittman Center than if they stayed on the parkway or exited at U.S. 321. Under the no-build alternative, population growth would occur, but without the slight increase provided by completion of Section 8B.

### 4.6.2 Housing

**Construction period.** The addition of 36 new households to the impact area under the conservative population growth estimate would have only minor impacts on the local housing market. The 36 dwelling units that would be needed represent only 3% of all vacant rental units in Sevier and Cocke counties, and only 2% of all vacant units that are either for rent or for sale. Therefore, even with the most conservative population growth estimate, construction-induced demand for housing could be easily met by the existing housing stock.

**Operations period.** The number of year-round dwelling units and vacation rentals in the impact area is expected to grow between now and 2005, when Section 8B would be completed. This trend is expected to continue whether or not the proposed project is undertaken. The Consensus Map for Pittman Center developed through the Futurescapes process shows that local residents prefer that the year-round dwellings developed in that community in future years be entirely single family and primarily low density. As for rental accommodations, current community intentions—as documented in the Futurescapes final report—are to avoid high-rise hotels in favor of lower-intensity rental units such as cottages, a low-rise inn, and bread and breakfast facilities.

Completion of Section 8B could result in a slight increase in the rate at which permanent and seasonal housing units were built in Pittman Center, as a result of parkway travelers being exposed to the heart of the Pittman Center community. This acceleration in the existing pace of residential development would be minor if the western terminus of Section 8B were located at or near U.S. 321 or if there were no western interchange at all. A greater increase in the development rate could occur if the western interchange were located at Pittman Center Road—especially if Section 8B were opened prior to completion of Section 8C. With Section 8B open in advance of Section 8C, approximately 1200 additional daily automobile trips would be expected on Pittman Center Road between the Foothills Parkway and U.S. 321. This would approximately double the total number of vehicles using this stretch of road and triple the number of tourist-related trips. Under those conditions, it is possible that local landowners would put increased pressure on local government officials to allow higher-density tourist accommodations and year-round dwelling units to be built in the community to respond to perceived demand. Under the no-build alternative, year-round housing and vacation units would still be added to the area, but at a slightly slower rate and with less pressure to alter existing development patterns than under the build options discussed above.

In the Cosby community as well as in the more rural area extending westward along the Foothills Parkway ROW to Pittman Center, the completion of Section 8B—regardless of interchange location or the schedule for opening the various segments to traffic—is expected to slightly increase the rate at which permanent and seasonal residential units are developed. However, the

*types* of units that are added are not likely to be affected. Throughout the remainder of Cocke and Sevier counties, the opening of Section 8B is not expected to have any noticeable impact on the pace of housing development or the types of units that are constructed.

### 4.6.3 Public Services

For all public services except solid waste, operations period impacts would be greater if the western interchange of Section 8B were located at Pittman Center Road than if the interchange were located at or around U.S. 321 or there were no western interchange at all. As for timing options, opening Section 8B before the completion of Section 8C would increase impacts. Under the no-build alternative, public service demands would be expected to increase beyond current levels as a result of ongoing growth in the impact area, but these impacts would be less than for any of the build options considered here.

#### 4.6.3.1 Education

**Construction period.** Approximately one-third (34.5%) of U.S. households have children under the age of 18 (U.S. Bureau of the Census 1994). Assuming that the 36 inmigrating construction workers follow this national pattern, there would be 12 households with children under 18 moving to the impact area as a result of Section 8B construction. On average, each U.S. household with children under 18 has 1.96 such individuals. Based on this national average, it is assumed that 24 children under the age of 18 would accompany inmoving construction workers. Assuming an equal distribution of children from birth to 18 years, it is likely that 17 school-age children would accompany their parents to the impact area. This represents an average of only 1.3 construction-induced students per grade (Kindergarten through 12th). These students are likely to be distributed among several schools in Sevier and Cocke counties. But even if they all attended a single school, such a small number of students would not be expected to cause noticeable impacts.

**Operations period.** As noted in Sect. 4.6.1, Section 8B operations could slightly increase the rate of population growth in the impact area, and this effect would probably be greatest if the western interchange were located at Pittman Center Road and if Section 8B opened before Section 8C was complete. But even under such conditions, any effects on student enrollment and the demand for educational services would be likely to be minor. That is because population increases directly attributable to the parkway would probably be small and many schools in the impact area have the capacity to handle additional students and continue to make, and plan for, improvements in their facilities.

#### 4.6.3.2 Water

**Construction period.** The small number of construction workers that could move to the impact area is not enough to noticeably impact local water systems and their ability to provide necessary services.

**Operations period.** The availability of safe, potable water is currently a major concern of Pittman Center residents. However, it is very likely that Pittman Center would be receiving water through a county-wide system within 20 years, and that the city could be receiving piped water by the time Section 8B were opened in 2005. In the absence of piped water, new dwellings and commercial

establishments would have to be served by individual wells and the allowable density of development would be limited. The slightly accelerated rate of relatively low-density residential development that could occur in Pittman Center as a result of Section 8B operations—and the accompanying demand for water—could probably be accommodated without difficulty by drilling new wells. But the development of higher-density residential settlements or commercial establishments in the heart of Pittman Center, both of which could be stimulated by an interchange at Pittman Center Road, could strain the community's ability to provide water service. Such problems would be alleviated, however, by the availability of piped water. As for Cosby and the rest of the impact area, there would be little or no impact to the availability or quality of potable water because of the minimal population increase that would be expected.

#### 4.6.3.3 Sewer

**Construction period.** As with water, the small number of construction workers moving into the impact area is not expected to have any noticeable effect on the provision of local wastewater treatment services.

**Operations period.** Pittman Center currently relies on septic systems for its wastewater disposal. It is expected that a small additional need for wastewater treatment would accompany the slight increase in residential growth that could result from Section 8B operations. This minimal demand for treatment services could be accommodated by the construction of a limited number of new septic systems. However, the development of higher-density residential settlements or commercial establishments, which could result from a Pittman Center Road interchange, might exceed the treatment capacity available through individual septic systems. Such problems could be alleviated by a centralized sewer system, but this is not likely to be available in Pittman Center in the foreseeable future. In Cosby and the more rural areas elsewhere along the Section 8B ROW, the small increase in the rate of population growth that could occur would be expected to have little or no adverse effect on local wastewater treatment capabilities.

#### 4.6.3.4 Solid Waste

**Construction period.** Because of the small size of the inmigrating work force, solid waste disposal facilities in Cocke and Sevier counties would not be adversely affected by worker-generated wastes. As for waste generated by parkway construction, it is assumed that this would be a "balanced" project, meaning that all materials cut from one part of Section 8B would be used as fill elsewhere on the same segment. Failing that, the contractor could use the excess material as fill at nearby construction sites—which would be the least expensive option—or dispose of it at a county or private landfill. It is anticipated that any solid waste that would require disposal as a direct result of this project would not significantly strain local landfill capacities.

**Operations period.** The amount of solid waste generated by any additional residents or commercial enterprises that might locate in the local area as a result of Section 8B operations, regardless of timing or interchange location, is expected to be easily accommodated by existing solid waste disposal facilities in the impact area.

#### 4.6.3.5 Police and Fire Protection

**Construction period.** The ability of local police and fire departments to protect public safety is not expected to be noticeably affected by the small number of construction workers that could move to the impact area.

**Operations period.** It is assumed that GSMNP rangers and seasonal employees would provide protection for parkway visitors and resources, so local police and fire departments would not be required to expend their resources for this purpose. Any slight acceleration in the rate at which relatively low-density residential development occurs in the impact area would likewise have only minimal impacts on local governments' abilities to protect the public safety. However, greater demands for police and fire protection could arise in Pittman Center from the addition of higher-density vacation accommodations, higher-density year-round residences, and commercial facilities—all of which might result from the location of an interchange at Pittman Center Road. Because of the limited size of Pittman Center's police and fire departments, their resources could be strained by the additional demand for services. As with other public service impacts, these would be greatest if Section 8B were opened before Section 8C is completed.

### 4.6.4 Land Use

**Construction period.** The major land use changes that would be likely to take place during the construction period would occur on the Section 8B ROW as the roadway itself is constructed. Because NPS currently owns all the land needed for the parkway, no additional property would be acquired. And because the inmoving construction work force would be very small, no land outside the existing ROW would be converted to new residential or commercial uses, as is sometimes necessary to accommodate a large work force.

**Operations period.** Between now and the proposed opening of Section 8B in 2005, tourist traffic in the impact area will continue to grow, and this is likely to stimulate further commercial development along major arteries—particularly U.S. 321—and the demand for new vacation rental units and year-round residences throughout the impact area. Because of Pittman Center's land use plan, its zoning ordinance, and its experience with the Futurescapes project, it is likely that the type and location of new residential units would conform to the community's desired vision for its future development. Along U.S. 321, however, development pressures are likely to be intense and could lead to more—or different types of—commercial establishments than many in the community would prefer. In Cosby, despite the fact that there is neither a land use plan nor a zoning ordinance, it is expected that existing patterns of development would continue because of the traditionally slow pace of land conversion in that community and the desire of many residents to avoid high-intensity commercial development.

While residential and commercial growth is expected to continue regardless of what happens with the Foothills Parkway, the completion of Section 8B could stimulate additional development in Pittman Center, Cosby, and the rural areas in between them. The nature and magnitude of that development would depend to a large extent on where Section 8B's western interchange is located and when the segment is opened to traffic. Should the interchange be located at Pittman Center Road, the community's land use patterns could change substantially, especially if Section 8B were opened before the completion of Section 8C. As mentioned earlier, roughly 1,200 additional

vehicles per day are expected to use Pittman Center Road between the parkway and U.S. 321 if Section 8B is opened in advance of Section 8C. This increase would approximately double the total number of trips along this portion of road and approximately triple the number of tourist trips. This could create significant pressure for high-intensity commercial development in the vicinity of the interchange and could also encourage strip commercial development along Pittman Center Road, southward all the way to U.S. 321. In addition, the presence of substantial numbers of tourists in the heart of Pittman Center could increase the demand for vacation rental units and year-round residences, elevating the attractiveness to local land owners of building higher-density units than is currently allowed. While such development is counter to the future envisioned in the town's consensus land use map and Futurescapes final report and would require changes in the current zoning ordinance, the local government is empowered to make such changes and conceivably might, if the political pressure brought to bear on this issue were sufficient. All other interchange options (i.e., western interchange at or near U.S. 321 and no western interchange at all) would result in substantially less development pressure in Pittman Center, although they would result in a slightly faster rate of relatively low-density residential growth within the community than would occur in the absence of the parkway. Completing Section 8B—regardless of interchange location—would be expected to lead to a slight increase over the no-build alternative's pace of residential growth along the Section 8B ROW, from Pittman Center's eastern boundary all the way to Cosby.

While the Pittman Center Road interchange could encourage the type of intense development described, it also would lessen—to some extent—the no-build alternative's pressure for commercial development along U.S. 321 east of Pittman Center Road by diverting travelers away from that segment of highway. Similarly, locating the interchange at or near U.S. 321 would reduce the pressure for commercial development along U.S. 321 east of Webb Creek Road. And the no-interchange option would lessen development pressure along U.S. 321 between Cosby and Gatlinburg by preventing travelers on the Foothills Parkway from exiting anywhere in the vicinity of Pittman Center.

### 4.6.5 Taxes

**Construction period.** Any increase in local property tax revenues received by local governments in the impact area as a result of the inmigration of 36 construction worker households would be negligible. However, sales tax revenues would be likely to increase slightly because of the purchase of construction materials by the road contractor and the purchase of consumer goods by construction workers. Assuming that the total cost of construction materials were $22.5 million (the high end of the range estimated for Section 8D), that these purchases were spread out evenly over a 5-year period (i.e., $4.5 million per year), and that all purchases were made in a single county, annual sales tax revenues in Sevier County would increase by approximately 0.5% and total revenues would increase by about 0.2%. If all purchases were made in Cocke County, the effect would be greater, with sales tax revenues increasing by roughly 3% and total revenues increasing by approximately 0.6%. Purchases of consumer goods would result in only a very small increase in local sales tax revenues. Assuming that all construction worker households would conform to the national average for consumer expenditures and spend approximately $20,000 annually on taxable goods and services (U.S. Bureau of the Census 1994) and that all of these purchases would be concentrated in a single county, sales tax revenues in Sevier County would grow by only 0.16% and total revenues would register an even smaller 0.06% rise. In Cocke

County, the projected increase in sales tax and total revenues resulting from construction worker purchases would be 0.98% and 0.17% respectively.

**Operations period.** Because of ongoing growth and development, tax revenues collected by local governments are expected to increase over time, even in the absence of Section 8B. Should Section 8B be completed, however, residential development in the impact area could be slightly accelerated, probably resulting in a small increase in local property tax revenues and a minor boost in sales tax receipts because of purchases made by new vacationers and year-round residents. These impacts would be expected to be minimal in Cosby and the rural area along the Section 8B ROW because of the small increase in residential development that would be expected. Similarly, tax impacts would be expected to be minor in the Pittman Center community with every interchange except for the one located at Pittman Center Road. As noted earlier, if the Pittman Center Road interchange were constructed, the community's land use patterns could change substantially, especially if Section 8B were opened before the completion of Section 8C. The high-intensity commercial development, strip commercial development, and higher-density residential units that could be built in Pittman Center would result in a greater increase in local property and sales tax revenues than under any other build option or the no-build alternative as a result of the addition of new high-value structures to the community and expanded purchases by tourists and new permanent residents. Such a jump in revenues would tend to bring per capita tax revenues in Pittman Center closer to the levels experienced in the rest of Sevier County.

### 4.6.6 Economic Structure

**Construction period.** Any changes to the economic structure of the impact area as a result of Section 8B construction would be minor because of the small number of new jobs that would be created. Even if all 69 construction workers came from Cocke County, that would amount to only 0.4% of the existing labor force. The maximum number of indirect jobs that could be created as a result of construction would represent the same small percentage of the local labor pool. In Sevier County, the new parkway-related construction jobs and indirect employment would each equal only 0.2% of the existing labor force. These small, temporary additions to the labor force would do nothing to alter the basic economic structure of either county.

**Operations period.** As mentioned earlier, tourist traffic in the impact area is expected to grow with or without the completion of Section 8B, and this is likely to stimulate further commercial development along major arteries—particularly U.S. 321. This commercial development would create some additional jobs, but these would be consistent with the existing economic character of the area and would not be expected to noticeably change local unemployment rates. Should Section 8B be built with an interchange at Pittman Center Road, commercial growth in the Pittman Center area could be stimulated and this would result in additional jobs for area residents. Again, this would not alter the economic nature of Sevier and Cocke counties or substantially decrease area unemployment; but it could represent a substantial change for Pittman Center, which has always been characterized by limited commerce. All other interchange options would result in substantially less development pressure on Pittman Center. And *any* interchange option—including the absence of a western interchange for Section 8B—would lessen the no-build alternative's pressure for commercial development along portions of U.S. 321 by diverting some travelers who would otherwise have used that highway.

### 4.6.7 Social Structure

**Construction period.** Any changes in local area population, economic character, and land use patterns that might arise during the construction of Section 8B would be so minor that they would cause no alteration in the social structure of the impact area. It is possible, however, that some people living in the immediate vicinity of the parkway ROW could object to the land disturbance and noise associated with road construction and could be distressed by their anticipation of possible changes to the character of the area arising from parkway operations.

**Operations period.** Tourist traffic in the impact area would continue to grow for many years to come, regardless of what happens with Section 8B, and this growth is likely to stimulate further commercial development along major transportation arteries, especially in Sevier County. Along U.S. 321, growth pressures are likely to be powerful and could lead to more intensive commercial development than many in the Pittman Center community would prefer. Such commercialization could in turn result in some modification to the traditional character of the community and, at least for some residents, degrade the existing quality of life. To some extent, these impacts could be lessened by operation of Section 8B, which—as explained earlier—would divert some travelers away from U.S. 321 in the vicinity of Pittman Center.

Current residents whose homes are located in close proximity to the Section 8B ROW could experience some negative impacts to their existing quality of life as a result of parkway operations. The major sources of these adverse effects would be the visual changes marking the conversion of previously undeveloped land to a paved parkway, the noise that would accompany automobile traffic on Section 8B, and the possible perception by some that their privacy is being invaded by the presence of tourists near their homes and property. These phenomena could disturb residents who value the current quiet and relative isolation of this area and who might perceive the parkway as an unwanted intrusion. However, the development of a narrow, low-speed parkway designed to afford tourists an opportunity to view the natural beauty of the area is not inconsistent with the low-impact ecotourism that many residents see as the most desirable type of future development for this area.

As explained previously, existing Pittman Center land use patterns could change substantially if the Section 8B interchange were located at Pittman Center Road, especially if Section 8B were opened before the completion of Section 8C. The increased traffic and especially tourist traffic through the heart of Pittman Center could create significant pressure for high-intensity commercial development in the vicinity of the interchange, could encourage strip commercial development along Pittman Center Road, and could stimulate the development of higher-density vacation rental units and year-round residences in the heart of Pittman Center. Such development would alter the existing nature of the community and is counter to the expressed desires of many Pittman Center residents. Accordingly, these changes could have serious negative impacts on the quality of life experienced by many community members. In addition, the heightened development pressures generated by an interchange at Pittman Center Road could lead to conflict within the community concerning future land use, particularly between those who are most attached to the current rural nature of the community and those who stand to reap significant economic benefits from more intensive development.

In Cosby, existing patterns of development are likely to continue, even in the absence of a land use plan and zoning ordinance. Section 8B operation would actually decrease traffic on Cosby's surface roads, and the pace of land conversion in the community has traditionally been slow. Accordingly, there are unlikely to be any noticeable impacts to the local social structure or to the quality of life experienced by local residents, except for the previously mentioned effects that might be felt by those living in the immediate vicinity of the Section 8B ROW.

#### 4.6.8 Environmental Justice

The purpose of an environmental justice analysis is to determine if a proposed project would have disproportionate impacts on poor and minority populations. Table 28 shows that the percentage of minority residents in Cocke and Sevier counties is much lower than in the state of Tennessee as a whole. Only 2.5% of Cocke County's and 1.1% of Sevier County's residents are non-white. In contrast, 17% of the state population is classified as non-white. However, as illustrated in Table 35, Cocke County does have a higher proportion of persons living below the poverty level (25.3%) than does the state as a whole (15.7%). In contrast, only 13.2% of Sevier County's residents have incomes that are classified as being below the poverty level. Because the greatest potential for socioeconomic impacts is in the Pittman Center community, which is located in Sevier County, it appears that low-income residents would *not* be disproportionately impacted by the proposed project. Furthermore, the extremely limited number of minority residents throughout the impact area indicates that this project would not disproportionately affect that population.

#### 4.6.9 Cumulative Impacts

In addition to focusing on the effects of Section 8B construction and operations, the preceding analysis also discusses the growth that is likely to take place as a result of continuing tourism in the impact area. The only other possible sources of cumulative impacts that should be noted are the provision of centralized sewer and water services to Pittman Center and the modification of that community's existing land use regulations to allow greater density of development. If any of these events occurred, additional changes to local population, land use, and social structure could follow.

#### 4.6.10 Summary of Findings

By exposing tourists to the heart of the Pittman Center community—which they would not have seen had they traversed the area along U.S. 321—Section 8B could have the effect of slightly accelerating the demand for vacation accommodations and year-round dwellings that is already anticipated and generally accepted by community members. The presence of Section 8B also could diminish the quality of life for some nearby residents as a result of automobile noise and the visual intrusion of the roadway itself; but the addition of a narrow, low-speed parkway designed to provide tourists with vistas of the GSMNP and surrounding countryside seems compatible with Pittman Center's intention to promote low-impact ecotourism in the community.

A parkway interchange at Pittman Center Road would result in a substantial increase in traffic through the Pittman Center community, especially if Section 8B were opened before completion of Section 8C, which runs westward from Pittman Center to Gatlinburg. With Section 8B open and Section 8C not yet in operation, roughly 1,200 additional daily trips would be expected on Pittman

Center Road between the Foothills Parkway and U.S. 321. This increase would roughly double the total number of vehicles using this stretch of road and triple the number of tourist-related trips. Not only would this change greatly increase surface road traffic through the center of town, but it could create substantial pressure for high-intensity commercial development of the open land close to the interchange and for strip commercial development along Pittman Center Road. It also could encourage the construction of higher-density residential developments—for both tourists and new year-round residents—than is currently allowed. These types of development are incompatible with the vision for the community developed through the recent Futurescapes project, which suggested lower-density residential uses for the areas in question, and would significantly alter local land use patterns and the existing nature of the community. Such an event represents the largest possible socioeconomic impact that Section 8B could have on the study area.

Should Section 8B's western interchange be located at or near U.S. 321 instead of at Pittman Center Road, commercial development in excess of what would occur in the absence of the parkway would not be generated. This would clearly be the case if parkway traffic were released directly onto U.S. 321, because no vehicles would be added to other roads in the Pittman Center community. It would also be true even if traffic were released onto Webb Creek Road. In the latter instance, commercial development would not be stimulated along Webb Creek Road because travelers would have to drive less than 250 m (800 ft) on that roadway to get to U.S. 321, and that entire segment lies on the Foothills Parkway ROW, making it ineligible for private development of any kind.

In Cosby, the site of Section 8B's eastern terminus, the opening of this parkway segment would result in fewer cars along local roads because the parkway would divert some travelers from U.S. 321/SR 32 onto Section 8B, and automobiles going west on Section 8A would have the option of staying on the parkway rather than exiting at Cosby as they currently must. Accordingly, commercial development in the Cosby area would not be expected to be stimulated by the proposed project. However, by exposing tourists to parts of the Cosby area that they might not otherwise have seen, parkway operations could result in a slight acceleration of the current pace at which vacation accommodations and year-round dwellings are being developed. As in Pittman Center, the presence of Section 8B could result in a degradation of the quality of life experienced by some nearby residents.

Socioeconomic impacts in the rural areas between parkway interchanges are expected to be minor because there would be no increase in traffic on surface roadways and hence no stimulus for commercial growth. However, ongoing development of vacation accommodations and year-round residences could be hastened slightly, and some residents could feel that their quality of life is diminished to some extent by the parkway's presence.

## 4.7 TRAFFIC AND NOISE

In the fall of 1996, ORNL completed an overall traffic study of the entire Foothills Parkway and vicinity. This study is described in Sects. 4.7.1 and 4.7.2 with the results documented in Sect. 4.7.3. The noise analysis results are then discussed in Sect. 4.7.4.

An extensive traffic analysis of the impacts of the proposed Foothills Parkway was performed using the best available traffic information collected from a number of agencies. The proposed Foothills Parkway sections included in the traffic study are Sections 8B, 8C, 8D, and the "missing link" between Sections 8E and 8F in Sevier, Cocke and Blount counties. Rather than just considering the traffic impacts associated with the construction of Section 8B, this study focused on the likely traffic flow patterns resulting from construction of the parkway as a whole. Based on these traffic flow patterns, traffic impacts associated with the construction of Section 8B are assessed.

### 4.7.1 Traffic Study Area

The area analyzed in the traffic study is illustrated in Fig. 81. The existing highway network for the study is comprised of the following roadway sections:

1. I-40 from west of the intersection with SR 66 (Exit 407) to east of the intersection with U.S. 321 (Exit 440)
2. U.S. 441 from west of Sevierville to south of the intersection with SR 73 in the GSMNP (including the Gatlinburg bypass)
3. U.S. 321 from just north of its intersection with Section 8A in Cosby to just north of its intersection with Section 8G in Walland
4. U.S. 411 from west of Sevierville to the intersection with I-40 in Newport
5. SR 416 from its intersection with U.S. 321 to just north of the intersection with Webb Creek Road
6. SR 32 from the convergence with U.S. 321 at Cosby to approximately 2 miles east of the convergence
7. SR 73 from the intersection with U.S. 321 near Townsend to the intersection with U.S. 441 in the GSMNP
8. SR 66 from the intersection with I-40 (Exit 407) to the intersection with U.S. 441/411 in Sevierville
9. Webb Creek Road (from SR 416 to U.S. 321)
10. Wears Cove Gap Road (from Wears Valley to Metcalf Bottoms)
11. Laurel Creek Road from SR 73 (Townsend Wye) to Cades Cove
12. Little River Road from SR 73 (Townsend Wye) to Elkmont
13. Snider Road (small section at intersection with I-40 at Exit 407 north of Sevierville)
14. Foothills Parkway Sections 8A, 8G, and 8H

#### 4.7.1.1 Data Collection and Acquisition

**Intersection traffic volumes.** The intersection peak-hour traffic volume information used for this study is based on data from several sources and was collected at different times. Many of these data were collected in traffic studies for Foothills Parkway Sections 8B and 8D. Vehicle turning movement and vehicle classification counts were collected in 1991 for the Section 8D study. Volume, turning movement, and vehicle classification counts were collected in 1994 for the Section 8B study. Other data sources include the NPS and a study by Wilbur Smith Associates published in 1994. A complete listing of intersections for which data were collected is shown in Table 60. The table also includes the location of each intersection and the source of the data. Collection locations are illustrated in Fig. 81.

**Table 60. Intersection traffic volume data locations and sources**

| Intersection | Location | Source | Year |
|---|---|---|---|
| Foothills Parkway Section 8A and U.S. 321 | Cosby | *Foothills Parkway Section 8B Environmental Report* by ORNL | 1994 |
| SR 416 and U.S. 321 | Pittman Center | *Foothills Parkway Section 8B Environmental Report* by ORNL | 1994 |
| Webb Creek Road and SR 416 | Pittman Center | *Foothills Parkway Section 8B Environmental Report* by ORNL | 1994 |
| U.S. 321 and SR 32 | Cosby | *Foothills Parkway Section 8B Environmental Report* by ORNL | 1994 |
| Newfound Gap Road and Little River Road | Sugarlands Visitor Center | *Foothills Parkway Section 8D Environmental Report* by ORNL | 1991 |
| U.S. 441 and U.S. 321 | Pigeon Forge | *Foothills Parkway Section 8D Environmental Report* by ORNL | 1991 |
| U.S. 321 and SR 73 | Townsend | *Foothills Parkway Section 8D Environmental Report* by ORNL | 1991 |
| Townsend "Y" | Townsend | Traffic Count by National Park Service | 1994 |
| I-40 and SR 66 | Kodak | *Sevier Transportation Network Evaluation* by Wilbur Smith Associates | 1994 |
| SR 66 and U.S. 441 | Sevierville | *Sevier Transportation Network Evaluation* by Wilbur Smith Associates | 1994 |
| U.S. 441 and U.S. 321 | Gatlinburg | *Sevier Transportation Network Evaluation* by Wilbur Smith Associates | 1994 |

**Roadway section traffic volume.** Historical annual average daily traffic (AADT) information was obtained from the TDOT and NPS. The 1994 AADT is presented in Fig. 82. These data were used to adjust 1991 intersection traffic counts to 1994 levels and as a reference for those intersections in the study for which no data were available. Historical data were also used to perform trend analysis in projecting future traffic volumes.

Historical park visitation information was also obtained from NPS. These data were used both in estimating current traffic volumes and in projecting future volumes within the GSMNP.

#### 4.7.1.2 Traffic Study Alternatives

Two alternatives have been considered in assessing potential traffic impacts associated with the construction of Section 8B: a build alternative, which consists of several construction and operational options, and a no-build alternative. It should be noted that other Foothills Parkway

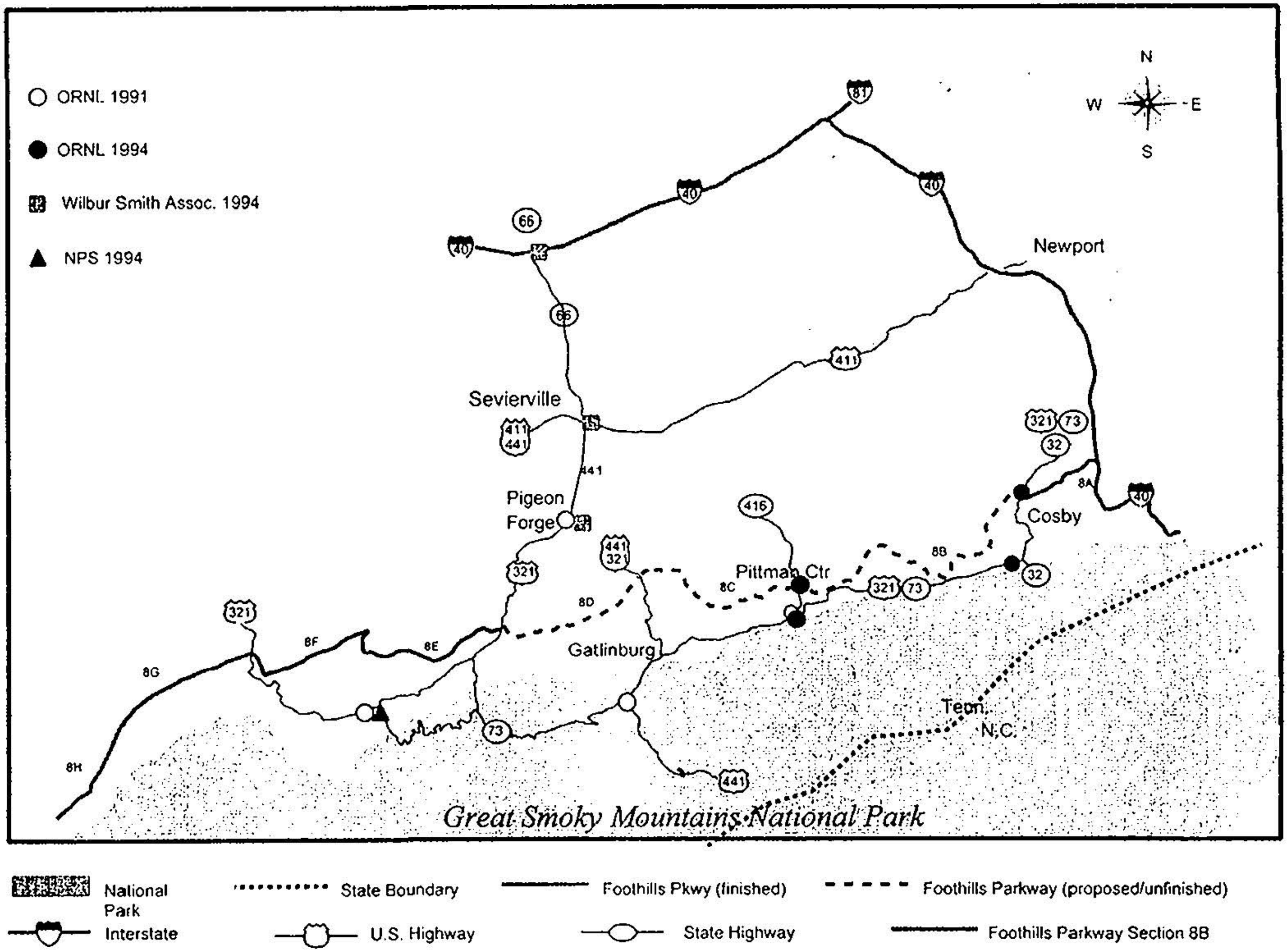
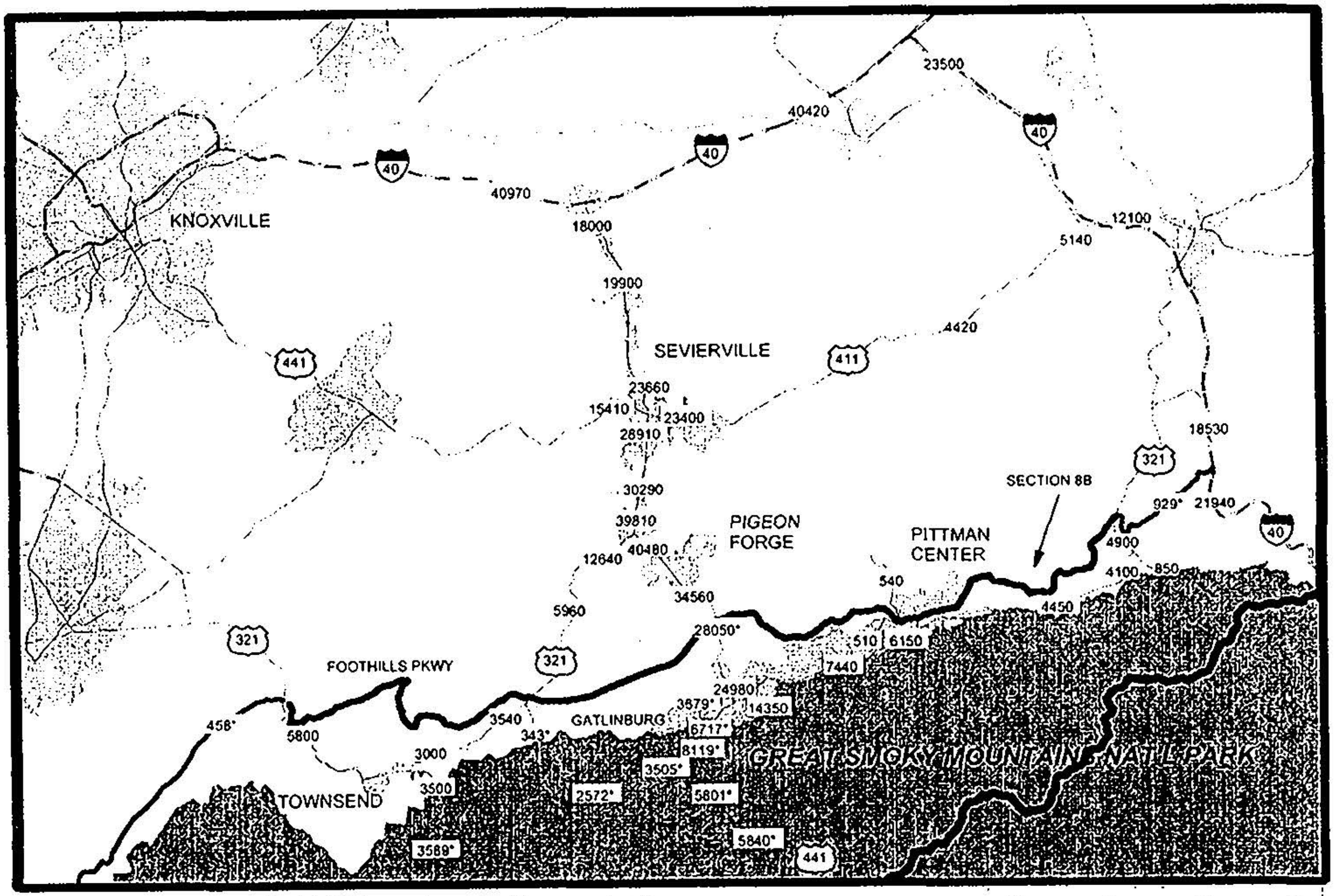



**Fig. 81. Location of traffic data counts.**




* Annual average daily traffic (AADT) counts marked by an asterisk were provided by NPS; all others were provided by TNDOT.

0 8 16 24
Miles

**Fig. 82. Annual average daily traffic—1994 (* AADT from NPS).**

sections, such as Section 8C, are included within the traffic network used in forecasting the future traffic flow pattern. However, traffic impacts are assessed only for Section 8B.

**Construct Section 8B with No Interchanges**

**Western Terminus Options**

- Foothills Parkway interchange at SR 416 with north ramp connected to Webb Creek Road
- Foothills Parkway interchange at SR 416 with south ramp connected to SR 416
- Foothills Parkway interchange at U.S. 321 with ramp connected to U.S. 321
- Foothills Parkway interchange at U.S. 321 with ramp connected to Webb Creek Road

**Operational Timing Options**

- Section 8B would be operational prior to the completion of Section 8C with interchange at SR 416.
- Section 8B would be operational prior to the completion Section 8C with interchange at U.S. 321.

**No-action**

- No-build alternative

For a more detailed description of these alternatives and options, please refer to Sect. 2 of this report. Note that the Webb Mountain option has little effect on the overall traffic flow patterns on the Foothills Parkway; therefore, no traffic impacts have been assessed. For the operational timing options, the traffic study focuses on traffic impacts associated with additional traffic on SR 416 and Webb Creek Road. No traffic impact has been assessed for different ramp configurations.

### 4.7.2 Future Traffic Projections

#### 4.7.2.1 Applied Methodology

Future traffic volume projections for roadway links within the study area were generated by using historical traffic volume data to determine volume trends and by using the future volumes indicated by these trends in a gravity model to generate future volumes for each link in the highway network. The methodology used to project the future roadway link volumes can be summarized as follows.

1. **Define the link-node network**
   The existing highway network described in Sect. 4.7.1 was coded as a link-node network. A node represents the intersection of two or more roadway sections, and a link represents the roadway section between intersections. The connections of yet-to-be-constructed parkway sections with the existing network vary in accordance with the different alternatives and options.
2. **Define the network entry/exit points and assign production and attraction volumes**
   The entry and exit points of the network were defined, and each was assigned a "production" volume (traffic entering the network) and an "attraction" traffic volume (traffic exiting the network). The traffic volume counts collected (described in Sect. 3.7.1) are used to calculate

the production and attraction volumes for each entry/exit point on the existing network. These include:

I-81 just north of intersection with I-40
I-40 just west of intersection with I-81
I-40 just east of intersection with Foothills Parkway Section 8A
U.S. 441 just south of intersection with SR 73 in the GSMNP
U.S. 441/411 just west of Sevierville
U.S. 321 just north of intersection with Foothills Parkway at Walland
U.S. 321 just north of intersection with Foothills Parkway in Cosby
SR 416 just north of intersection with Webb Creek Road
SR 32 just east of its convergence with U.S. 321 near Cosby
Snider Road just north of intersection with I-40
Webb Creek Road just east of intersection with SR 416
Belz Outlet Mall in Pigeon Forge near convergence of U.S. 441/321
West end of Foothills Parkway Section 8H

In addition to entry and exit links, sources and sinks along each link in the network were modeled. Sources and sinks represent areas along a link that may attract or produce traffic that does not travel the length of the link. This allows the model to account for traffic entering/exiting shopping centers, residential areas, motels and campgrounds, large parking areas, and other places.

3. **Use a gravity model to develop an origin-destination traffic volume matrix for the network**
   A gravity model was used to develop a matrix of traffic volumes between each production and attraction pair (i.e., origin and destination pair). This model was then calibrated so that the assigned traffic matched, as closely as possible, the observed counts along each link of the network.
4. **Generate future production and attraction traffic volume growth factors**
   The growth factors were used to estimate the future production and attraction volumes. It was assumed that future traffic patterns would remain much the same for the time of the study period (i.e., through 2006 until 2026).
5. **Apply the future production and attraction volumes to the gravity model to generate future traffic volumes**
   A new matrix was generated by the gravity model using the production and attraction volumes for the years 2006 and 2026. These volumes were then applied to the network configuration that corresponds to each alternative and the various options that apply.
6. **Diverting traffic to the proposed Foothills Parkway sections**
   It was assumed that the proposed Foothills Parkway would function solely as a scenic parkway; that is, the proposed sections would not give motorists any travel time advantage over the existing roadway network. Therefore, motorists would travel on the parkway only to experience its scenic beauty. This implies that no existing local traffic would use the proposed Foothills Parkway as a "short cut" between two locations. In light of this assumption, ORNL used a traffic diversion model to estimate existing traffic flow on the parkway and adjusted other traffic volumes accordingly. In doing this, it was assumed that only GSMNP traffic and tourist-related traffic destined to and originating from Sevierville, Pigeon Forge, and Gatlinburg would divert to the parkway. (As traffic increases and the LOS deteriorates on

existing roadways, some local traffic may be diverted to the Foothills Parkway. Because of lack of information on local traffic flow patterns in the study area, the diversion of the local traffic onto the Foothills Parkway has not been quantified; however, it is believed that the diversion of local traffic onto the parkway would be relatively low.)

#### 4.7.2.2 Future Infrastructure Changes

In performing capacity analysis, data describing the geometrical aspects of the transportation network are essential. Changes to the transportation network structure (i.e., addition or demolition of highway sections) must be considered in routing future traffic. The TDOT was contacted in order to discern any planned changes to the transportation network in the study area within the time frame of the study. According to TDOT, two modifications to the highway system are planned for the future: (1) in Sevier county, 9.3 km (5.8 miles) of U.S. 321 from Rattlesnake Hollow to SR 416 (from Gatlinburg to Pittman Center) will be widened to five lanes and (2) in Cocke county, 11 km (6.8 miles) of U.S. 321 (in Cosby) will be widened to four lanes along its convergence with SR 32. It is assumed that these construction projects will be completed by 2006. Since these changes would affect capacity only and would not affect routing, they were considered only in the capacity analysis.

The existing I-140 connects U.S. 70/U.S. 11 (Kingston Pike) to U.S. 129 (Airport Highway). Currently, construction is under way to connect I-140 to I-40 and U.S. 162 (Pellissippi Parkway) to the north. In the meantime, TDOT plans to extend I-140 from U.S. 129 to U.S. 321 in Maryville (Blount County). The schedule of the I-140 southern extension from U.S. 129 to U.S. 321 in Maryville has not been determined. This study, however, assumes that the I-140 southern extension from U.S. 129 to U.S. 321 in Maryville would be completed later than 2006 but earlier than 2026. This study also assumes that the completion of the I-140 southern extension would provide people in the greater Knoxville area with a better alternative route to the study area compared with the route using I-40. Thus, 10% of the greater Knoxville area traffic from I-40 would be diverted to U.S. 321 in Maryville in year 2026.

#### 4.7.2.3 Projecting Future Traffic Production and Attraction Growth

Trend analyses of historical park visitation and traffic volume data were used to project future production and attraction volumes. It was assumed that future traffic patterns would remain much the same for the time of the study period (i.e., through 2006 until 2026).

Different historical data were used to project future traffic volumes for various entry/exit links. Volumes for entry/exit links within the GSMNP were projected using historical recreational visitation information for the park from 1960 to 1993. These data and the ORNL projection are presented in Fig. 83. It should be noted that the park's procedure for estimating recreational visitation information has been modified since 1960. However, because of the long-range nature of the forecasts involved in this study—approximately 30 years into the future—the counting procedure modifications can be viewed as one of the inherent fluctuations dictated by other factors, such as economics and availability of gasoline. This was taken into consideration during the forecast model identification and development stages.

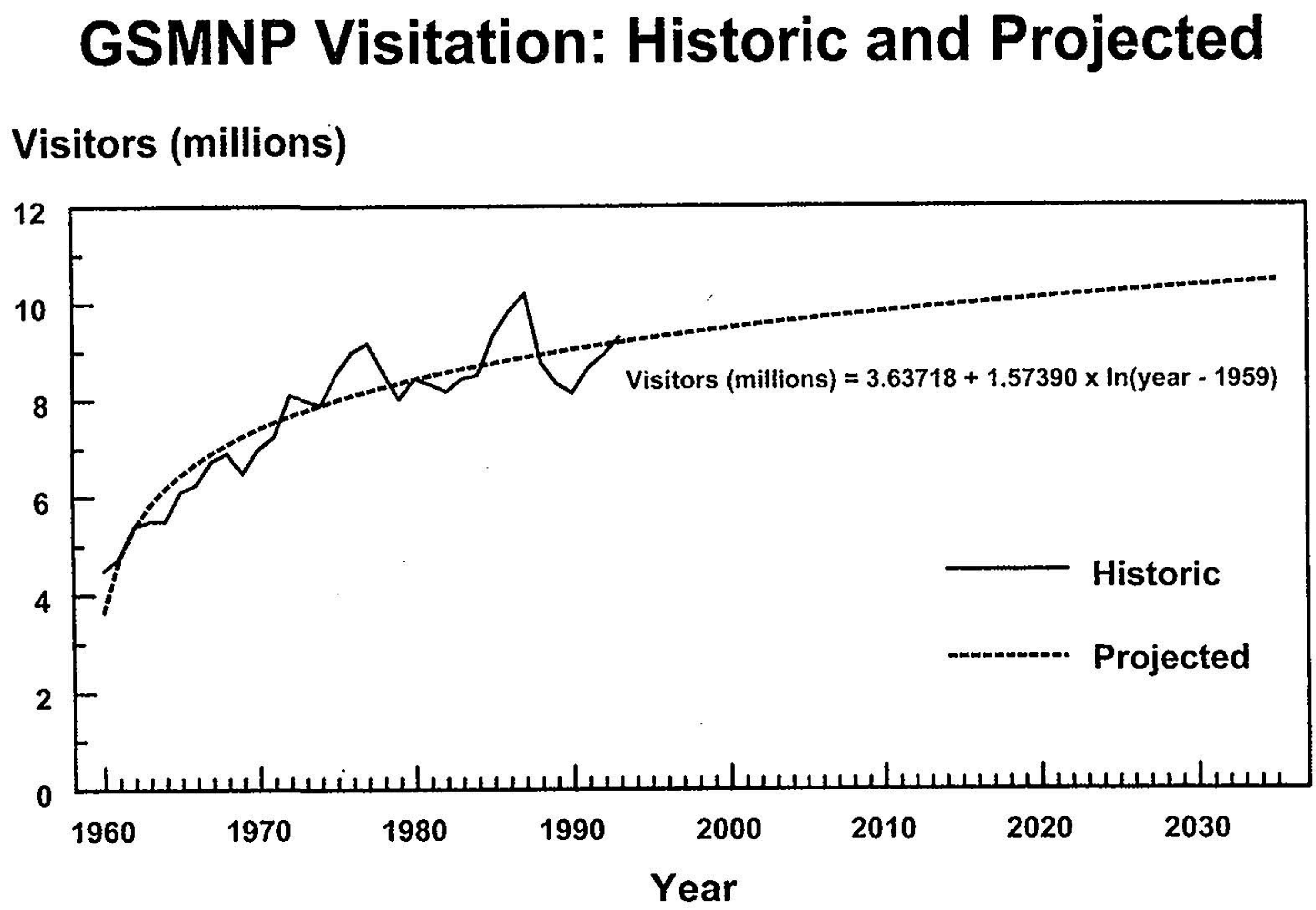



Fig. 83. Great Smoky Mountains National Park historic and projected recreational visitation.

The annual recreational visitation reached over 4 million persons during 1960 and continued to grow during the following decade. The visitation reached over 8 million persons in 1972, continued to increase to over 10 million by 1987, and dropped to 8.1 million by 1990. The visitation increased steadily after 1990, reaching 9.3 million by 1993. The 1994 visitation, however, reversed the recent trend and dropped slightly. This is mostly because of the temporary closure of the Little River Road in the park after the 1993–1994 winter storm. Based on the historical annual park recreational visitation trend, the future park visitation would most likely level off.

A logarithmic linear regression forecasting model has been developed to estimate future recreational visitation based on the historical visitation data. Because of the historical visitation trend, the limited additional capacities of the surrounding highways that lead into the park, and the limited capacity of the park's facilities, it is projected that recreational visitation at the park would level off at approximately 9.66 million in 2006 and approximately 10.23 million in 2026 (± 1.5 million for each estimate). These recreational visitation forecasts translate into a 4.1% increase in 1993 traffic by the year 2006 and a 10% increase by the year 2026 (Fig. 83).

Future traffic volume projections for other roadways within the study area were generated by determining historical traffic volume trends and applying these trends to current conditions. Volume trends were determined by applying a least square error technique to historical data from 1987 to 1994. In some cases, the trends were calculated for the sum of the volumes on multiple links within an area. This method was used because it resulted in less year-to-year fluctuation in volume. Historical and projected traffic volume trends are illustrated in Figs. 84 and 85, respectively.

The production and attraction volumes for the entry/exit point on Foothills Parkway Section 8A were estimated by applying the projected GSMNP park visitation growth factor to the 1994 traffic volume. On Section 8A, it was estimated that a 4.1% increase over its 1994 traffic would occur by the year 2006 and a 10% increase would occur by the year 2026.

**4.7.2.4 Determining Traffic Diversion to the Foothills Parkway**

As mentioned above, the Foothills Parkway is envisioned solely as a scenic parkway. The proposed speed limit is assumed to be 30 miles per hour. Because of the winding nature of the roadway and the low speed limit, it is unlikely that the proposed Foothill Parkway would be used by the public as an alternative route to save travel time. Thus, traffic on the proposed Foothills Parkway would be primarily focused on the scenic aspect of the parkway. This is consistent with the National Park policy that the Foothills Parkway is an integral part of the GSMNP and is not intended for commercial and local traffic. In reality, a portion of the local traffic would use the parkway to move around local areas as traffic on existing roadways increases and as LOS deteriorates in the future. Because of lack of information on local traffic flow patterns in the study area, the diversion of the local traffic onto the Foothills Parkway has not been quantified. However, it is believed that the diversion of local traffic onto the parkway would be relatively low. It is further assumed that only traffic related to GSMNP and other tourist-related traffic would be attracted by the scenic aspect of the Foothills Parkway. Thus, a traffic diversion method was used to estimate the future traffic volumes on it. This method involved the following two steps.

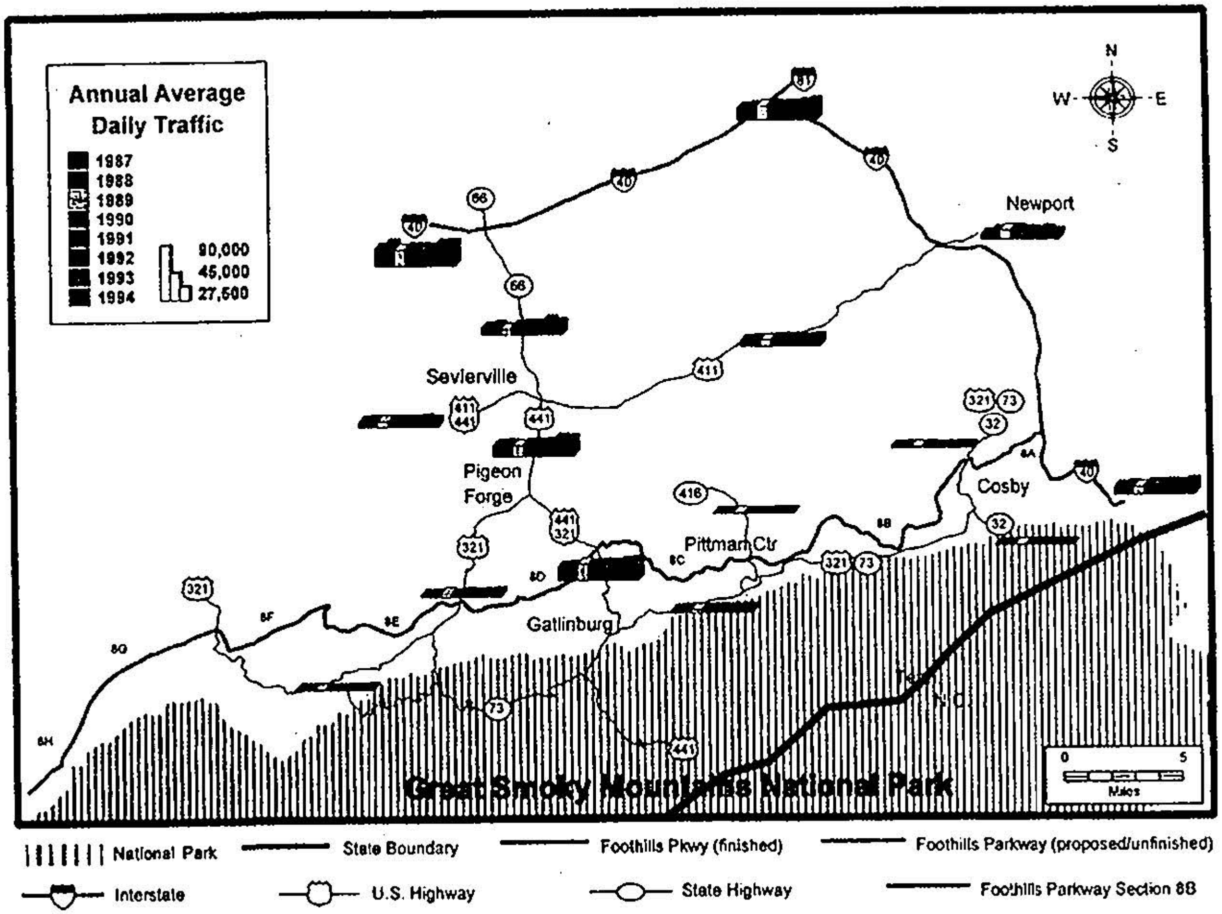



Fig. 84. Historical traffic trends: 1987 to 1994.

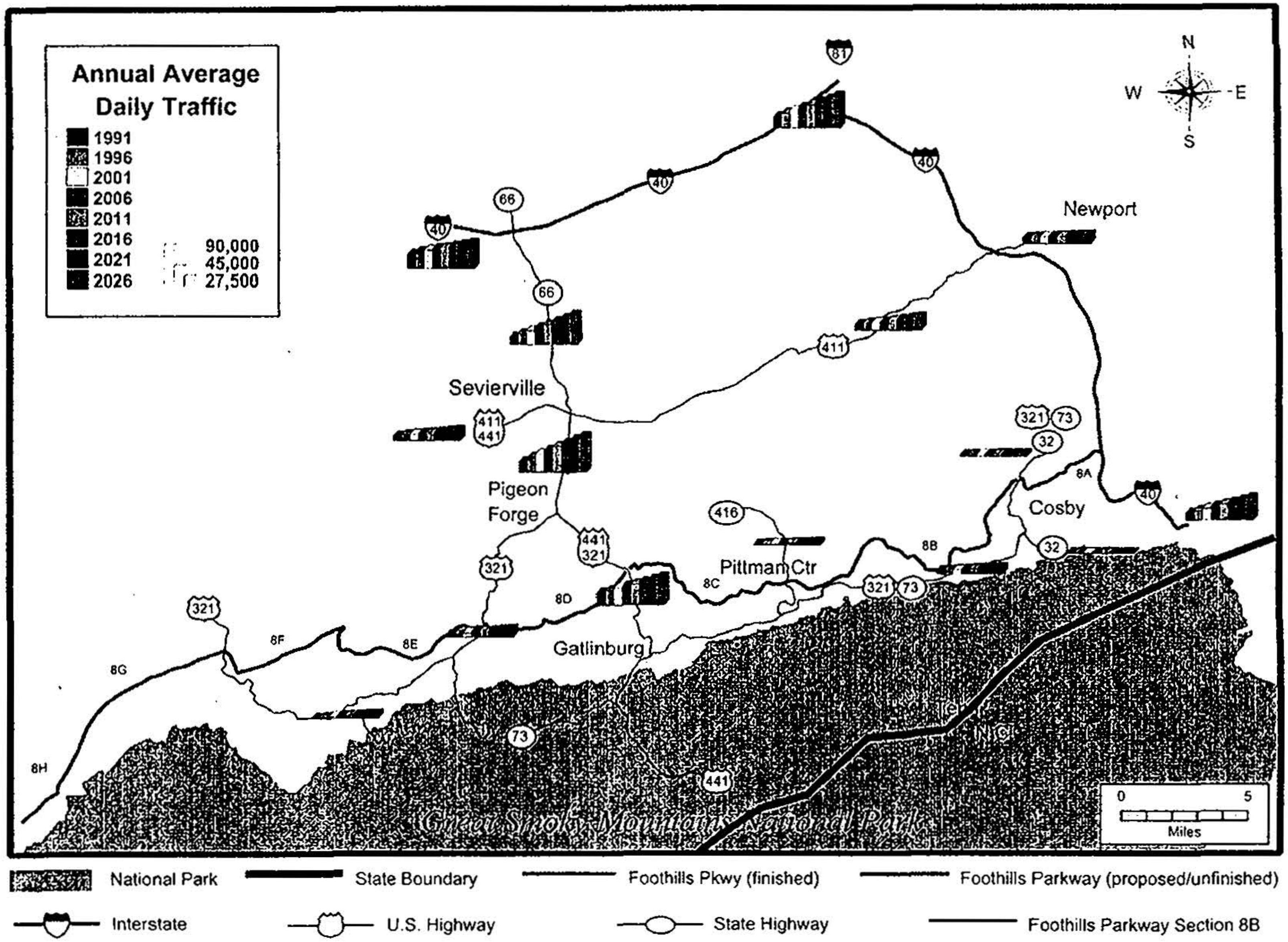



Fig. 85. Traffic growth projections: 1991 to 2026 in five-year intervals.

1. **Identify the links parallel to Foothills Parkway**
The first step in determining traffic diversion was to identify the links from which tourist-related traffic might divert to the parkway. These links mostly consist of those highway sections that run parallel to the parkway (Table 61).

**Table 61. Roadways parallel to the Foothills Parkway**

| Foothills Parkway sections | Parallel roadways |
|---|---|
| Section B | U.S. 321 between SR 416 and SR 32<br>U.S. 411 between SR 92 and I-40 |
| Section C | U.S. 321 between Proffit Road and SR 416 |
| Section D | U.S. 321 in Wear Valley<br>Little River Road in the GSMNP |
| Sections E and F | U.S. 321 between Walland and Townsend |

2. **Identify potential traffic for diversion**
The next step was to identify the kinds of traffic that would divert to the parkway. As stated above, this was assumed to consist strictly of tourist-related traffic. Thus, traffic within the study area was divided into four categories: GSMNP-related, primary tourist-related, secondary tourist-related, and other. The GSMNP, primary and secondary tourist-related traffic was diverted to the applicable parkway sections. Other traffic, such as local and pass-through traffic, was not diverted by the model. For each parallel highway section, a percentage of tourist-related traffic was diverted to the parkway. The percentage for each section was based on the origin and destination locations. Tourist-related highway traffic and their diversion percentages are displayed in Table 62.

**Table 62. Diversion factors for various origins and destinations**

| Origin and destination | Traffic type | Diversion factors |
|---|---|---|
| Cades Cove<br>Elkmont<br>Newfound Gap Road | GSMNP-related traffic | 50% |
| Gatlinburg<br>Pigeon Forge | Primary tourist-related traffic | 20% |
| Townsend<br>Fringe Area of Pigeon Forge<br>Fringe Area of Gatlinburg | Secondary tourist-related traffic | 10% |

After the described diversion procedure was applied, the resulting link volumes were calculated and capacity analysis was performed.

### 4.7.3 Traffic Study Results

Based on the methodology discussed in Sects. 4.7.1 and 4.7.2, future traffic volumes for the two alternatives and subsequent options have been projected for the years 2006 and 2026. The levels of service for roadways within the study area have been determined for the morning and afternoon peak periods for the weekday and weekend peaks for each alternative and associated options for both 2006 and 2026. These data are quite voluminous. Therefore, traffic volumes for each roadway are given in Appendix J of this document.

Almost all of the intersections within the study area would involve construction or reconstruction in the future. Intersections of Section 8A and U.S. 321 in Cosby, and SR 416 and Webb Creek Road in Pittman Center would be replaced by interchanges for Sections 8A, 8B, and 8C with U.S. 321 in Cosby and SR 416 in Pittman Center. Under certain build options, new intersections between the Section 8B ramp with Webb Creek Road or U.S. 321 near Pittman Center would be built. The convergence of U.S. 321 with SR 32 and the intersection of U.S. 321 with SR 416 would be affected by TDOT's planned widening of U.S. 321 to four lanes in Cosby and Gatlinburg. It is assumed that these intersections would be designed and built to maintain adequate levels of service. Therefore, LOS for these intersections was not predicted in this study.

#### 4.7.3.1 Construct Sections 8B and 8C with no Interchanges

**For 2006**: In general, proposed Section 8B would alleviate the traffic on U.S. 321 because (1) Section 8B is parallel to U.S. 321 from Cosby to Pittman Center and (2) a portion of the tourist-related traffic from U.S. 321 would use Section 8B. Consequently, U.S. 321 from Cosby to Pittman Center should experience a better LOS in 2006 with the construction of Section 8B. Sections of U.S. 321 with four lanes would operate at LOS B in 2006. Two-lane portions of U.S. 321 would experience LOS D in 2006 under this build option.

SR 416 would still operate at LOS B in 2006 since proposed Section 8B and 8C would have no interchange at Pittman Center and therefore no traffic entering or exiting the parkway at this location.

Traffic on proposed Section 8B would be moderate in 2006, operating at LOS C.

Based on the projected future traffic on U.S. 321, SR 416, and the Foothills Parkway in 2006, it can be concluded that the construction of Section 8B would not have significant traffic impact on the surrounding roadway under this build option.

**For 2026**: Although projected traffic volumes would increase between 2006 and 2026, the LOS ratings along many roadway sections would remain the same as in 2006. Only one section of roadway would exceed an acceptable LOS, and none would exceed the levels of service predicted for the no-build alternative.

Levels of service on all sections of U.S. 321 would degrade from 2006 conditions by one LOS category on weekends as would the section west of SR 416 on weekday mornings. Only the section of U.S. 321 from SR 416 to the convergence with SR 32 in Cosby would reach unacceptable levels of congestion (LOS E) on weekends under this build option. However, this is

the same LOS predicted for the no-build alternative. Traffic on U.S. 321 west of SR 416 would experience slightly less traffic and a better LOS (C) on weekends than it would with the no-build alternative (LOS D).

Levels of service on SR 416 would remain at LOS B in 2026 and would experience no significant growth in traffic volumes.

Levels of service along Section 8B would remain the same from 2006 to 2026, except for weekday mornings, which would decrease from LOS B to LOS C.

#### 4.7.3.2 Western Terminus Options

The western terminus options incorporate the timing option for Section 8B being constructed but not opened until Section 8C is complete. The timing option for Section 8B being constructed and put into operation before the completion of Section 8C is discussed later in Sect. 4.7.3.3.

**Interchange at SR 416 with north ramp connected to Webb Creek Road for 2006.** In this build option, the proposed parkway would have an entrance and exit ramp connecting to the existing T-intersection of SR 416 and Webb Creek Road. Because most of the Section 8B traffic would continue to and from Section 8C, the exiting and entering traffic on the northern ramp would be low. Thus, the traffic flow pattern under this option would be similar to the traffic flow pattern under the no-interchange option. The traffic on SR 416 would increase only slightly in 2006. This minor traffic increase on SR 416 would have no impact on LOS. SR 416 would still operate at LOS B in 2006 under this option. The traffic on U.S. 321 would decrease slightly in 2006, but U.S. 321 would still operate at the same LOS as in the no-interchange option (Sect. 4.7.3.1).

Under this option, the northern ramp of the parkway would connect to the existing T-intersection of SR 416 and Webb Creek Road. This configuration would require reconstruction of the existing intersection. It is assumed that the future intersection would be designed and built properly so that it would operate at an acceptable LOS.

A location has conflicting traffic when different traffic flows would like to use the same roadway facility at the same time. The best example of conflicting traffic is traffic at an intersection. For conflicting traffic, traffic control devices such as traffic signals or stop signs are needed to alternate the ROW to each conflicting traffic stream. The advantage of the northern ramp option is that it channels the added conflicting traffic to an existing intersection. Thus, the added conflicting traffic from the parkway would be consolidated with existing conflicting traffic. Any existing and future traffic problems could be resolved by the planned future reconstruction of the intersection.

Based on the projected future traffic on U.S. 321, SR 416, and the Foothills Parkway in 2006, it can be concluded that the construction of Section 8B under this option would not have significant traffic impact on the surrounding roadway.

**Interchange at SR 416 with south ramp connected to SR 416 for 2006.** The difference between this option and the north ramp option is that the entrance and exit ramp for the parkway would be connected to SR 416 south of the Webb Creek Road intersection. As stated previously, traffic on

the ramp would be light. This study assumes the future intersection of the parkway and SR 416 would be designed and built properly so that the new intersection would operate at an acceptable LOS.

In general, the traffic on all roadways near Section 8B would have the same traffic pattern as in the north ramp option in both 2006 and 2026. Thus, construction of Section 8B would not have a significant impact on the traffic on surrounding roadways under this option.

**Interchange at SR 416 (both ramp options for 2026).** Although traffic volumes would increase between 2006 and 2026, the LOS rating along most roadway sections would remain the same as in 2006. Only one section of roadway would exceed an acceptable LOS, and none would exceed the levels of service predicted for the no-build alternative.

Levels of service on all sections of U.S. 321 would remain the same as in 2006 during weekday peak periods but would degrade by one LOS category during weekend peaks. Only the section of U.S. 321 from SR 416 to the convergence with SR 32 in Cosby would reach unacceptable levels of congestion (LOS E) on weekends. However, this is the same LOS predicted for the no-build alternative.

Levels of service on SR 416 would remain at 2006 levels (LOS B) and would experience no significant growth in traffic volumes.

Traffic on Section 8B would continue to operate at LOS C in 2026 under this option.

**Interchange at U.S. 321 with ramp connected to U.S. 321 for 2006.** The difference between this option and the SR 416 north and south ramp options is that the entrance and exit ramp for the Foothills Parkway would be connected to U.S. 321 directly. Traffic would not travel through Pittman Center via SR 416. This study assumed the future intersection between the parkway and U.S. 321 would be designed and built properly so that it would operate at an acceptable LOS.

Since most of the Foothills Parkway traffic would remain on Section 8C, the entering and exiting traffic from the Foothills Parkway on this ramp would be light in 2006. Only a very small portion of the traffic on SR 416 would be diverted to U.S. 321 in 2006. Therefore, the traffic on all roadway segments near the Section 8B area would have the same traffic pattern as in the SR 416 north and south ramp options. Therefore, it can be concluded that the construction of Section 8B would not significantly affect traffic on the surrounding roadway under this option.

**Interchange at U.S. 321 with ramp connected to Webb Creek Road for 2006.** The difference between this option and the other U.S. 321 ramp option is that the Foothills Parkway entrance and exit ramp would be connected via Webb Creek Road to U.S. 321. The advantage of this ramp configuration is that it would channel the added conflicting traffic to an existing intersection. Any existing and future problems can be resolved by the future reconstruction of the intersection.

The intersection between the Foothills Parkway ramp and Webb Creek Road would be built and the existing intersection between Webb Creek Road and U.S. 321 would be reconstructed. This study assumes the future intersections would be designed and built so that the new intersection and reconstructed existing intersection would operate at an acceptable LOS.

The traffic on all parkway segments near the Section 8B study area would have the same traffic pattern as with the direct connection to U.S. 321 in both 2006 and 2026. Therefore, it can be concluded that the construction of Section 8B would not significantly impact traffic on surrounding roadways under this option.

**Interchange at U.S. 321 (both ramp options for 2026).** Although traffic volumes would increase between 2006 and 2026, the LOS rating along most roadway sections would remain the same as in 2006. Only one section of roadway would exceed an acceptable LOS, and none would exceed the levels of service predicted for the no-build alternative.

Levels of service on all sections of U.S. 321 would remain the same as in 2006 during weekday peak periods but would degrade by one LOS category during weekend peaks. Only the section of U.S. 321 from SR 416 to the convergence with SR 32 in Cosby would reach unacceptable levels of congestion (LOS E) on weekends. However, this is the same LOS predicted for the no-build alternative.

Levels of service on SR 416 would remain at 2006 levels (LOS B) and would experience no significant growth in traffic volumes.

Traffic on Section 8B would operate at LOS C in 2026 under this option.

#### 4.7.3.3 Operational Timing Options

The discussion in this section will concern only those timing options where Section 8B would be operational prior to Section 8C being completed. The scenarios that would occur if Section 8B were not opened until Section 8C was completed are discussed in Section 4.7.3.2 in conjunction with the Western Terminus Options.

**Section 8B operational prior to the complete Section 8C with interchange at SR 416 for 2006.** In this option, Section 8B would be built and operational before the completion of Section 8C. All traffic on Section 8B would have to enter and exit using the ramp in Pittman Center via SR 416. Thus , all Section 8B traffic would use SR 416. This translates into an increase of traffic on SR 416 of approximately 85% over the no-build alternative (Section 4.7.3.6). The LOS would be C compared with B for the no-build option in 2006. This is still an acceptable LOS.

The traffic on Section 8B would be diverted to U.S. 321 from SR 416 outside of Gatlinburg. Consequently, U.S. 321 from SR 416 to near Gatlinburg would operate at LOS C in 2006.

Although two roadway segments would experience lower LOS in 2006 under this option, both of them would still operate at an acceptable LOS. Therefore, it can be concluded that the construction of Section 8B under this alternative would not have a significant traffic impact on the surrounding roadways.

**Interchange at SR 416 (both ramp options for 2026).** Traffic conditions under this timing option would be similar to those that would occur if Section 8B were not opened until after 8C was completed (see Sect. 4.7.3.2). This option would have no effect on levels of service on the

sections of U.S. 321 east of SR 416 or on Section 8B. The section of U.S. 321 west of SR 416 and the southern end of SR 416 would generally experience LOS one category worse than if Section 8B was not opened prior to the completion of 8C. Like the western terminus option, the section of U.S. 321 from SR 416 to the convergence with SR 32 in Cosby would reach unacceptable levels of congestion (LOS E) on weekends in 2026. However, this is the same LOS predicted for the no-build alternative. All other roadway sections would operate at acceptable levels.

Compared to the no-build alternative, traffic conditions would operate at essentially the same LOS, except along SR 416 in 2026. Levels of service on SR 416 would generally operate at one LOS category worse than for the no-build scenario. Still, traffic conditions would be acceptable along this roadway section.

**Section 8B operational prior to the complete Section 8C with interchange at U.S. 321 for 2006.** All traffic on Section 8B would have to enter and exit using the ramp connected to U.S. 321 near Pittman Center or the ramp connected to Webb Creek Road. All Section 8B traffic would use U.S. 321. Traffic on SR 416 would not be affected under this option.

The traffic on Section 8B would be diverted to U.S. 321 from SR 416 outside of Gatlinburg. Consequently, U.S. 321 from SR 416 to outside of Gatlinburg would operate at LOS C in 2006.

**Interchange at U.S. 321 (both ramp options for 2026).** Traffic conditions under this timing option would be similar to those that would occur under the U.S. 321 interchange option if Section 8B were not opened until after 8C was completed (see Sect. 4.7.3.2). This option would have no effect on levels of service on the sections of U.S. 321 east of SR 416 or on Section 8B. The section of U.S. 321 west of SR 416 and the southern end of SR 416 would generally experience LOS one category worse than if Section 8B was opened after 8C was complete. Thus, it would experience LOS C during the weekday peaks and LOS D on weekends in 2026. Like the other option, the section of U.S. 321 from SR 416 to the convergence with SR 32 in Cosby would reach unacceptable levels of congestion (LOS E) on weekends in 2026. However, this is the same LOS predicted for the no-build alternative. All other roadway sections would operate under acceptable levels.

Compared to the no-build alternative, traffic conditions would operate at essentially the same LOS, except along U.S. 321 west of SR 416 in 2026. Levels of service on this section of roadway would generally operate at one LOS category worse (LOS C) than for the no-build scenario during the weekday peaks but would remain at the same LOS (D) as the no-build scenario during weekends. Still, traffic conditions would be acceptable along this roadway section.

#### 4.7.3.4 Traffic Impacts Due to Construction

The lack of a detailed engineering plan and construction schedule limits the assessment of traffic impacts from construction of Section 8B. Therefore, the traffic impacts associated with construction are described only in general terms.

There are no estimates of the workforce required to complete the construction of Section 8B during the peak construction period. However, it is assumed that it would not exceed the peak

workforce of 69 persons required for the construction of Section 8D (Sect. 4.6.1). Therefore, traffic generated by commuting construction workers would not have a significant effect on existing traffic. Trucks hauling construction-related materials would also have little effect on the level of service of local roads. However, the use of heavy trucks would significantly reduce the remaining service life of the pavement on these roads. Because a construction-related heavy-truck circulation plan has not yet been developed, it is uncertain which local roads would be affected.

#### 4.7.3.5 Cumulative Effects of All Sections Open to Traffic

If all sections of the Foothills Parkway were open to traffic, the traffic pattern in the study area (from Cosby to Pittman Center) would be similar to the traffic pattern with Sections 8B and 8C open to traffic. It is estimated that no more than an additional 500 vehicles per day or 10 vehicles per peak-hour through traffic would travel between Sections 8C and 8D since the traffic within the area is mostly tourist-related. The tourist-related traffic is heavily concentrated on U.S. 441 between Sevierville, Pigeon Forge, and Gatlinburg. The highest traffic volume on this corridor exceeded 4,000 vehicles per hour during the peak hour in 1994. This heavily traveled corridor, however, is not parallel to the proposed Foothills Parkway; thus it is not expected that much of this tourist-related traffic would be diverted to the proposed Foothills Parkway. U.S. 321 is parallel to Sections 8B, 8C, 8D, 8E and 8F of the proposed Foothills Parkway. Traffic on U.S. 321 ranges from 870 to 1,700 vehicles per hour and is relatively light compared with the traffic on U.S. 441. Thus, it is estimated that there would be no major cumulative increase in traffic with all segments of the Foothills Parkway open.

#### 4.7.3.6 No-Build Alternative

**For 2006**: Traffic would continue to increase on U.S. 321 from Cosby to Pittman Center to 2006. The traffic growth rates on U.S. 321 within the Section 8B area would range from 20% to over 40%. The existing traffic on SR 416 from Webb Creek Road to U.S. 321 would be light compared with traffic on U.S. 321. However, the traffic growth rate would be close to 200% on SR 416 to 2006. Despite high growth, traffic on SR 416 would still operate at LOS B in 2006.

As mentioned before, two modifications to U.S. 321 are planned by TDOT for the future: (1) in Sevier county, 9.3 km (5.8 miles) of U.S. 321 from Rattlesnake Hollow to SR 416 (from Gatlinburg to Pittman Center) would be widened to five lanes and (2) in Cocke county, 11 km (6.8 miles) of U.S. 321 in Cosby would be widened to four lanes along its convergence with SR 32. These segments of U.S. 321 would operate at LOS B in 2006. The two-lane segment of U.S. 321 from the convergence of SR 32 to SR 416 would experience LOS E in 2006 without the construction of Section 8B.

**For 2026**: By 2026, conditions on U.S. 321 between SR 416 and the convergence with SR 32 in Cosby would continue to operate at an unacceptable LOS on weekends but would not degrade beyond LOS E. Conditions on U.S. 321 west of SR 416 would generally degrade by one LOS category by 2026. Traffic volumes on U.S. 321 north of the convergence with SR 32 would increase, causing weekend levels of service to degrade from LOS B to LOS C.

Traffic volumes on SR 416 would increase modestly and remain at LOS B during all peak periods.

#### 4.7.3.7 Bicycle Traffic

Foothills Parkway Section 8B is proposed as a scenic roadway used primarily for auto touring. Bicycling, however, is an increasingly popular activity, making it important to determine how much bicycling traffic might occur on Section 8B if constructed. At present, there is no standard, accepted method for modeling bicycle traffic flow along roadways or estimating activity levels in a given area. Therefore, ORNL estimated usage, in a very general sense, based on the suitability of Section 8B for cycling. In doing so, ORNL compared the physical characteristics of Section 8B with the "bike-way" characteristics desirable to two kinds of users, (1) casual users and (2) enthusiasts (i.e., those who are advanced bicyclists or consider bicycling a hobby), to evaluate how attractive Section 8B would be to each user type. The analysis indicates that the parkway, as designed, is not well suited for either user type and is unlikely to receive significant bicycle use.

Most of Section 8B would be built on mountainous terrain and, based on analysis of the current roadway design profile, would contain many steep uphill and downhill slopes. From Pittman Center to Cosby, the roadway slopes downward for 49.5% of its length and upward for 50.5%. About two-thirds (65.6%) of the downward sloping mileage and 60.2% of the upward sloping mileage have grades in excess of 5%. Thus, overall, 14.3 km (8.9 miles) of Section 8B would have a slope in excess of 5% grade, and a bicyclist would have to traverse more than 7 km (4 miles) of steep up-hill slopes in excess of 5% grade from either Pittman Center or Cosby. Bicycling these slopes would be physically challenging, which would deter many potential bicyclists.

The California Department of Transportation (CDOT) Highway Design Manual (one of the few available manuals containing bikeway design criteria) Section 1003.3, paragraph (12), recommends that the maximum grade for bike paths be 5%. If a wide range of riders is to be accommodated, it suggests that sustained grades be limited to 2%, although steeper grades can be tolerated for short sections [e.g., up to about 150 m (490 ft)] (CDOT 1995). In its assessment, ORNL staff have applied these criteria as those sought by cyclists in choosing a place to ride. The physical characteristics of Section 8B differ markedly from the California State Department of Transportation bikeway design criteria, especially in terms of the grade requirements for use by "a wide range or riders." This suggests that casual riders, or non-enthusiasts, would be unlikely to use the Section 8B due to its physically demanding ascents. Furthermore, since parkway grades typically exceed 5% for long sections, this criterion suggests that use by enthusiasts might also be limited.

In order to better understand the potential usage by enthusiasts, NPS and ORNL staff met informally with members of several biking organizations in the Knoxville area on October 2, 1997. Most cyclists at the meeting described current bicycle use as heavy in the Knoxville area, but use near the park was significant only on select routes. Most cyclists at the meeting felt that local and park roads surrounding the GSMNP were too narrow and unsafe for most serious or recreational bike riding. They expressed some interest in riding completed sections of the parkway, but only when traffic was extremely light. Most roads in the vicinity of the parkway are frequently much too busy to be used safely.

The cyclists were unable to estimate the potential bicycle usage of the parkway section, either on the proposed automotive roadway or on some widened or additional path area. Bicycle use and

popularity has grown substantially in the past 5–10 years, but great concern was expressed again regarding the safety of the narrow existing and proposed roads. Based on the current design of Section 8B, the Foothills Parkway would be a two-lane parkway with one lane in each direction. The lane width is 3.1 m (10 ft) with no paved shoulder. Some of the access roads have a lane width of 2.7 m (8.8 ft). There was general agreement from those attending the meeting that bicycle usage for Section B would be very light if designed and constructed as currently envisioned.

Based on analysis of the Foothills Parkway Section 8B design plan and a comparison of that design with both the bikeway design criteria specified in the CDOT Highway Design Manual and comments solicited from members of several biking organizations in the Knoxville area, it has been concluded that the future bicycle use of this section of the Parkway would be very low and that any traffic flow impact associated with bicycle use on Section 8B would be negligible.

#### 4.7.3.8 Summary

The Foothills Parkway is envisioned as a scenic, low-speed touring road and an integral part of the GSMNP, although it would not lie within the park boundary. Section 8B of the parkway would connect Cosby and Pittman Center. The analysis presented here indicates that traffic operation along this segment would be at LOS C and would accommodate future traffic adequately.

TDOT plans to widen the existing U.S. 321 near Cosby and Gatlinburg to four lanes. This would alleviate traffic congestion on U.S. 321 in the future. The four-lane segments of U.S. 321 would operate at LOS B in 2006. However, one segment of U.S. 321 from SR 416 to the convergence of U.S. 321 and SR 32 in Cosby would still be a two-lane highway. This two-lane segment of U.S. 321 would operate at LOS E in 2006 without the construction of Section 8B.

Construction of Sections 8B and 8C would alleviate some traffic on U.S. 321 from Cosby to Gatlinburg. The four-lane segments of U.S. 321 would still operate at LOS B in 2006. However, the two-lane segment of U.S. 321 would operate at LOS D in 2006.

Completion and opening of Section 8B prior to the completion of Section 8C would have a minor traffic impact on surrounding roadways between Cosby and Pittman Center. Traffic on SR 416 would increase by 85% compared with the no-build alternative if the Foothills Parkway interchange were connected to SR 416 in Pittman Center. The LOS would be C as compared to B under the no-build alternative in 2006. Otherwise, the two-lane segment of U.S. 321 would operate at LOS E during weekend peak periods if the Foothills Parkway interchange were connected to U.S. 321 near Pittman Center.

Traffic conditions for all alternatives and options in 2026 would be similar to those in 2006, except that traffic volumes would be somewhat higher and LOS along some roadway sections would degrade by one LOS category. All roadway sections would still operate at acceptable levels of service during the weekday peak periods, but the section of U.S. 321 between SR 416 and the convergence of U.S. 321 and SR 32 would operate at an unacceptable LOS (E) during weekend peak periods. This is true for the no-build scenario as well.

Almost all intersections within the Section 8B area would be constructed with Section 8B or would be included in currently planned highway improvement programs. These intersections would be designed and constructed properly so that all intersections would operate at an acceptable level of service in the future.

In general, completion of Section 8B would not have a significant traffic impact on surrounding roadways between Cosby and Pittman Center. Based on preliminary analysis, there would be no significant construction-related traffic due to the construction of Section 8B. Furthermore, there is no cumulative traffic effect if all Foothills Parkway segments are built and open to traffic in the future.

### 4.7.4 Future Noise Projections

#### 4.7.4.1 Applied Methodology

ORNL projected future noise levels for 41 representative sites in the Section 8B study area for the A.M. and P.M. peak hours during weekdays and weekends for 2006 and 2026 for all construction alternatives and options. These noise level projections were calculated using the simple version of the FHWA Highway Traffic Noise Prediction Model. This procedure can be applied either by performing noise level calculations manually or by using FHWA's computerized version. The computerized version was used in this analysis; thus, it was only necessary to input the appropriate data into the model to generate scenario results. However, a description of the FHWA noise level prediction methodology is provided to help the reader understand the factors that affect predicted noise levels and to describe some of the assumptions made in the estimation process.

The FHWA model predicts traffic noise equivalency level ($L_{eq}$) using a series of calculations regarding the characteristics of the noise source and its spatial relationship to the receptor. The model considers the vehicle types and typical speeds of the vehicles that will be operating on the roadway, the roadway geometry, the terrain surface type between the source and the receptor, the presence of shielding between the source and receptor, and the uphill grade that will have to be traversed by vehicles. The following equation represents a simplified version of the methodology. A detailed description can be found in FHWA 1978.

Noise level = Reference energy mean emission level
+ Traffic volume adjustment
+ Distance adjustment
+ Finite roadway adjustment
+ Shielding adjustment

This methodology assumes that all traffic noise from passenger vehicles is caused by the friction between tires and the roadway. Therefore, the sound source is modeled at an elevation of 0 m (0 ft) (i.e., ground level). For heavy trucks, noise is generated from tire-roadway friction, engine noise, and exhaust. Engine noise and exhaust are modeled several feet above ground level. However, this model assumes no heavy trucks will be operating on the roadway (this is explained later). The receptor is assumed to be an average-sized human standing at the specified location; thus, the receptor is modeled at 1.5 m (5 ft).

As indicated by the equation, the first step in the analysis is to determine the reference energy mean emission level. The reference energy mean emission level is the typical level of sound energy emitted from a given vehicle type (i.e., passenger car, medium truck, heavy truck) traveling over a flat, straight roadway surface at a given speed as measured at a receptor site that is 15 m (49.2 ft) away. For this analysis, it was assumed that all traffic on Section 8B would travel at 48 kph (30 mph); all traffic on U.S. and State highways would travel at 80 kph (50 mph); and all traffic on local streets would travel at 40 kph (25 mph).

Once the reference energy mean emission level is determined, this estimate is adjusted based on the predicted amount of traffic that will travel over the roadway during a given time period. ORNL has predicted traffic volumes for several peak periods in the years 2006 and 2026. These projections were used to adjust the reference energy mean emission level by the number of vehicles of each type that would be traveling along the roadways near each receptor site. It was assumed that all vehicles on the Foothills Parkway would be passenger vehicles. For other vehicle routes, vehicle turning movement percentages and their associated vehicle type counts were used to determine vehicle type percentages. The percentage of heavy trucks was determined to be negligible; thus, the percentages of medium trucks resulting from these counts are listed below:

U.S. 321 from Foothills Parkway Section 8A to SR 32 (9%)
U.S. 321 from SR 32 to SR 416 (7%)
U.S. 321 from SR 416 toward Gatlinburg (5%)
SR 416 from U.S. 321 toward Sevierville (7%)

All other vehicles are assumed to be passenger vehicles.

As previously mentioned, the reference energy mean emission levels assume that the receptor is 15 m (49.2 ft) from the source. However, since most receptors will be closer to or farther away from the source, it is necessary to adjust the noise level by considering the actual distance between each receptor and the noise source(s). Therefore, the noise level is again adjusted upward for receptors that are closer to the source and adjusted downward for those further away. The amount of adjustment is calculated using a standard formula for the attenuation of noise over doubled distance. This attenuation is typically modeled as a drop of 3 dBA per doubling of distance for cases where a hard (mostly reflective) surface lies between the source and receptor, and is modeled as a drop of 4.5 dBA per doubling of distance when a soft (absorptive) surface exists. Other adjustments were made for small hills, berms, or other terrain features that may block the line of sight from the receptor to the roadway. Distances between the source and receptor were measured on-site using tape measures or range-finding devices where applicable. In other instances, distances were determined from maps or aerial photographs.

Possibly the most complex part of the analysis is determining the finite roadway adjustment factor. All calculations up to this point of the procedure assume that the roadway stretches out infinitely in both directions in a straight line. However, this is often not the case. This factor allows the analyst to correct for the potential impacts of roadway geometry on the sound level. For example, a house that is located in a sharp bend in a road may be closer to a larger portion of the roadway than if the roadway were straight. Conversely, a house located on the outer side of the bend may have more of the roadway farther away. In such instances, it is necessary to divide the roadway into separate sections, estimate the noise level for each section, and combine these estimates into a

single noise level (remember that noise levels are not additive). By doing so, the roadway is analyzed in finite rather than infinite sections. The calculations for these finite sections are relatively complicated; thus, the original source material should be consulted for a more mathematically oriented explanation of the procedure. Also, it should be noted that this calculation is not always necessary. Aerial photographs and maps were used to determine roadway geometry and other factors that would warrant sectioning the roadway for analysis purposes.

The final noise level adjustment accounts for any objects located between the source and receptor that would absorb sound or reflect it away from the receptor, such as noise barriers, trees, buildings, or other natural or man-made structures. This adjustment is based on FHWA guidelines and the judgement of the analyst, who considers several factors such as the size and position of the barrier as well as the reflective or absorptive nature of the barrier. For example, a row of houses between the roadway and the receptor might require a −3 dBA adjustment, in the judgement of the analyst, while 30.5 m (100 ft) of mature forest between the roadway and the receptor might require a −5 dBA adjustment. Aerial photographs and notes taken during data collection were used to determine the presence, position, and size of barriers such as buildings and vegetation.

Sections 4.7.4.2 and 4.7.4.4 discuss the results of the traffic noise analysis. Actual noise level projections for all alternatives and options and comparisons with the no-action alternative are presented in Tables L1–L11 of Appendix L. Site locations are presented in Figs. 86–90.

#### 4.7.4.2 Traffic Noise

**Construct Sections 8B and 8C with no interchanges.** The opening of Sections 8B and 8C would divert tourist-related traffic from U.S. 321 to the Foothills Parkway. The Foothills Parkway traffic would be light and most of the U.S. 321 traffic would stay on U.S. 321. Similar to the no-build alternative, most sites would experience little traffic noise impact and would experience noise levels within the FHWA standard for residential areas. In 2006, the highest $L_{eq}$ noise level at 34 sites would be below 50 dBA; no sites would experience levels between 50–60 dBA; and 5 sites would experience levels between 60–67 dBA. In 2026, the highest $L_{eq}$ noise level at 34 sites would be below 50 dBA, and 5 sites would experience levels between 60–67 dBA. Noise levels at two sites (sites 6 and 19) would exceed standards by 2006. The addition of Section 8B would slightly decrease the traffic volume along U.S. 321, thereby decreasing the projected noise levels for sites 6 and 19 on U.S. 321 (Figs. 87 and 89).

Sites 16, 17,18, 25, 26, 27, and 40 would experience perceptible increases in traffic noise, as much as 12 dBA during some peak periods, compared with the no-build alternative. The sometimes significant increases in traffic noise levels at these sites would be due to the low existing traffic noise levels. The projected noise levels for these sites are still low, ranging from 30 to 42 dBA. It should be noted that the existing noise levels measured at these sites are higher than the projected traffic noise levels. This suggests that ambient noise other than traffic noise dominates the noise level at these sites.

**Foothills Parkway interchange at SR 416 with north ramp or south ramp.** Under these build options, some of the traffic on Sections 8B and 8C would use SR 416. Such Foothills Parkway-related traffic on SR 416 would be very light. Therefore, the noise impact would be similar to that

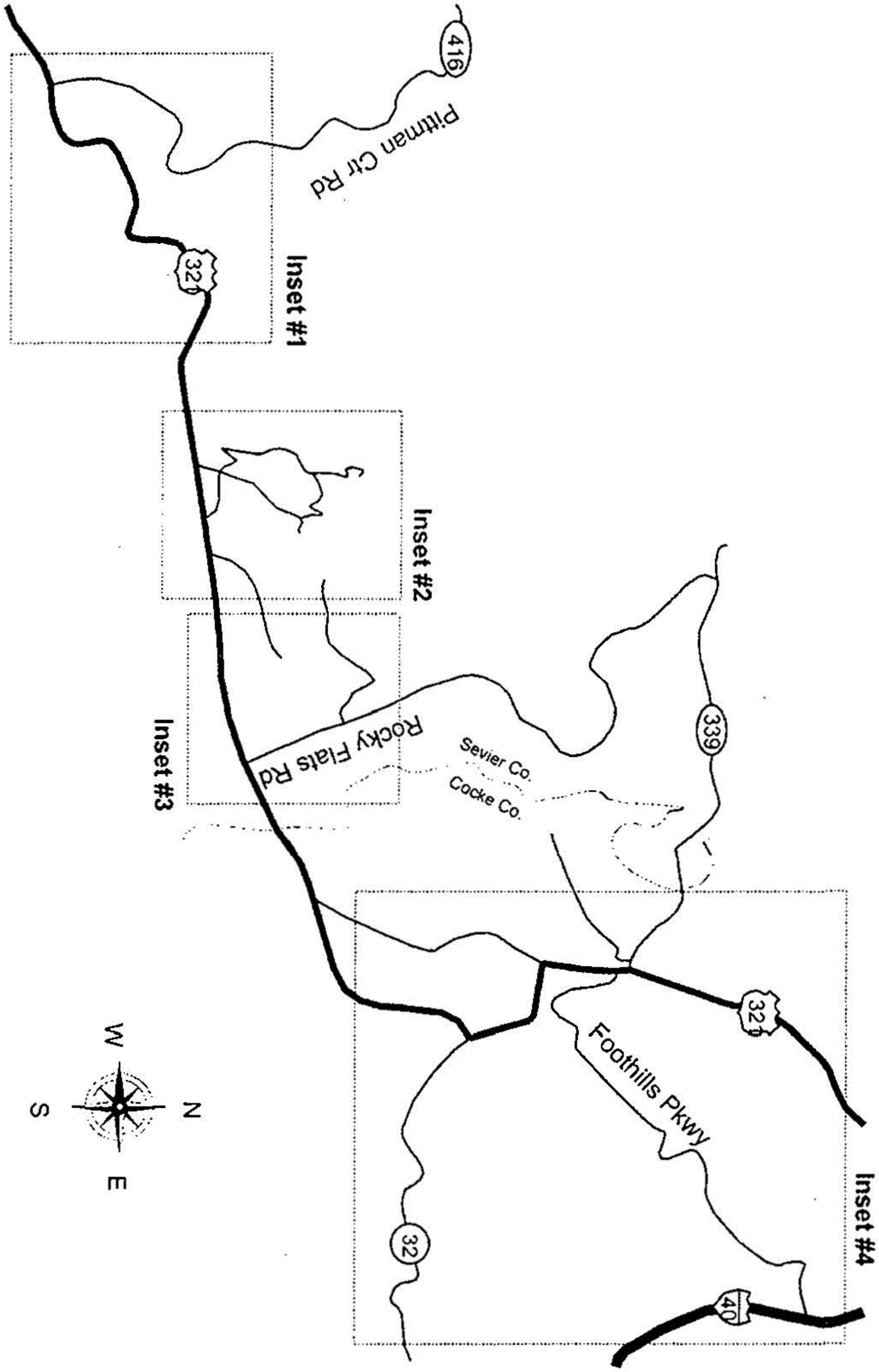



**Fig. 86. Area map for ambient noise level measurement sites.**

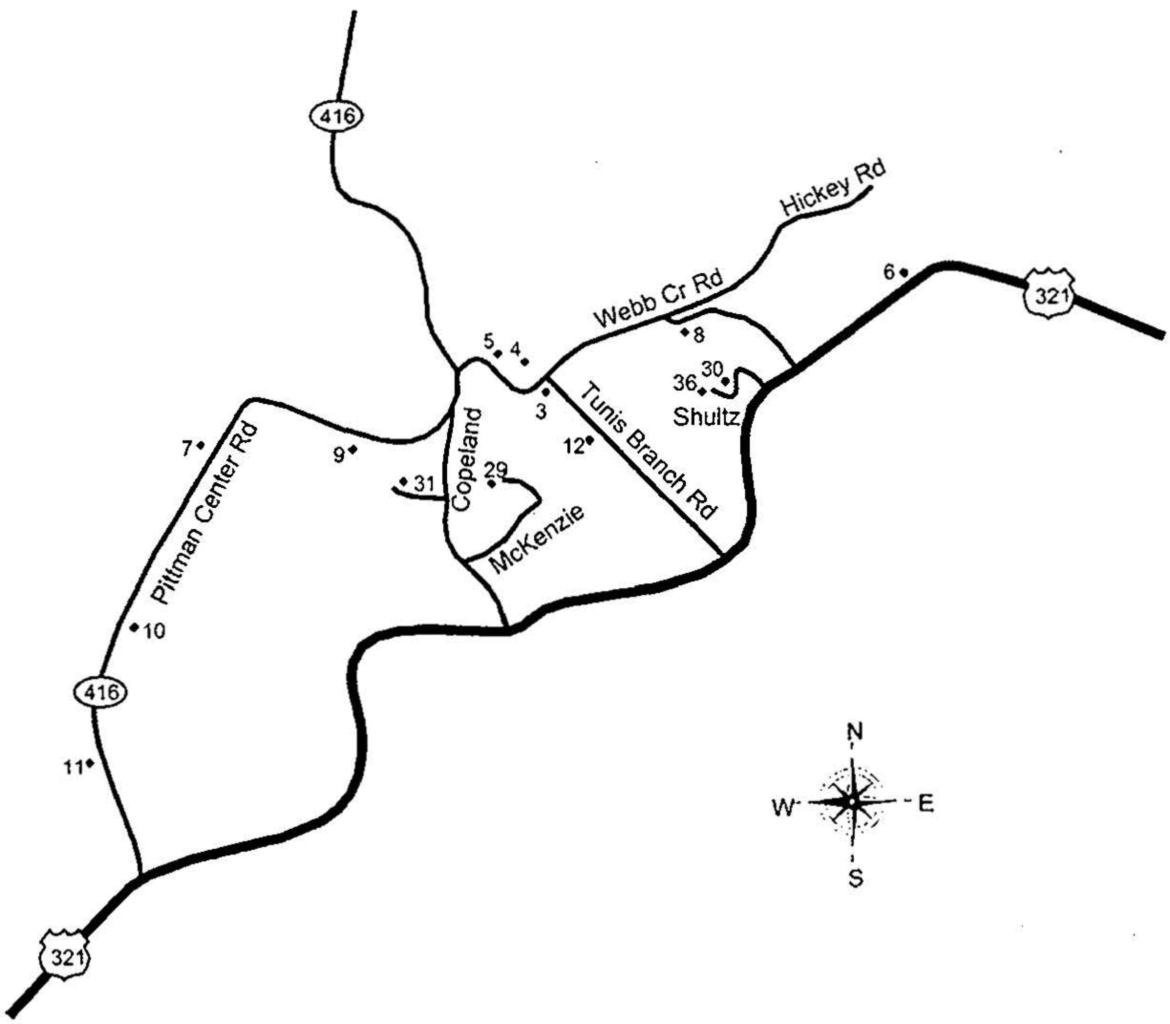



**Fig. 87. Area map for ambient noise level measurement sites, Pittman Center area.**

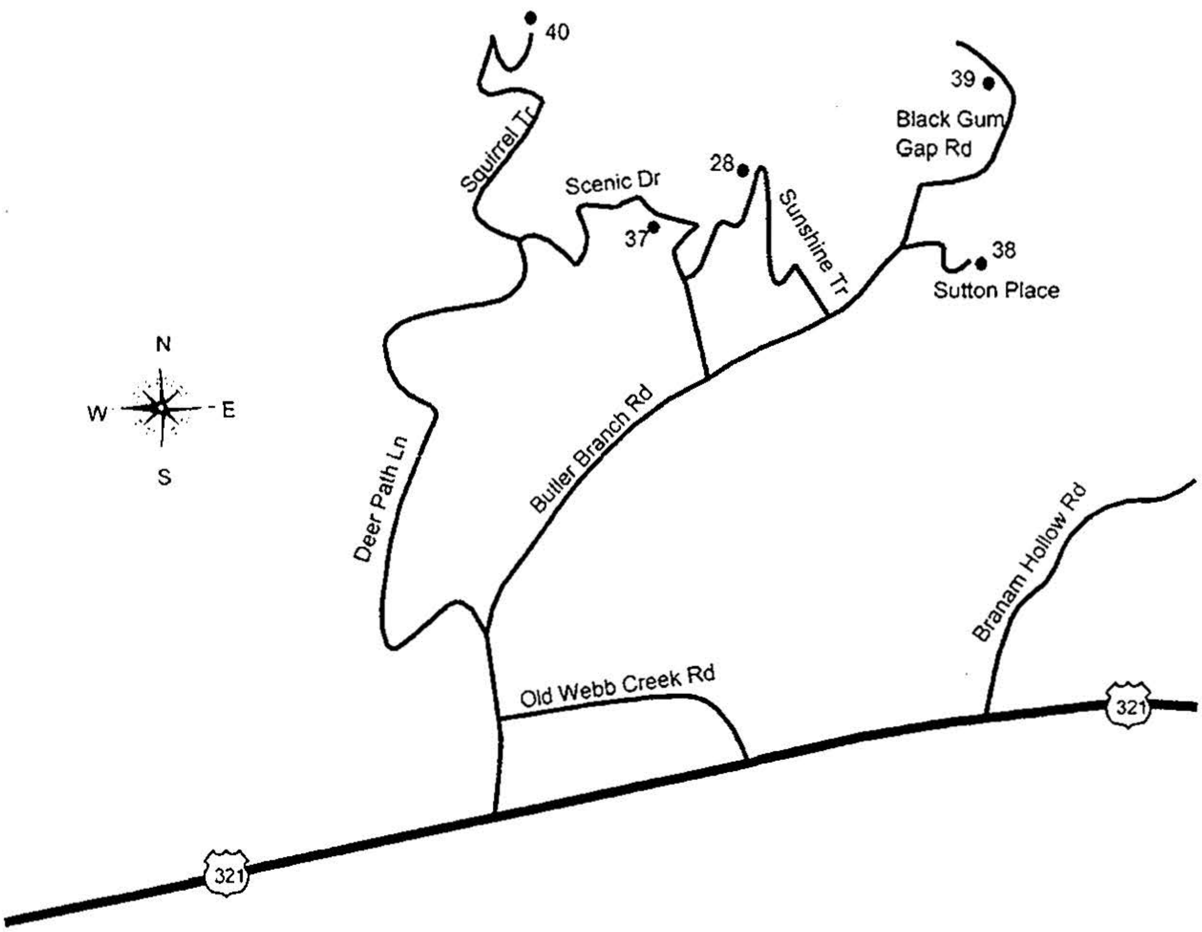



**Fig. 88. Area map for ambient noise level measurement sites, Cobbly Nob area.**

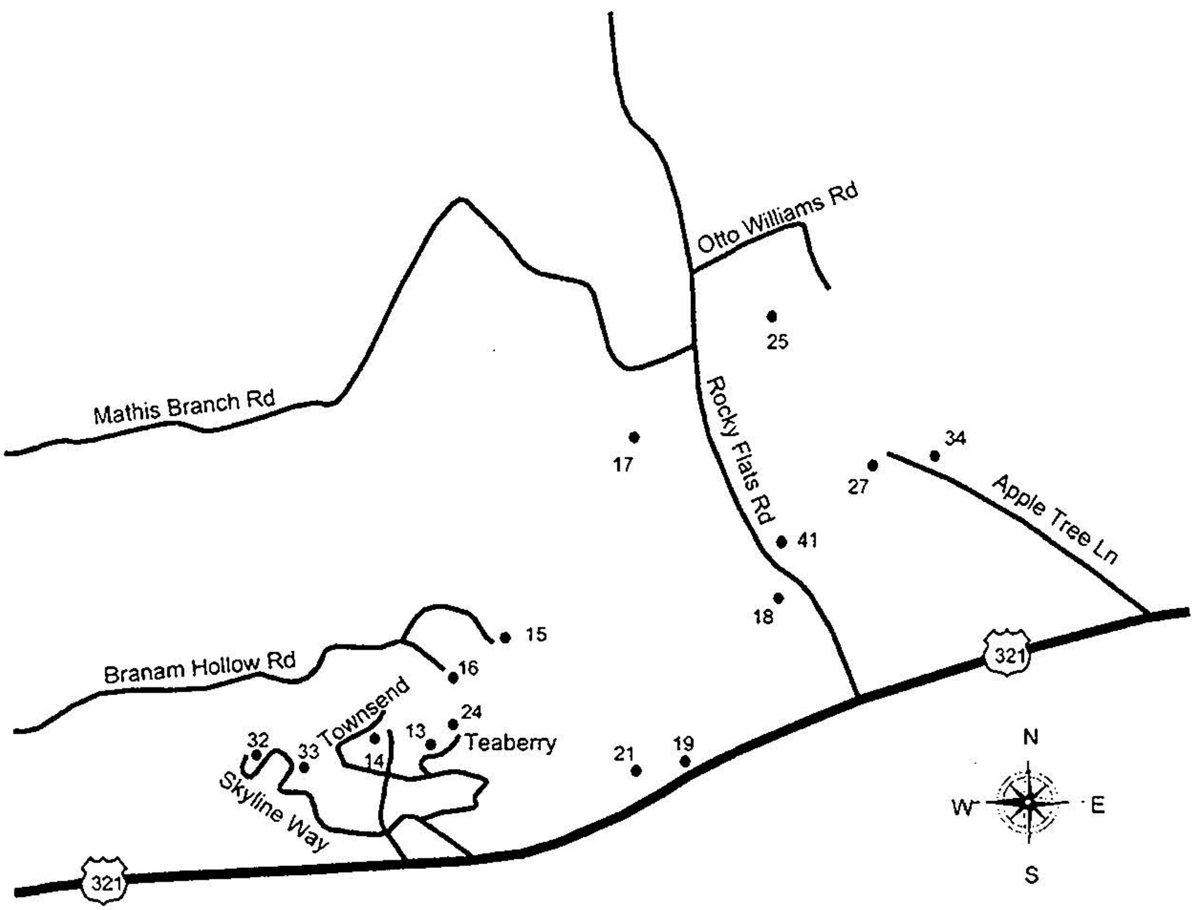



Fig. 89. Area map for ambient noise level measurement sites, Rocky Grove area.

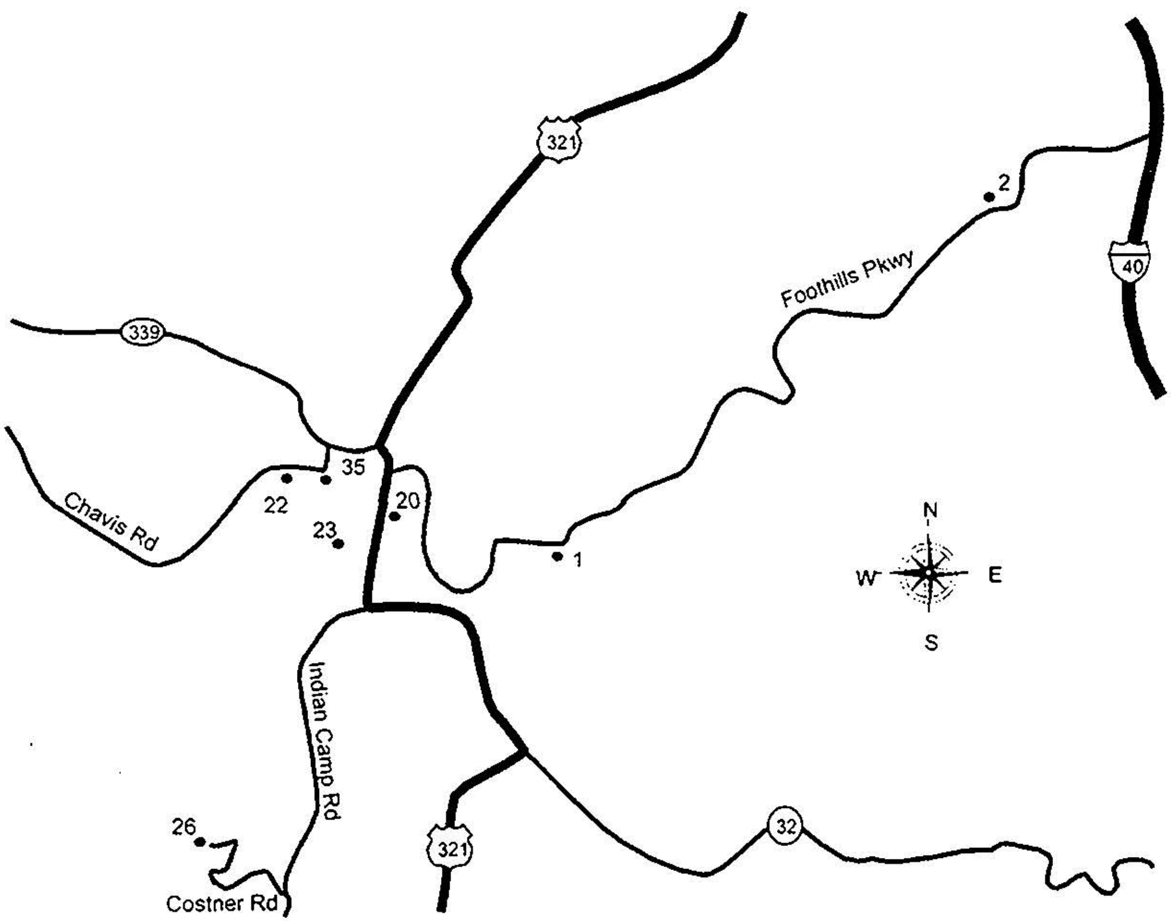



**Fig. 90. Area map for ambient noise level measurement sites, Cocke County area.**

of the "no interchange" option (i.e., most sites would experience little traffic noise impact and would experience noise levels within the standard for residential areas). By 2026, the highest $L_{eq}$ noise level at 34 sites would be below 50 dBA, and 5 sites would experience levels between 60–67 dBA. However, all sites along SR 416 would experience noise levels below the FHWA-established standard of $L_{eq}$ = 67 dBA. Noise levels at sites 6 and 19 along U.S. 321 (Figs. 87 and 89) would exceed standards by 2006.

Sites 16, 17, 18, 25, 26, 27, and 40 would experience perceptible increases in traffic noise, as much as 12 dBA during some peak periods, compared with the no-build alternative. These increases would be identical to those under the "no interchange" option. The significant increases in traffic noise levels at these sites would be due to the low existing traffic noise levels. The projected noise levels for these sites are still low, ranging from 30 to 42 dBA, and fall well below the FHWA-established standard for residential areas. The existing noise levels measured at these sites are higher than the projected traffic noise level. This indicates that ambient noise rather than traffic dominates the noise level at these sites.

**Foothills Parkway Interchange at U.S. 321 with two different ramp connection configuration options.** These build options are very similar to those discussed for the SR 416 ramp options, except that the Foothills Parkway Pittman Center interchange would be at U.S. 321 instead of at SR 416. Some of the Section 8B and 8C traffic would use U.S. 321 directly. Such traffic would be very light. Most sites would experience little traffic noise impact and would experience noise levels within the standard for residential areas. By 2026, the highest $L_{eq}$ noise level at 34 sites would be below 50 dBA, and 5 sites would experience levels between 60–67 dBA. Noise levels at sites 6 and 19 along U.S. 321 would exceed standards by 2006.

Sites 16, 17, 18, 25, 26, 27, and 40 would experience perceptible increases in traffic noise compared with the no-build alternative, as much as 12 dBA during some peak periods. The sometimes significant increases in traffic noise levels at these sites would be due to the low existing traffic noise levels. The projected noise levels for these sites are low, ranging from 30 to 42 dBA, and fall well below the FHWA-established standard for residential areas. As indicated, the existing noise level measured at these sites is higher than the projected traffic noise. This indicates that ambient noise other than traffic dominates the noise level at these sites.

**Section 8B begins operation before completion of Section 8C with interchange at SR 416.** Under this alternative, all traffic on Section 8B must use SR 416 to enter and exit the Foothills Parkway and continue trips on U.S. 321. Consequently, the noise levels at site 10, in addition to those at sites 6 and 19, near SR 416 would exceed FHWA residential noise standards by 2006. Most other sites would experience little traffic noise impact and would experience noise levels within the standard for residential areas. By 2026, the highest $L_{eq}$ noise level at 34 sites would be below 50 dBA, and 4 sites would experience levels between 60–67 dBA. Noise levels at sites 6 and 19 along U.S. 321 (Figs. 87 and 89) would exceed standards by 2006.

Sites 10, 11, 16, 17, 18, 25, 26, 27, and 40 would experience perceptible increases in traffic noise, as much as 12 dBA during some peak periods, compared with the no-build alternative. The increase in traffic noise levels at sites 10 and 11 would be due to added Section 8B traffic on SR 416. Traffic noise level increases at the other sites would be identical to those under the "no-build" option. The increases in noise levels at these sites would be due to the low existing noise

levels. Still, the projected noise levels for these sites are low, ranging from 30 to 42 dBA, and fall well below the FHWA-established standard for residential areas. As indicated, the existing noise levels measured at these sites are higher than the projected traffic noises. This indicates that ambient noise rather than traffic dominates the noise level at these sites.

**Section 8B begins operation before completion of Section 8C with interchange at U.S. 321.** Under this build option, all traffic on Section 8B could use U.S. 321 directly to enter and exit Foothills Parkway. No Foothills Parkway–related traffic would use SR 416. Thus, most sites would experience little traffic noise impact and would experience noise levels within the standard for residential areas. By 2026 the highest $L_{eq}$ noise level at 34 sites would be below 50 dBA, and 5 sites would experience levels between 60–67 dBA. Noise levels at sites 6 and 19 along U.S. 321 (Figs. 87 and 89) would exceed standards by 2006.

Sites 16, 17, 18, 25, 26, 27, and 40 would experience significant increases in traffic noise, as much as 12 dBA during some peak periods, compared with the no-build alternative. The significant increases in traffic noise levels at these sites would be due to the low levels of existing traffic noise. Still, the projected noise levels for these sites are low, ranging from 30 to 42 dBA, and fall well below the FHWA-established standard for residential areas. As indicated, the existing noise levels measured at these sites are higher than the projected traffic noise levels. This indicates that ambient noise rather than traffic dominates the noise level at these sites.

**No-action alternative (no-build).** Noise projections for the study area indicate that, for the no-build alternative, most sites would experience little traffic noise impact and would experience traffic noise levels below the FHWA-established standard for residential areas through the year 2026. Most sites (34 sites) have a projected noise level of less than 50 dBA during the noisiest peak period in both 2006 and 2026; two sites have levels 50–60; and only three sites have levels between 60 and 67 dBA.

Two sites along U.S. 321 would experience noise levels that exceed this standard by the year 2006 because of their close proximity to the highway and the large volume of traffic expected to travel along it. The projected $L_{eq}$ noise levels at these sites (i.e., sites 6 and 19) would range from 70 to 73 dBA by 2006 and from 70 to 75 dBA by 2026. Both sites are located very close to U.S. 321 (Figs. 87 and 89). Thus, it should be noted that the noise from U.S. 321 would dominate the overall noise levels at these sites, making the impact of parkway noise negligible.

#### 4.7.4.3 Construction Noise

Calculation of construction noise levels is usually not necessary for traffic noise analyses. Such analyses are data intensive and are usually reserved for complex or controversial major urban projects. FHWA guidelines suggest that, in cases where a noise analysis is not warranted, a common-sense approach to noise management and abatement be used (FHWA 1984). Standard noise mitigation methods suggested by the FHWA are presented in Sect. 5.7.3.

ORNL does not expect any serious noise impacts from the Section 8B construction process. The nearest sensitive receptors are over 91 m (300 ft) from the proposed centerline of the parkway and should be approximately 76 m (250 ft) from any related construction activity, such as clearing, cutting, or filling. Furthermore, construction activity would be temporary and would most likely be

conducted during regular working hours. Still, noise from construction equipment is harsh and annoying, and the relative serenity of the surrounding area is likely to make these noises more noticeable. Rental properties that depend upon the serenity of the area might also be temporarily affected by construction noise. Thus, the NPS may want to consider conducting a formal noise study if it feels the topic of construction noise is controversial or highly sensitive to area residents. A noise study might also be warranted if the proposed location of the parkway is changed in the future so that it lies closer to existing residences.

It should be noted that, at this time, a formal, accurate, quantitative analysis of noise impacts cannot be performed. Detailed engineering and construction plans for Section 8B are not yet developed, and the contract for construction has yet to be prepared. Thus, detailed information on the number of the various pieces of equipment that would be used, their specifications, the locations at which they would be used, and their operation schedules are not yet available.

In projecting the air quality impacts of the construction process, ORNL has made some assumptions regarding the number of pieces and types of equipment that would be used in constructing Section 8B, along with the amount of time this equipment would be in operation. However, while these assumptions are adequate for estimating air pollution, they are less useful for estimating the resulting sound levels that would be experienced by sensitive receptors in the area. Emission of airborne pollutants depends primarily on the types of equipment used and the amount of time each is in operation. For adequate noise level analysis, however, the number of pieces of each type of equipment that would be working simultaneously at each site must be determined. Furthermore, the position of the sound source(s) relative to sensitive receptors must be determined so that the effects of topology, terrain, and other noise-attenuating factors can be considered as well. Thus, the NPS, the FHWA, or the contractor would have to provide a construction schedule and haul road routes if an accurate noise analysis were to be performed.

Table 63 has been provided to describe the noise levels that are typically emitted by various types of equipment used in highway construction, as well as some generalized estimates of the amount of attenuation that can be expected at various distances from the construction area. A number of assumptions have been made regarding terrain, the presence of natural noise barriers (e.g., trees), and other factors that affect noise attenuation. It should be understood that these noise levels are rough estimates for single pieces of equipment only (except in the cases of scrapers and dump trucks) and do not represent an actual analysis.

### 4.7.4.4 Traffic Noise Summary

The noise analysis indicates that, for each of the build options, noise impacts would be quite similar, and none of the construction options should increase noise levels above FHWA standards for residential areas by 2026. The traffic noise levels would increase significantly at some receptor sites, but would still remain lower than the ambient noise levels currently existing. Therefore, existing noise levels would dominate, and traffic noise impacts would be negligible at most sites.

The analysis does, however, indicate that noise levels at two sites along U.S. 321 will likely exceed FHWA standards by the year 2006 under almost all alternatives and options, including the no-build alternative. It is likely, however, that traffic unrelated to the Parkway will be primarily

**Table 63. Construction noise levels for typical equipment types at various distances**

| Equipment type | Generalized noise level $L_{eq}$ (dBA) at distance from source 50 feet | 100 feet | 200 feet | 300 feet | 400 feet | 500 feet | 750 feet | 1,000 feet | Noise source type |
|---|---|---|---|---|---|---|---|---|---|
| Backhoe | 82.6 | 73.1 | 63.5 | 57.1 | 52.0 | 47.6 | 43.2 | 40.1 | Point |
| Loader | 83.1 | 73.6 | 64.0 | 57.6 | 52.5 | 48.1 | 43.7 | 40.6 | Point |
| Compressor | 88.4 | 78.9 | 69.3 | 62.9 | 57.8 | 53.4 | 49.0 | 45.9 | Point |
| Pile driver | 90.4 | 80.9 | 71.3 | 64.9 | 59.8 | 55.4 | 51.0 | 47.9 | Point |
| Pump | 70.1 | 60.6 | 51.0 | 44.6 | 39.5 | 35.1 | 30.7 | 27.6 | Point |
| Crane | 80.6 | 71.1 | 61.5 | 55.1 | 50.0 | 45.6 | 41.2 | 38.1 | Point |
| Rock drill | 88.1 | 78.6 | 69.0 | 62.6 | 57.5 | 53.1 | 48.7 | 45.6 | Point |
| Std. jackhammer | 79.1 | 69.6 | 60.0 | 53.6 | 48.5 | 44.1 | 39.7 | 36.6 | Point |
| Concrete pour | 72.1 | 62.6 | 53.0 | 46.6 | 41.5 | 37.1 | 32.7 | 29.6 | Point |
| Batch plant | 89.1 | 79.6 | 70.0 | 63.6 | 58.5 | 54.1 | 49.7 | 46.6 | Point |
| Pump (concrete) | 84.1 | 74.6 | 65.0 | 58.6 | 53.5 | 49.1 | 44.7 | 41.6 | Point |
| Concrete mixer | 81.9 | 72.4 | 62.8 | 56.4 | 51.3 | 46.9 | 42.5 | 39.4 | Point |
| Generator | 80.1 | 70.6 | 61.0 | 54.6 | 49.5 | 45.1 | 40.7 | 37.6 | Point |
| Grinder | 69.1 | 59.6 | 50.0 | 43.6 | 38.5 | 34.1 | 29.7 | 26.6 | Point |
| Concrete saw | 87.1 | 77.6 | 68.0 | 61.6 | 56.5 | 52.1 | 47.7 | 44.6 | Point |
| Fan | 82.1 | 72.6 | 63.0 | 56.6 | 51.5 | 47.1 | 42.7 | 39.6 | Point |
| Welder | 70.1 | 60.6 | 51.0 | 44.6 | 39.5 | 35.1 | 30.7 | 27.6 | Point |
| Bulldozer | 93.1 | 86.6 | 80.1 | 75.5 | 71.6 | 68.1 | 65.5 | 63.6 | Area |
| Grader | 65.3 | 58.8 | 52.3 | 47.7 | 43.8 | 40.3 | 37.7 | 35.8 | Area |
| Compactor | 91.0 | 84.5 | 78.0 | 73.4 | 69.5 | 66.0 | 63.4 | 61.5 | Area |
| Paving equipment | 60.9 | 54.4 | 47.9 | 43.2 | 39.4 | 35.9 | 33.3 | 31.4 | Area |
| Dump truck (quiet) | 52.2 | 45.7 | 39.2 | 34.5 | 30.6 | 27.2 | 24.6 | 22.7 | Line |
| Dump truck (noisy) | 57.2 | 50.7 | 44.2 | 39.5 | 35.6 | 32.2 | 29.6 | 27.7 | Line |
| Scraper (muffled) | 60.9 | 54.3 | 47.8 | 43.2 | 39.3 | 35.9 | 33.2 | 31.3 | Line |
| Scraper (nonmuffled) | 71.9 | 65.3 | 58.8 | 54.2 | 50.3 | 46.9 | 44.2 | 42.3 | Line |

*Source:* Estimates in this table were based primarily on data and methods in Vanderbilt 1982, Bowlby and Cohn 1983.

Note: A wide variation of noise level in equipment is not uncommon. It was found that, in the field, nominally identical pieces of equipment could produce noise levels that differ from 10 dB or more. Usually, a relatively few pieces of heavy equipment are used at the same time at a construction site. Caution must be exercised in any use of average noise levels for a specific case.

Assumptions:

(a) Terrain was assumed to be soft, non-reflective.

(b) Trucks and scrapers were assumed to travel by every 6 min while in operation. Trucks were assumed to travel at 56 kph (35 mph); scrapers were assumed to travel at 48 kph (30 mph).

(c) Equipment is assumed to operate for 6.5 hours per 8-hour workday.

(d) A small amount of attenuation was assumed that would be due to natural vegetation barriers (such as trees) between the source and receptors. This attenuation was increased from 0 dBA at 15 m (50 ft) to 10 dBA at 1524 m (500 ft), approximately 2 dBA per 30.5 m (100 ft) up to a maximum of 10 dBA.

responsible for these exceedances. Therefore, it is believed that traffic flows resulting from the construction of Section 8B would have little effect on the noise levels prevalent in the surrounding areas.

Parkway construction would likely cause an elevation in noise levels at some sites. These increases would be temporary in nature, would take place during normal working hours, and should pose no threat to the personal health of persons at the studied sites. The nearest sensitive receptors should be located more than 91 m (300 ft) from the Parkway centerline and would likely be at least 76 m (250 ft) from any construction activity. This distance between the source and receptor, along with the presence of trees and other sound barriers, should provide for adequate attenuation of noise during construction. However, the NPS should consider measures to reduce construction noise where possible and monetarily feasible.

## 4.8 AESTHETIC RESOURCES

### 4.8.1 Introduction

This section deals with the environmental (aesthetic) consequences of potential actions in parkway development. There are both positive and negative considerations. These include clearing of forest, improved visual access to the GSMNP, interpretative resource improvement, and the effect of the parkway itself being seen from many different vantage points or by people with different interests and values. Safety around developed viewing or interpretative areas also weighs heavy in some areas close to public roads.

### 4.8.2 Views From the Parkway

Effects from development of aesthetic resources will be reviewed for the parkway section as a whole and for specific sites listed in Table 64.

To develop major aesthetic resources listed in Table 64 would involve clearing and maintaining approximately 10.75 ha (25.34 acres) of land in low vegetation on road fills and existing native forest adjacent to the proposed parkway. About 60 percent of the clearing would be at the highest elevations with 4 ha (10 acres) being maintained on the top of Webb Mountain alone.

To develop major aesthetic resources listed in Table 64 of Section 8B would involve maintaining low vegetation on approximately 10.75 ha (25.34 acres). Low vegetation includes grasses, shrubs, and trees that are periodically trimmed back to about two feet in height and permitted to regrow until it interferes with viewing scenery. The frequency of trimming would range from more than once a year to once every several years. About 60 percent of the maintained vegetation would be at the highest elevations with a good portion of this [4 ha (10 acres)] being maintained on top of Webb Mountain. Eight of the eleven sites involve maintaining less than 1 ha (<2.54 acres).

There are some negative ramifications as a result of this vegetation maintenance. From an aesthetic perspective, the maintained vegetation will appear rough with briars, stumps, and thick growth of short vegetation. Unusual plants and selected wildlife may occupy these areas and provide some interesting experiences. At the same time, exotic pest plants may become established. Also, the

**Table 64. Sites identified for scenic, aesthetic, and interpretative development along 23.8 kilometers of proposed parkway**

| Segment number | Roadway station | Rating and view identification | | Forest cleared (ha) | Forest cleared (acres) | Description |
|---|---|---|---|---|---|---|
| 1 | 1-400 to 1-680 | 1-2 | 1A | 0.75 | 1.85 | West terminus at Little Pigeon River |
| 2 | 2-380 to 2-970 | 2 | 2A | 0 | 0 | Webb Creek valley view of water, farm land, and houses |
| 2 | 4-580 to 4-700 | 3 | 2C | 0.4 | 0.99 | Good westerly view of GSMNP with tree clearing |
| 3 | 6-500 to 7-200 | | 3A1 | 0.25 | 0.62 | Quiet stream walkway |
| 3 | 8-700 | 2 | 3C1 | 0.3 | 0.74 | Trail to scenic view south of GSMNP |
| 3 | 8-120 to 9-170 | 1 | 3C | 2.5 | 6.18 | Composite views south from lower parking lot and parkway |
| 3 | Upper parking | 1 | 3D | 4.0 | 9.88 | Upper Webb Mountain parking panorama |
| 5 | 15-050 to 15-600 | 3 | 5A | 0.25 | 0.62 | Valley alternative for aesthetics, stream, and old stone walls |
| 6 | 18-800 | 4 | 6C | 0.5 | 1.24 | View east spectacular of developed, but narrow view |
| 7 | 21-200 | 3 | 7A | 1.0 | 1.24 | East-southeast view up GSMNP ridge w/pull-over at Camp Creek |
| 7 | 23-800 | 3 | 7C | 0.8 | 1.98 | View of stream, Cosby Creek, and community |
| | | Total | | 10.75 | 25.34 | |

continued maintenance of the vegetation generates long term expenses. Such trimming of vegetation may also add negative contrast by widening the appearance of the corridor and creating vegetation cover that has a different color and texture to forests that appear in the background.

The views selected for development accomplish one or more of three things:

- Enhance special views of the GSMNP from desirable angles,
- Provide cultural or historic interpretation opportunities,
- Enable closer view of water and the natural environment

An evaluation according to these objectives showed:

- 6 sites provided excellent views of all aspects of the GSMNP
- 5 sites addressed cultural, environmental, or historical resources
- 4 of the 5 interpretive sites brought viewers close to water

These sites stretch the entire length of 8B with many concentrated near the top of Webb Mountain where views are most spectacular and at both ends of the ROW where water and cultural resources are present. The effect to the view is to offer the themes of culture, environment, wilderness, and panoramas where passive or active participation can be involved at each location.

The views of the eastern half of GSMNP from 8B offer, for the public, the opportunity for exceptional scenic viewing that would otherwise not be available. U.S. 321, the most likely alternative, is positioned at a low elevation and is bordered most of its length by trees, commercial development, or homes. Some commercial developments offer nice views of the park but only to the paying public. It is also likely that incremental development and the accompanied fragmentation and/or removal of resources would make it increasingly difficult in the future to capture the aesthetic resources the parkway would offer the public.

#### 4.8.2.1 Safety

The development of parking lots and trails near existing roads is an enticement for various problems. These include waste dumping, vandalism, and personal safety, especially at night. This is of special concern at both ends of 8B and include sites 1A, 2A, 5A, and 7C.

The opportunity for excess waste dumping, problems in not collecting wastes on time, and users dropping trash and garbage on trails and in streams could contribute to the pollution of relatively clean streams. Pest animals (e.g., skunks, opossums, bears, raccoons, rats, and feral cats and dogs) could also be attracted and create problems in these developed areas, especially where they are close to other developments.

Flooding can happen very quickly in and around the GSMNP. Development of interpretive facilities in floodplains (sites 1A, 2A, 5A, and 7C) could create a dangerous situation in time of flash floods.

General safety at overlooks and interpretative sites is always a concern. For example the parking lot atop Webb Mountain, as planned, would include high retaining walls. These may be up to 28 ft (8.5 m) high which could pose safety problems. Another example is one where people lose their way from trails and get lost.

#### 4.8.2.2 Cuts and Fills

Views of parkway cuts and fills from the parkway would be unsightly at first and only gradually improve to a more natural state. The additional clearing and maintenance of vegetation at developed viewing sites, in one or two cases, would increase the visibility of cuts and fills nearby. These would be most pronounced at the steepest areas, mainly the lower parking lot on Webb Mountain.

### 4.8.3 Aesthetic Quality

Two major points are exhibited by Table 65. First, the aesthetic quality of view sites does not exhibit a normal distribution. The overall experience, although seemingly dominated by larger numbers of lower-rated views, would be remembered based on the very best views.

**Table 65. Aesthetic quality rating summation**

| Aesthetic experience | Number of sites |
|---|---|
| 1 (very best) | 3 (all in segments 3 and 4) |
| 2 (best) | 6 (none in segments 5, 6, and 7) |
| 3 (better) | 9 (fairly evenly spread) |
| 4 (good) | 11 (none in segment 3, most in 4, 5, and 6) |
| 5 (fair) | 3 (more exist but tended to be disregarded as views) |

The second conclusion from the table is that the viewing experience from the eastern portion of the proposed Section 8B parkway is considerably less exciting than that from the center and western portions. The average viewing quality ratings by segment reveal this more clearly. Starting with segment 1 and progressing to 7, the average ratings are 3, 3.5, 1.8, 3.2, 4, 3.8, and 3.3, respectively. Segment 3 is the closest to the peak of Webb Mountain and presents the most panoramic views. Segments 5, 6, and 7 have no views that are rated 1 or 2. It would be necessary in these segments to provide pull-out improvements to views rated as 3. This draws attention to View 7A (see Sect. 3.8) where a pull-over may be possible.

### 4.8.4 General Analysis for Views of Section 8B

The potential impacts of viewing the proposed parkway (from other than the parkway itself) have been summarized in Table 66. The analysis for Table 66 involved assessing the degree of negative visual impact of the parkway. This was based on the contrast of the parkway features with surrounding conditions, the distance from which parkway features would be viewed, and the sensitivity as well as number of viewers. The most severe negative impacts are anticipated to be to landowners (residents) where the parkway would be in the foreground or midground of their view (their having assumed the view would always be forested). Most of this is located along the east side of Cobbly Nob, segment 4, and along segment 6.

The visual and aesthetic effect of the parkway on viewers traveling U.S. 321 and stopping at commercial developments along this route are minor. These effects are mainly concentrated in areas where the parkway comes close to U.S. 321. This would be near Webb Creek Road; near site 2C at Timothy Creek and on U.S. 321; just west of Rocky Flats; and along a portion of segment 6 near view 6B.

The anticipated effect of the parkway to hikers in the GSMNP would depend on levels of haze in the air. At 5 to 8 kilometers (3 to 5 miles) distant, the parkway would be conspicuous only on clear days. Most views from near Mount LeConte, Charlies Bunyon, Mount Cammerer, and Mount

**Table 66. General impacts from views of the proposed parkway**

| Distance of view | Source of viewing | Context of view | Noted contrasts | Negative severity rating[a] |
|---|---|---|---|---|
| Foreground | U.S. 321 | With other roads and traffic | Slightly more cuts and fills with limited added contrasts in form, line, color, texture, etc. | 2 |
| Foreground | Landowners away from U.S. 321 | Wooded with some houses | Major change in view and contrasts in form, line, color, texture, noise, etc. | 4–5 |
| Midground | U.S. 321 | Combination of development and forest view; focus is toward GSMNP | Moderately added contrasts in line, color, and texture (not all variables) | 3 |
| Midground | Resort/landowners away from U.S. 321 | Forests with some houses | Major changes in most variables and high sensitivity | 4 |
| Farground | Hikers in GSMNP | Nearly total forest and rolling mountains | Road inflicts significant texture and color contrasts; viewer sensitivity significant | 3–4 |

[a]A severity rating of 1 implies total acceptability and minimum contrast; a rating of 3 implies minimally acceptable conditions of visual impact (mitigation may help significantly); a rating of 5 implies heavy impact and slim opportunities through mitigation to make the visual experience acceptable.

Guyot would not reveal Webb Mountain but several overlooks do (see Fig. 72). Only the most astute hikers would notice the parkway's development.

The proposed parkway would impose cuts, fills, and a linear road surface into scenes that have some combination of natural forests and development. Forests have their own characteristic lines, colors, textures, and even forms (e.g., shapes of whole stands of one forest type) set into a geological landscape having its own combinations of forms (e.g., rounded mountains) and lines (e.g., horizons and ridgetops). Development has its forms, lines, and colors, too. Contrasts (in this case implying negative visual impact) arise when these background conditions are significantly changed by new development such as Section 8B.

Table 66 provides evaluations of groups of views. This was done to simplify the presentation of results. Several specific views are evaluated later in the text with slightly more explanation. The specific ratings still fall within those of the viewing groups in Table 66. The evaluations were analyzed in considerable detail, but worksheets were not developed.

The parkway would have cuts and fills that have their own rounded forms. These new forms would not match the forms of the mountains, the forests, and some components of development. If other roads and road cuts were present, the contrast would be diminished because the new road would fit in better with the other roads and the view would not be changed very much.

These cuts and fills are most pronounced when their color and texture exists nowhere else in the landscape and they are in stark difference to the surroundings. Fills of orange/red dirt or bright, freshly crushed rock contrast with forest greens and browns. Contrasts can be diminished by distance, reshaping cuts and fills to match the landscape, changing the color of cuts and fills to better match their surroundings, and modifying the texture to mimic forest canopies. Table 66 assesses these issues in very summary form.

The outcome of this assessment (see Table 66) suggests that the most significant visual impacts would occur with observations of the parkway from (1) foreground and midground views by local landowners and (2) farground views by hikers in the GSMNP. The viewing of the parkway by traffic along U.S. 321 would be affected, but the severity of impacts would not be large.

For the GSMNP hikers, mitigation measures along segment 3 can probably lessen viewing impacts to a solid 3 rating, which would probably be minimally acceptable. Even by employing the most extreme mitigation measures to reduce the unsightliness of cuts and fills, local land owners may not be satisfied (Table 67).

Mitigation measures should be focused on the following issues.

- Reduction of contrasts of cuts and fills along segment 3 to GSMNP trail hikers.
- Minimizing the surface area of cuts and fills and reducing contrasts of these to background vegetation, especially along segments 3 and 4 where most landowners are affected.
- Reducing impacts of cuts and fills (i.e., high-contrast views) at the western terminus where local landowners, U.S. 321 traffic, and high-quality visual resources (water) are involved.

### 4.8.5 Aesthetic Impacts of No Action

The no-action alternative has some strong aesthetic benefits as well as costs. These are, for the present, in fairly close balance. Perhaps the main question is whether the benefits of the views created from the parkway would be significantly offset by the negative views of the parkway. The initial balance would be close because the effects of road construction, cuts, fills, and notches for pull-overs and ridgetop crossings would be most pronounced in their new state. If the aesthetic decision were based on this temporary condition, the analyses would favor no action. It would take time to reduce these initial negative impacts. Once accomplished, however, the analyses would favor action with significant qualifications about the cut and fill issues. Without the development of the parkway, the entire issue of mitigation is avoided. However, some of the best viewing of the GSMNP from the entire parkway (not just Section 8B) would not be realized.

Views of the GSMNP along U.S. 321 are the closest substitute if Section 8B is not constructed. U.S. 321 is relatively straight, allows higher speeds, and has places to pull-over on gravel shoulders for several views of the GSMNP. There are not as many viewing opportunities as from the proposed parkway, and the views are of substantially lower quality from U.S. 321 because of the limitation of views, speed of traffic, developed nature of most of the foreground, obstruction

**Table 67. Specific views of Section 8B**

| View description | Rating |
|---|---|
| Near Timothy Creek along U.S. 321 toward parkway km 4.8 (foreground). Cuts and fills on wooded hillside behind roadside development | 3 |
| Along U.S. 321 near Darky Branch with a view of segment 3 (farground). Cuts and fills on wooded far mountain with development in foreground | 3 |
| To rear of Deer Ridge Mountain Resort houses (foreground and midground). Cuts and fills in total forest seen from private residence | 4–5 |
| Along U.S. 321 near Texas Creek of parkway km 12 to 13 (mostly foreground). Cuts highly visible on near slopes just behind development | 3 |
| Along U.S. 321 near Rocky Grove Church of parkway km 14–500 to 14–800 (mostly foreground. Development in foreground, moderate requirement to look up to see view | 2 |
| Along U.S. 321 west of Sevier/Cocke County line at parkway km 17–000 (midground). Considerable development and orchard near U.S. 321, scrubby forest, but some direct viewing of parkway on low midground-foreground ridge | 2–3 |
| From trails in the GSMNP (farground) mostly of segment 3. Other segments would blend closer with U.S. 321 developments. Cuts and fills against entirely wooded hillside and scene (U.S. 321 often hidden from view) | 3–4 |

[a]A severity rating of 1 implies total acceptability and minimum contrast; a rating of 3 implies minimally acceptable conditions of visual impact (mitigation may help significantly); a rating of 5 implies heavy impact and slim opportunities through mitigation to make the visual experience acceptable.

by foreground vegetation, and noises and smells when stopping. U.S. 321 cannot be considered an adequate proxy for Section 8B in viewing experience of the GSMNP. No view from U.S. 321 can be rated a 1 or perhaps even a 2. The views from U.S. 321 can be expected to decline with time as development becomes more prolific. Development of U.S. 321 in place of Section 8B would not provide a comparable aesthetic experience.

The negative visual effects of serious road cuts on the upper face of Webb Mountain facing the GSMNP would not take place with the no-action alternative. The face would appear completely forested and wild from U.S. 321, from other points on the parkway, and from trails in the GSMNP. This is the major aesthetic benefit of not constructing the parkway.

The construction of the proposed parkway would set in motion the long-term commitment of the region to higher quality public tourism and traffic control. Without parkway construction, the area would be at the mercy of individual development interests and, to a lesser extent, municipal

planning. A long-term outlook on aesthetics and tourism favors construction of the parkway. A near-term outlook is less clear but still favors the aesthetic advantages construction of the parkway would provide to tourists.

The no-action alternative allows the fewest people to capture existing benefits while not changing benefits to a greater number of people. Those who benefit tend to be local residents near U.S. 321 and hikers in the GSMNP. In comparison, the build options provide benefit to a greater number of individuals while reducing aesthetic benefits to these same few people (i.e., local residents).

### 4.8.6 Summary of Aesthetically Preferred Build Options

**Western exit ramp across the Little Pigeon River**: The north option is recommended. Both the north and south alternatives for this exit ramp would be within forest cover of the Little Pigeon River floodplain. The south option is longer, meaning more forest clearing. It would also be more easily seen upon descending into the floodplain coming from the east. Alignment of the north alternative with Webb Creek Road at its intersection with SR 416 is also more aesthetically desirable. Access to the parkway would be less confusing, seem more direct, and be well connected to the aesthetics of Webb Creek Road itself. This assumes most of the access would be related to U.S. 321 nearby.

The intersection in the north option would be in a more closed, wooded, mountainous, and streamside situation (e.g., confluence of Webb Creek and Little Pigeon River) than the south option. The south option places an intersection in a private residence front yard. This is not a desirable environment for a scenic parkway exit intersection.

**Tunnel versus no tunnel options**: The absence of a tunnel means steep road cuts would be highly visible. These would only be visible to the parkway traveler. It would also mean more roadfill for the parkway where it crosses Tunis Creek. The presence of a tunnel in itself creates variation and change in experience deemed desirable. It avoids the viewing of such large road cuts and reduces the amount of road fill needed to span Tunis Creek valley. Therefore the tunnel option is favored.

**SR 416 exit ramp versus U.S. 321 exit ramp**: The U.S. 321 exit ramp occurs where many steep cuts at a high visibility location would occur. This would occur on slopes visible from U.S. 321 and where possible development of an aesthetic site is suggested. From an aesthetic standpoint, there is no question that the SR 416 exit ramp is the better option.

**East and west option exit ramps for the parkway at U.S. 321**: The U.S. 321 option that involves exiting on to Webb Creek Road is much more desirable than exiting U.S. 321 directly. The west option would occur in a very local setting with a small field enclosed by wooded ridges and a rustic streamside road. The east option would occur at a higher speed highway not far from another intersection and at a location where utility wires and private development occupy much of the site's view. The east alternative also places additional, highly visible cuts on a slope facing

U.S. 321. These cuts would be added to parkway cuts already present from the main route of the parkway.

**Webb Mountain lower parking area**: The proposed parking area occurs within the length of the parkway having a series of excellent panoramas of the GSMNP. It is at the most level and straight location for drivers to stop. It also provides convenient access via a possible short trail to the top of a ridge enabling even better views. The parking lot as proposed is recommended.

**Webb Mountain access road and parking loop**: The Webb Mountain access road and parking loop would open up the most dramatic panoramas of the GSMNP along Section 8B, if not all of the Foothills Parkway. The top of Webb Mountain provides panoramas to the southwest, south, southeast, north, and northeast. It also provides the experience of being at the peak of a mountain which is not so apparent elsewhere on the Foothills Parkway. The parking loop would also generate negative effects as seen from other locations. These are expected to be within acceptable limits. Therefore, the access road and parking loop atop Webb Mountain are recommended for development.

### 4.8.7 Overall Analyses Summary

A summary of the positive and negative impacts of the possible alternatives for the Foothills Parkway are discussed below.

#### 4.8.7.1 Positives

The best views of the GSMNP would be captured: this greatly increased the availability of quality scenery to the public. There is no need to develop more sites than those recommended and it may be acceptable to eliminate perhaps 2 or 3 sites from consideration. The lowest priority sites would be 2A, 5C, and 6A. The parkway would make available a visual resource that would be increasingly difficult to secure as development encroaches around the GSMNP. The quality of the views justifies the development of the parkway.

There are no major negative aesthetic impacts to the general public. Views of the parkway from U.S. 321 and other public points do not offer unacceptable aesthetic impacts except perhaps at a few locations where the parkway and U.S. 321 are in close proximity. Road cuts and fills (mainly fills) are the issue.

The parkway alignment tends to maximize views of the GSMNP by being on top of ridges or on the south sides of slopes looking toward the park. The purpose of the parkway is to capture the best possible views of the GSMNP. The 8B alignment tends to do this by looking east or west to view succeeding ridges and the spine of the GSMNP.

#### 4.8.7.2 Negatives

The most negative impacts would be to individual land owners and residences where the parkway appears to pass through their backyard. This is not true all along the parkway but where it does occur, it is a major issue with those people. The cutting of forest, the visual effects of cuts and fills, the noise from parkway traffic, and the feeling of one's privacy being invaded are involved.

Safety and maintenance issues are a concern. The safety issues are most prevalent where interpretive sites and trails would be located near public roads and in floodplains. The safety issues are personal safety, waste management (sanitation), trail identification, and flash floods.

The vegetation maintenance requirements are large from an expense and visual impact perspective. Ten to eleven ha (25 acres) of steep inaccessible slopes and ridge tops is expensive to keep clear. This is particularly true when this land is divided among 11 different sites. Further, the clearing of some of this land is on exposed ridge tops which enhances the negative aspects of cleared forests. The main concerns are around sites 3C and 3D.

Cuts and fills generated by parkway construction would be conspicuous and look bad to viewers for 10 to 20 years if left to natural revegetation. The sites most negatively impacted would be 2A, 3C, 3D, and along large fills in parts of segments 4 and 6. Revegetation or minimization of cuts and fills need innovative solutions to minimize their negative aesthetic impact.

The no-build alternative offers very little opportunity to capture significant scenic resources of the GSMNP. The alternative to the parkway is assumed to be U.S. 321. Views of the park from U.S. 321 are blocked by trees and commercial development. It is also located near the bottom of a valley where views of the park would be difficult to develop.

## 4.9 CULTURAL RESOURCES

### 4.9.1 National Register Properties

In the area of Section 8B there is one *National Register*-listed property, the Tyson McCarter Place. This farmstead is within the boundary of the GSMNP south of U.S. 321 and about 0.6 km (0.4 mile) south of the Section 8B ROW (see Appendix N for details). The property is at 555 m (1820 ft) elevation. At its closest point to the Tyson McCarter Place, the centerline of the Section 8B ROW is at an elevation of 600 m (1960 ft). Given the similarities in elevation, the construction of Section 8B may have an adverse visual impact upon the Tyson McCarter Place. The exact visual effect would be dependent upon the grade and cut of the parkway, as well as the level of screening by vegetation. No other *National Register* properties would be impacted by any of the build alternatives of Section 8B.

### 4.9.2 National Register Eligible Properties

As a result of the Cultural Resources Survey, seven properties appear to meet *National Register* criteria. No audible or visual effects are predicted as a result of the construction and operation of the build alternatives of Section 8B to six of the properties listed below:

Sam Wilson House in Cocke County, CK-55
Laurel Springs Primitive Baptist Church in Cocke County, CK-79
Dr. John Huff Store and Post Office in Cocke County, CK-68
Shults-Williams Farmstead in Sevier County, SV-1090
Shults Grove Methodist Church in Sevier County, SV-1091
Pittman Center Home Economics Building in Sevier County, SV-1544

The G. Torrell Lunsford Cantilever Barn, in Cocke County (CK-B93), is approximately 0.4 km (0.25 mile) northwest of the Big Ridge portion of the Section 8B ROW centerline. At the closest point to the property, the ROW is along the top of Big Ridge at elevations ranging from 520 m (1700 ft) to 560 m (1840 ft) above sea level. The Lunsford barn is within the Chavis Creek valley at approximately 460 m (1520 ft) above sea level. Separating the property from the ROW is a steep slope covered with dense woodlands. Because of the distance and intervening topography, there would be no audible effects to the Lunsford Barn. However, there are potential visual impacts to the property, depending on which side of Big Ridge the parkway were placed on. If it were placed on the western slope of Big Ridge, there would be a potential visual effect. If it were placed on the eastern slope of Big Ridge, there would be no visual effect.

### 4.9.3 Cultural Landscapes

Three areas were evaluated to determine if they could be considered rural historic landscapes. These areas were the Cosby Valley, Pittman Center, and Rocky Flats. None of the landscapes met the National Register criteria for Rural Historic Landscapes. Therefore, construction and operation of Section 8B would not adversely impact cultural landscapes.

## 4.10 SUMMARY OF IMPACTS

Listed in Table 68 below is a summary of environmental impacts. The impact summary is organized by resource area for the build and no build alternatives. Potential impacts resulting from options within the build alternative are also summarized.

## Table 68. Summary of potential environmental impacts

| Resource areas | (1) Build Section 8B of the Foothills Parkway — Options within the Build Alternative: A. Construct with no interchanges | B. Western terminus (interchange at SR 416 or U.S. 321) | C. Webb Mountain | D. Operational timing | (2) No Build (No-Action) |
|---|---|---|---|---|---|
| **Geology and soils** | Slope instability and exposure of pyritic materials. | Similar to option A. | Similar to options A and B. | No adverse impacts. | No negative impacts. |
| **Water resources** | Streambed erosion, water runoff, and sedimentation (especially to Webb Creek, Matthew Branch, Dunn Creek, Carson Branch, and to a lesser extent, the Little Pigeon River). The tunnel option will slightly decrease some of these impacts. Acidification of streams is also possible.<br><br>Rocky Flats—Impacts from the valley option include soil compaction, sedimentation, and alteration of wetlands. The hillslope option would decrease the impacts of soil compaction and alteration of wetlands, but would have increased erosion and sedimentation to Dunn Creek and associated wetlands. | Increased soil compaction, surface runoff, and sedimentation and decreased floodplains when compared to option A. The interchange at U.S. 321 would have more impacts than at SR 416, because more cut and fill would be required causing more surface runoff, soil compaction, sedimentation, and erosion, that would negatively impact Webb Creek. | Increased surface runoff and erosion from options A and B.<br><br>Spur Road and Overlook Facility—Deterioration of water quality in Matthew Creek due to substantial increases in sediment loading, siltation, runoff from the roadway and parking area, and leachate from septic systems. | No adverse impacts. | No negative impacts. |

## Table 68. Continued

| Resource areas | (1) Build Section 8B of the Foothills Parkway — Options within the Build Alternative: A. Construct with no interchanges | B. Western terminus (interchange at SR 416 or U.S. 321) | C. Webb Mountain | D. Operational timing | (2) No Build (No-Action) |
|---|---|---|---|---|---|
| Aquatic ecology | Turbidity and sedimentation impacts to aquatic communities in streams including Sheep Pen Branch, Copeland Creek, Lindsey Creek, Mill Dam Branch, Warden Branch, Butler Branch, Matthew Creek, Carson Branch, Chavis Creek, and Sandy Hollow Creek.<br><br>The tunnel option in the Pittman Center area would lesson potential impacts on aquatic organisms.<br><br>The base of the hillslope option in Rocky Flats would have the lesser impact to aquatic communities in Dunn Creek, Carson Branch, and associated wetlands, compared to the valley option. | Similar impacts to option A with additional turbidity and sedimentation impacts in either the Little Pigeon River (SR 416 interchange) or Webb Creek (U.S. 321 interchange) areas. Less impacts to aquatic organisms would be expected with the SR 416 interchange. | Impacts would include those of option A plus additional impacts of construction on Webb Mountain. The lower parking area along the parkway edge would have less impacts on fish and benthic organisms than the spur road/overlook option. | No adverse impacts if the roadway is built and paved immediately. If the roadway is built and not paved sedimentation and turbidity impacts would be expected. | No negative impacts. |

## Table 68. Continued

| Resource areas | (1) Build Section 8B of the Foothills Parkway | | | | (2) No Build (No-Action) |
|---|---|---|---|---|---|
| | *Options within the Build Alternative* | | | | |
| | A. Construct with no interchanges | B. Western terminus (interchange at SR 416 or U.S. 321) | C. Webb Mountain | D. Operational timing | |
| **Terrestrial ecology** | Removal of 40 to 120 ha (100 to 300 acres) of forest vegetation and wildlife habitat, increase of wildlife mortality, change of microclimates, decrease in forest habitat and state listed plant species, increase in edge and non-native plant species, impairment of wetlands, and impacts to vegetation from air pollution.<br><br>Habitat may be improved for certain bird species. | This option would include the same impacts as option A with additional impacts from the construction of the SR 416 interchange to the floodplain habitats of the Little Pigeon River. Less impacts would occur if the U.S. 321 interchange or Alternative 2 (no-action) were employed. | This option would include the same impacts as option A with additional impacts to native vegetation, forest dependent wildlife, and a wetland seep. | No adverse impacts are anticipated unless a delay in final construction also were to delay final revegetation. | No negative impacts. |
| **Air quality** | No potential impacts from particulate matter.<br><br>Minor contributions to ozone depletion. | The SR 416 option would have the same impacts as option A with more visibility impacts to the Pittman Center area. | This option would have similar impacts as option A. | No significant impacts. | No negative impacts. |

## Table 68. Continued

| Resource areas | (1) Build Section 8B of the Foothills Parkway — Options within the Build Alternative: A. Construct with no interchanges | B. Western terminus (interchange at SR 416 or U.S. 321) | C. Webb Mountain | D. Operational timing | (2) No Build (No-Action) |
|---|---|---|---|---|---|
| **Socioeconomics** | No significant impacts from additional workforce, traffic, housing, public utilities, or to the existing social structure. | If the SR 416 option is chosen, traffic, population growth, and housing development of the Pittman Center area could increase at a slightly faster rate than with the other interchange options (i.e., U.S. 321 or no interchange). This is especially the case if 8B is opened prior to 8C. This in turn could have a slight impact on Public Services and on local land use patterns and existing community character. Pittman Center could benefit from tax revenues as a result of the SR 416 option. | No significant impacts. | No significant impacts | Housing development and population would continue to grow. |
| **Traffic** | Overall, Section 8B would not have any significant environmental or cumulative impacts on traffic. The parkway would alleviate some traffic on U.S. 321. | No significant impact from any of these options. | No significant impacts. | If 8B opened prior to 8C, some minor impacts to SR 416 would occur. | Under this option, traffic on U.S. 321 would become unacceptable near Cosby. |
| **Noise** | Some exceedances of FHWA noise standards are anticipated during construction. However, due to the short duration, they are not expected to be significant. With or without the parkway, FHWA noise standards will be exceeded at certain points along U.S. 321. | No significant impacts. | No significant impacts. | No significant impacts. | No negative impacts. |

## Table 68. Continued

| Resource areas | (1) Build Section 8B of the Foothills Parkway — *Options within the Build Alternative*: A. Construct with no interchanges | B. Western terminus (interchange at SR 416 or U.S. 321) | C. Webb Mountain | D. Operational timing | (2) No Build (No-Action) |
|---|---|---|---|---|---|
| **Aesthetics** | Disturbance of 25 acres for viewing locations. Tunnel option is favored aesthetically because it avoids large cuts that would be required otherwise. | Options on SR 416 are favored. The option to directly connect to U.S. 321 would have significant adverse aesthetic impacts due to extensive cuts in a very steep area. | Clearing on Webb Mt. would be a adverse aesthetic impact, as the face of Webb Mt. would include serious road cuts initially. These negatives are offset by the panoramic views provided. | No significant impacts. | This alternative would eliminate the negatives of road cuts and the positives of views. |
| **Cultural** | Potential significant impacts to the National Register-listed property Tyson McCarter Place could occur. Visual effects would depend upon the grade and cut of the parkway, as well as the level of screening by vegetation. Depending on which side of Big Ridge the parkway is constructed, negative impacts to the G. Torrell Lunsford Cantilever Barn could occur. | No significant impacts. | No significant impacts. | No significant impacts. | No negative impacts to cultural resources. |

# 5. RECOMMENDED MITIGATION MEASURES

## 5.1 GEOLOGY AND SOILS

Mitigation of the potential impacts would include those described below and as indicated in Table 69.

**Table 69. Mitigation measures for each build option**

| | | Conceptual option[a,b] | | | | |
|---|---|---|---|---|---|---|
| Impact | Mitigation | 2.1.1 | 2.1.2 | 2.1.3 | 2.1.4 | 2.2 |
| Slope stability | Propose and evaluate site specific engineering mitigation measures in the EIS and the design and construction process | Yes | Yes | Yes | Yes | None |
| Pyritic rocks | Additional sealing during construction | Yes | Yes | Yes, slightly less | Yes | None |
| Deep weathering | Propose and evaluate site specific engineering mitigation measures in the EIS and the design and construction process | Yes | Yes | Yes, slightly less | Yes | None |
| Brittle faults | Additional sealing or removal during construction | Yes | Yes | Yes, slightly less | Yes | None |
| Colluvium | Propose and evaluate site specific engineering mitigation measures in the EIS and the design and construction process | Yes | Yes | Yes, slightly less | Yes | None |

[a]"Yes" means mitigation would be needed.
[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).

Construction problems due to the nature of the geology and soils of proposed Section 8B of the Foothills Parkway are anticipated to be relatively small. The main problems likely to be encountered are related to slope stability in moderately to deeply weathered Pigeon Siltstone along the main 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 mitigation techniques (benching, lower cut slope angle, etc.) into engineering design of cuts (Table 69). An

exception to this assessment might occur where unstable slopes related to construction of the deep cut (rather than the tunnel alternative) on Section 8B west of Cobbly Knob 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 was not a problem in construction of the westbound lanes of the four-lane section of U.S. 441 just east of Pigeon Forge, but it remains a problem with the eastbound lanes of the highway in the same area.

The potential exposure of pyritic materials would need to be addressed in only a few places. Both the magnitude (volume) and numbers of places where this problem would arise should be small. These materials, once located, could be effectively sealed throughout the construction period and afterwards so that they should remain stable enough to keep impact on streams to a minimum. Greater impact on streams should be anticipated from improperly controlled sediment derived from construction than from pyritic materials.

Brittle fault zones that would be crossed by the route could cause minor problems with groundwater seepage or, more likely, produce unstable rock during construction. However, they probably would cause no problems. If such problems did arise, the zones could readily be sealed (for groundwater seepage), or excess loose rock could be removed during construction.

## 5.2 WATER RESOURCES

### 5.2.1 Construction of the Parkway with no Interchanges

Mitigation measures would be required to protect downslope stream and riparian habitat from alteration by erosion, increased sediment loading, siltation, and major changes in storm- and base-flow discharges. Disturbances that result in increases in surface runoff during storms and reduction in shallow subsurface flow need to be minimized. Compaction of alluvial soils should be minimized during construction. In areas where lateral subsurface flow is intercepted (e.g., by cuts or excavations), it should be recharged into permeable layers of rock constructed under fills.

Surface runoff from paved, grassy, and cut-and-fill slopes should be maintained wherever possible as distributed, downslope sheet flow rather than channelized into narrow swales, gutters, or culverts. Wherever possible, drainage ways should be designed as broad swales that are gently graded to prevent high-energy flows and to direct water into subsurface recharge areas. Sediment detention structures should be constructed where large flows are expected. All streams crossed by the parkway should be bridged where feasible, or routed through box culverts with floors containing rocks if the stream is small and bridging is not feasible.

Erosion and sediment control during and following construction of all cuts and fills is of critical importance for reducing impacts from sediment loading and siltation on downgradient streams. Erosion control is particularly critical for all cuts and fills in the Webb Mountain and Rocky Flats areas to mitigate impacts to Webb Creek, Matthew Creek, and Dunn Creek. Erosion control is also critical in the southwestern end of Big Ridge to mitigate impacts to Carson Branch and its riparian wetlands. New, innovative soil bioengineering techniques involving various combinations of vegetation plantings and structural features are available for enhanced short- and long-term

stabilization and visual improvements of roadway cuts and fills (Gray and Sotir 1996). Such high-quality controls must be implemented early in each phase of construction, particularly in the sensitive areas listed above.

Appropriately sized bridging should be used to mitigate impacts to many of the streams crossed by the roadway. Bridging over Dunn Creek in the Rocky Flats area is particularly critical to protect this high-quality stream. The floodway width of Dunn Creek must be carefully determined to ensure that the bridge over this stream is sufficiently long to accommodate flow easily from the largest floods expected and to prevent the channel downcutting that would ensue if flood waters were laterally constrained by roadway fill or support structures.

To mitigate potential acidification of streams due to exposure of sulfide-bearing rock, rock excavated or exposed in the Webb Mountain area must be inspected by a geologist as construction proceeds. Any sulfide-bearing materials found should be sealed in place from water and the atmosphere, or encapsulated and buried in fill so that the materials are not exposed to drainage water. The geologist and site engineer should jointly determine the disposition of such materials based on the amount and concentration of the sulfide and the options available at that point in construction.

For aesthetic reasons and to reduce potential impacts to the small streams in the Pittman Center/SR 416 area, a tunnel excavated by boring appears to be the most desirable option. If geologic conditions are not favorable, however, construction and maintenance of a tunnel may not be desirable (e.g., economic safety, or water quality impacts related to exposure of acidic rock). Additional geologic investigation is needed before a decision is made concerning a tunnel.

To mitigate water quality problems resulting from parkway maintenance, the use of pesticides, herbicides, deicing chemicals, and fertilizers should be avoided. Special care should be taken with fuels and lubrication oils to minimize spills or leakage from equipment during construction.

### 5.2.2 Western Terminus Options

All of the western terminus options would require stabilization and revegetation of cuts and fills early in construction to prevent erosion and sediment loading and siltation of streams, particularly Webb Creek. The easternmost interchange option, involving a steep access road from the parkway on the slopes of Webb Mountain to U.S. 321, would pose a particularly serious problem in this regard; and stabilization of cuts and fills required for this option should involve the most appropriate soil bioengineering techniques implemented early in construction. Even with mitigation, this interchange option may result in significant sediment loading and siltation in Webb Creek.

### 5.2.3 Webb Mountain Options

The option involving construction of a parking area along the parkway and a trail to the top of Webb Mountain would require stringent erosion control and stabilization of cuts and fills during construction to mitigate erosion and sediment loading to Matthew Creek. Application of soil bioengineering techniques early in construction could mitigate the most serious impacts on this

high-quality stream. If restroom facilities were provided here, wastes should be contained and transported out; a septic system should not be installed.

The option involving construction of a spur road to an overlook facility would have much more serious impacts to Matthew Creek. All cuts and fills along the roadway and parking/overlook facility would have to be stabilized early in construction using appropriate soil bioengineering techniques. Box culverts capable of facilitating the largest floods expected would have to be installed where the roadway crosses Matthew Creek and any of its tributaries. If restroom facilities were located here, all wastes should be collected and transported out of the area, rather than a septic system installed, to minimize the potential for degradation of Matthew Creek water quality from human wastes. During all excavation activities, timely inspection of excavated rock must be conducted by a geologist to determine if any sulfide-bearing rock has been disturbed; if so, the material should be sealed in place, encapsulated, and buried as described in Sect. 5.2.1.

### 5.2.4 Operational Timing Options

If the operation of parkway Section 8B were delayed until Section 8C were completed, then the road surface should be paved to mitigate erosion and sediment-loading impacts that would ensue with an unpaved roadway. Otherwise, no additional mitigation measures are needed for these options.

### 5.2.5 No-action Alternative

No mitigation measures are needed for this alternative, assuming that the NPS retains ownership of the ROW and prevents development of it.

## 5.3 AQUATIC ECOLOGY

Measures to mitigate changes in surface water hydrology are outlined in Sect. 5.2. The mitigation measures suggested in that section to distribute surface runoff as downstream sheet flow should reduce the likelihood of high storm flows (spates) and consequently moderate adverse effects on aquatic habitats from land clearing and soil compaction. An important mitigation measure is to minimize delays in paving the road surface once the roadway is constructed; this will reduce the amount of soil erosion, and turbidity and sedimentation in the streams along Section 8B.

Culverts or other structures that are used to bridge streams should be constructed to ensure that fish movements are not blocked. With the exception of Sheep Pen Branch, all of the streams considered to be most susceptible to changes in hydrology and streambed erosion (i.e., Copeland Creek, Lindsey Creek, Mill Dam Branch, Warden Branch, Butler Branch, Matthew Creek, Carson Branch, Chavis Creek, and Sandy Hollow Creek) support fish. Maintaining fish passage over all stream flows is particularly critical in these smaller streams.

## 5.4 TERRESTRIAL RESOURCES

### 5.4.1 Vegetation and Wildlife

Impacts of a non-forested corridor through surrounding forest are unavoidable. The width of the cleared area along the corridor would be determined by the cut and fill areas, grubbing of vegetation along the roadway, and removal of overstory trees. Impacts to existing forest ecosystems could be minimized by keeping these cleared areas as small as possible.

Extensive cut and fill and removal of forest vegetation, as shown on existing road plans, would also change the existing forest by altering the microclimate, which could in turn alter adjacent vegetation and associated wildlife. These changes could be minimized by replanting cleared areas with native forest trees and by bridging drainages rather than leveling them with cut and fill. Soil bioengineering techniques that ensure rapid re-establishment of native woody species should be used where possible (Sotir 1992; Link 1993). Potentially suitable techniques include using live stakes from rapidly growing tree shrub species and fascine bundles to act as traps for seeds of surrounding forest trees.

Mitigation of impacts to wildlife is problematic because some species benefit from wider clearings associated with roadways (i.e., increased habitat, fewer predators, less tendency to cross the roadway, which results in fewer road deaths) while others benefit from narrower clearings (i.e., less effective fragmentation of habitat, fewer predators). Interior species (those that require fairly large expanses of continuous forest, such as many neotropical migrant songbirds) benefit from minimal removal of forest canopy. Because of increasing concern for such species, minimal disturbance of the forest cover is recommended. Cut and fill areas should be replanted with native forest vegetation, rather than low-growing herbaceous or shrub ground cover.

Consideration should be given to not constructing the Spur Road and overlook. This construction would negatively impact forest habitat important to area-sensitive bird species and other wildlife. If the Spur Road is built, however, it should be constructed without grass shoulders to minimize forest fragmentation impacts. Likewise, the overlook facility and parking area should be as small as possible.

### 5.4.2 Protected Species

**Federally protected plants and wildlife.** No federally protected plant or wildlife species were found on the ROW. State listed species are discussed below. The Allegheny snaketail dragonfly is discussed with species of interest to the GSMNP.

**State protected plants.** For the ramp option at the western terminus, the ramp in the Pigeon River floodplain should be sited as far to the west as possible to avoid directly impacting the population of state threatened butternut.

Many native vascular plant species can be transplanted successfully while they are dormant if an adequate root ball is dug (Taylor and Hamblin 1969). Ginseng, for instance, can readily be transplanted if plants are growing directly in the line of construction. Most of the rare plants on the ROW probably can be moved successfully during the dormant season from areas to be affected

by construction to comparable habitat (K. Langdon, GSMNP, personal communication to L. K. Mann, ORNL, Sept. 18, 1996). Survival beyond a few years is unknown, however, because some species do not transplant successfully (Taylor and Hamblin 1969; North Carolina Wildflower Preservation Society 1977; E. E. C. Clebsch, Native Gardens, Greenback, Tennessee, personal communication to L. K. Mann, ORNL, no date). Orchids rarely survive transplanting, so moving the pink lady's-slipper orchid is not practical. Because not all species transplant well, and some rare species may have unique microhabitat requirements, transplanting should be regarded as experimental and may not be successful in the long term (K. Langdon, GSMNP, personal communication to L. K. Mann, ORNL, Sept. 18, 1996; E. E. C. Clebsch, Native Gardens, Greenback, Tennessee, personal communication to L. K. Mann, ORNL, no date). Thus, transplanting or creating new habitat may mitigate impacts to some protected plant species on the ROW, but would not provide adequate mitigation for others because many species of the native flora do not survive or flourish after transplanting. Plants that are moved should be monitored for 1 or 2 years until they appear to be established or are no longer alive.

Mitigation to protect the population of the ash-leaved bush-pea on the Webb Mountain segment of the ROW could consist of moving the plants to newly disturbed sites, but the feasibility of transplanting this species is unknown. The plant is quite showy in bloom and, if it could be re-established, might be threatened by illegal collection as a result of increased access after construction of the parkway. Transplants should be placed where they would not be readily visible from the roadway.

**State protected wildlife.** No special mitigation measures are anticipated for state listed wildlife other than minimizing native habitat loss.

**Wetlands and other special habitats.** In all areas where wetlands are located on or near the actual roadway, construction activities, including the travel of heavy equipment, should be avoided as much as possible to minimize impacts to wetlands. To maintain wetland functions and ensure revegetation with hydrophytic plants, the hydrology of areas impacted by equipment traffic during construction should not be permanently changed by alterations to the drainage patterns.

Possible mitigation measures to minimize impacts to overall hydrology of the ROW are discussed in Sects. 5.1 and 5.2. Construction methods that would minimize obstruction of lateral flow of water would minimize impacts to wetlands downslope from the roadway. Mitigation should include the use of mechanical barriers where necessary to prevent accidental heavy equipment travel through sensitive areas, and training equipment operators to avoid wetland areas.

In the Rocky Flats segment, bridging wetlands would minimize long-term impacts to hydrology and sensitive biota of wetlands, streams, and riparian vegetation.

For the Webb Mountain options, a span or large box culvert should be used for crossing Matthews Branch to minimize impacts to the stream and downstream wetlands.

No special mitigation measures are anticipated for special habitats other than wetlands. In all areas where sensitive habitats—cobble bar, talus or boulder slopes, calcareous soil—are located, construction activities, including movement of heavy equipment, should be minimized where feasible.

### 5.4.3 Additional Species of Interest to NPS

**Plants.** Mitigation of impacts to the rare bryophytes and the rare hornwort growing in stream channels and wetlands on the ROW could require spanning streams and wetlands. This would be especially desirable in the Rocky Flats segment where the globally rare hornwort is located.

**Wildlife.** Minimizing stream bottom disturbance and siltation and choosing ramp access options that minimize impacts to streams containing the Allegheny snaketail dragonfly are recommended. If possible, timing of construction impacting these streams should be planned to minimize disruption of the dragonfly's life cycle. Construction that would affect the streams where this species occurs should be avoided during the period when adults are emerging and laying eggs (i.e., mid/late April to early July). Construction during late summer dry periods, when flow is low and less likely to affect habitat and when nymphs are large enough to tolerate some disturbance, should have the least impact to this species (K. Tennessan, Tennessee Valley Authority, personal communication to L. K. Mann, ORNL, Mar. 18, 1996). Disturbance to existing riparian vegetation should be kept to a minimum, and affected stream banks should be stabilized with native riparian species.

Partial mitigation of impacts to interior forest nesting bird species could include minimizing both the removal of mature forest canopy and the establishment of regularly mowed grassy areas along roadsides.

**Exotic or alien species.** Mitigation to control populations of aggressive exotic plants could entail eradicating existing populations on the ROW prior to construction, monitoring the ROW for at least 3 years following construction, and removing exotic species as they are found. Although it is not on the ROW, eradication of the adjacent population of garlic mustard prior to construction is especially important because of the aggressive nature of this species and the potential for major expansion along the ROW following construction. Kudzu should also be eradicated prior to construction. Control of Japanese grass, honeysuckle, and multiflora rose is probably currently impractical on the ROW, and the impact is, therefore, unavoidable (Clebsch and Wofford 1989, Remaley 1996). Although eradication of existing populations of privet may not be feasible, efforts should be made to prevent its establishment in newly disturbed areas.

### 5.4.4 Summary

Most impacts to natural resources on the ROW could be mitigated by avoiding accidental construction damage in the vicinity of the resource, modifying the design of drainage systems under the roadway in some locations, and replacing some cut and fill with bridges or other spans. It might not be possible to mitigate impacts to some populations of state protected plant species and other species of interest to NPS. Protection of the rare hornwort liverworts and protected species on the ROW should involve further consultation with experts to develop mitigation options. Successful mitigation to protect sensitive habitats and associated biota would result in few negative cumulative effects to the terrestrial ecology of the region.

## 5.5 MITIGATION MEASURES FOR METEOROLOGY AND AIR QUALITY

### 5.5.1 Construction

Mitigation of fugitive dust from road construction can often be accomplished by scheduling to minimize the size of the area disturbed on any particular day. Excavation and earth moving operations, especially operations requiring heavy trucks moving over unpaved surfaces, can be reduced when meteorological conditions are unfavorable (e.g., relatively stable conditions with low wind speeds) and/or when the ground is dry (e.g., when no precipitation has occurred for several days). However, competing economic factors must often be considered. In this case, there may also be competing environmental considerations involving visibility and atmospheric ozone concentrations. Scheduling intense construction activities for the summer months can reduce visibility effects, but summer is the season of highest ozone concentrations and is therefore by far the most likely season for intensive construction activities to contribute to an exceedance of the NAAQS for ozone.

Visibility is most likely to be of concern to visitors during the clear days of October, a month when the number of visitors reaches a peak and the background visibility is likely to be high. Such days are also favorable for construction activities. Scheduling such activities so that fugitive dust would be minimized in October might require more earthwork in summer. However, because of the relatively large number of visitors during the summer months, minimizing construction activities during those months might be desirable to minimize the number of people potentially affected by high ozone levels. It might also reduce plant damage associated with high ozone levels. However, because the amount of ozone resulting from construction activities would be small compared to already existing ozone levels in the area, the positive effects of minimizing construction activities to reduce ozone in summer would be limited and might not outweigh considerations involving the seasonal changes in background visibility.

Sprinkling with water can be an effective method of reducing fugitive dust in a construction area or along an unpaved road. If material must be hauled long distances (greater than about 250 m), the nature of the road is an important consideration. Use of gravel or other material with low silt content can reduce emissions of fine dust particles. Therefore, when possible, it could be environmentally and economically effective to first establish a gravel roadbed for the parkway, and then to use that gravel route for hauling of material by truck. Paved surfaces or other hard surfaces also emit relatively little fine dust. Tarpaulins or other covers should be used whenever possible to reduce dust emissions from loads transported by truck.

More than 8 hours per day of work could be scheduled, especially during the summer when evaporation is highest and therefore dust suppression by watering is least effective. If such work involved disturbing large amounts of surface material, intensive watering might be needed to reduce dust emissions to acceptable levels.

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. These effects could be eliminated by not permitting any burning of woody materials at the construction site. The wood could be removed from the site and used elsewhere or chipped on-site for use as mulch. Alternative

mitigation measures include attention to fire weather information while scheduling burning operations and the presence of fire-fighting equipment whenever burning operations are conducted. Fires should be completely extinguished before sundown. Smoke from smoldering ashes can lead to high concentrations of airborne particulate matter near the ground during the night, when the atmosphere is very stable and turbulent mixing of pollutants is consequently reduced. An even worse situation could occur if a partially extinguished fire should re-ignite at some point during the night, when no one was present to control it.

### 5.5.2 Operation

If there was an accident in the proposed tunnel, it could block traffic. It is not likely that such an incident could lead to any life- or health-threatening situations resulting from high CO concentrations, but unhealthy conditions could occur as a result of a serious accident causing blockage of both lanes of the proposed road. If a tunnel were constructed, such risk could be mitigated by signs posted in the tunnel to alert motorists to turn off their engines in case of a stoppage of traffic lasting more than a few minutes.

Exceedances of the NAAQS for $O_3$ occasionally occur in and near the boundary of GSMNP. Because of the regional distribution of sources contributing to these high existing $O_3$ concentrations, mitigation must be largely the responsibility of the community outside the boundaries of the park.

Paving any parking areas that might be constructed along the route would greatly reduce local fugitive dust emissions, thereby accommodating persons with respiratory problems and reducing the carry-out of road dust which is a major source of PM-10 emissions from roadways. Reducing PM-10 emissions would also mitigate any contribution of the parkway to visibility degradation in the area.

## 5.6 SOCIOECONOMICS

Locating the western interchange of Section 8B at Pittman Center Road, as described in Sect. 4.6, could result in substantial socioeconomic impacts, especially in terms of land use and social structure in the Pittman Center community. Any of the other interchange locations or the no-build alternative would avoid most of the growth-related impacts likely to accompany a Pittman Center Road interchange. But if no western interchange at all were built, the pressure for commercial development in the impact area would likely be less than under any of the build options or the no-build alternative, because the result would be less traffic on U.S. 321.

It is recommended that the NPS take appropriate action to mitigate the quality of life impacts that could affect people living in close proximity to the Section 8B ROW. Specifically, steps should be taken—through roadway design, construction techniques, and landscaping—to minimize the visibility of the parkway to area residents, to limit changes in the natural topography and vegetation of the area, and to control the construction and traffic noises to which nearby residents are exposed.

## 5.7 MITIGATION MEASURES FOR PARKWAY TRAFFIC AND TRAFFIC NOISE

### 5.7.1 Parkway Traffic Mitigation

In general, completion of Section 8B would not have a significant traffic impact on surrounding roadways from Cosby to Pittman Center, nor would there be any significant traffic impact from the construction process. Furthermore, there should be no cumulative traffic effect if all Foothills Parkway sections built and open to traffic in the future.

Although some roadway sections are projected to operate at unacceptable levels in the future, this would not be due to Parkway traffic, but rather to traffic on existing roads. Also, almost all intersections within the Section 8B area would be reconstructed with Section 8B or would be included in currently planned highway improvement programs. These intersections should be designed and constructed so that all intersections would operate at an acceptable LOS in the future.

In light of these considerations, ORNL feels that no traffic flow mitigation measures would be necessary as long as the Section 8B interchanges were constructed to provide an adequate LOS for the projected traffic volumes.

### 5.7.2 Parkway Traffic Noise Mitigation

Noise analysis by ORNL indicates that traffic noise resulting from the addition of Section 8B would not significantly affect sensitive receptors in the surrounding areas. Therefore, no traffic noise mitigation measures should be necessary.

### 5.7.3 Parkway Construction Noise Mitigation

ORNL does not expect any serious noise impacts from the Section 8B construction process. The nearest sensitive receptor would be over 91 m (300 ft) from the proposed centerline of the parkway and should be approximately 76 m (250 ft) from any related construction activity, such as clearing, cutting, or filling. Furthermore, construction activity would be temporary. Still, noise from construction equipment is harsh and annoying, and the relative serenity of the surrounding area likely would make these noises more prominent. Therefore, ORNL suggests that the following FHWA mitigation measures be considered.

**Establish effective community relations.** Effective communication between NPS and the communities that would be affected by construction is essential. NPS should inform residents and other stakeholders of any potential construction noise impacts, as well as the measures that would be employed to reduce these impacts. NPS should also establish and publicize a responsive complaint mechanism for the duration of the Section 8B construction period and instill an awareness of public attitudes and reactions in construction equipment operators so that unnecessary annoyances may be avoided. Establishing a good rapport with the community could provide high benefits for low cost.

**Design consideration.** Early coordination and communication with the Foothills Parkway design agency could greatly aid in locating and sequencing construction operations to minimize potential

construction noise impacts at sensitive receptors. Noisy elements (such as compressors and haul roads) should be located in less sensitive areas when possible, making use of any existing natural or artificial features that can shield the construction noise. Permanent noise barriers, if required by the project, should be constructed as early as possible to reduce potential construction noise impacts. Alternative construction methods could also be employed to lessen potential construction noise impacts (e.g., using cast-in-place piles rather than driven piles, or using rubber-tired equipment rather than steel-tracked equipment).

**Source control**. New construction equipment is generally quieter than older equipment. Special, very quiet types of new equipment are also available. However, specification of the exclusive use of new, quiet construction equipment on Section 8B construction might be very costly and would be justifiable only in cases of extremely severe noise impacts. Control of noise from existing construction equipment is usually limited to requirements for mufflers and continued good maintenance on all equipment. Additional modifications to construction equipment for noise reduction are usually not reasonable because they involve large increases in cost.

**Site control**. Measures to abate Section 8B construction noise could be to modify the time, place, or method of operation for a particular noise source. NPS could also limit the work hours on a construction site. Careful project planning could aid in locating noisy construction activities as far as possible from sensitive receptors or in areas where natural shielding is possible. Building temporary noise barriers or special equipment enclosures is usually quite expensive and limited to use only in instances of severe construction noise equipment.

## 5.8 AESTHETIC RESOURCES

### 5.8.1 Road Cuts and Fills

Treatment of cuts along the proposed parkway is difficult to assess because the rockiness and steepness of the cuts is not known. Vertical rocky cliffs as cuts are much more interesting than graded grassed slopes. Of course, cut stability is the key issue. Wherever possible, rocky cuts should be vertical. Along areas of segment 3 and at the western terminus of Section 8B, stone walls should be considered. Slopes should be re-established using bioengineering techniques as appropriate.

It is recommended that a special effort and plan be initiated to revegetate cuts and fills with natural vegetation as quickly as possible. Seedlings in sufficient quantities would have to be ordered years ahead of time to prepare for the effort. Special effort should go into recognizing the concerns of landowners and residence whose scenery would be significantly affected. Near these areas, attention to seedling planting, survival, and fast growth is important. This may involve repeated applications of fertilizers, weed control, and even soil amendments. Where cuts and fills are particularly conspicuous to large numbers of viewers, the use of retaining wells is recommended, especially near U.S. 321 and to a greater extent than the conceptual plans now call for.

Fills are a more difficult visual element to control. The principle concern is the contrasts fills inflict on the existing landscape. The contrasts are the lighter color, different color, and rougher

(large rock) or smoother texture (gravel or grass) when viewed from a distance. Retaining walls using dark rock can help but become prohibitively expensive. In comparing alternatives, three objectives to minimizing the negative visual impacts should be considered. The first is to minimize the length of downslope by using materials that increase the angle of repose. Several alternatives exist which accomplish this objective such as terracing with posts, rip-rap, and wire mesh. These measures minimize the area of disturbed natural vegetation. The second is to use materials that match surrounding colors and textures to the extent possible. Red dirt and freshly cut limestone (light gray to white) are examples of materials that should not be used for visual reasons. The third is quick establishment of vegetation that matches the green-brown color and general texture of surrounding natural vegetation (i.e., tree tops). Grasses contrast forests because of their brighter yellow-green color and smooth texture. Both shrubs and trees are the best solutions.

Recognizing the above issues, special mitigation efforts on road cuts and fills are needed at several locations:

- In the valley of the Little Pigeon River at the western terminus of Section 8B
- Where the proposed parkway crosses Webb Creek and its associated valley, especially along the east side of the valley where the parkway descends into the valley and where it is also visible from U.S. 321
- Along most of segment 3
- Where the proposed parkway ascends heading west out of Rocky Grove and around a ridge next to U.S. 321
- Along the southwest end of Big Ridge (east side of Rocky Grove) where the parkway can be seen from U.S. 321 at fairly close range

### 5.8.2 Proposed Parkway Alignment

The conceptual design of the main alignment of the parkway is good. Ways to improve the use of the aesthetic resources are itemized below.

- Develop the Little Pigeon River exit ramp using the north ramp alternative.
- Install the tunnel option east of the Little Pigeon River exit ramp.
- Do not develop an exit ramp near the intersection of U.S. 321 and Webb Creek Road.
- Build the parking loop on top of Webb Mountain.
- Develop the lower parking lot on Webb Mountain which enables the use of the access road to the top loop parking lot on Webb Mountain.
- On the west side of Rocky Flats, develop the valley (lower) alignment to avoid large cuts into the nearby steep hillside.
- At the Cosby exit ramp, utilize the southern exit option to hide the ramp in forest as much as possible.

### 5.8.3 Development of Pull-Overs and Vegetation Clearing for Views

Specific site developments and clearing of vegetation have been proposed based on a long list of considerations in their development. The purpose of these considerations was to establish a baseline to assess impacts and mitigation measures. After evaluating the impacts, there are some mitigation measures recommended.

- Eliminate the development of either site 1A or 2A. They tend to present the same aesthetic resources and only one is necessary. Site 1A is the prettier of the two but is more congested with the exit ramp. Therefore site 2A is recommended for development and site 1A is recommended not to be developed. This would mean additional treatment of cuts with retaining walls where the parkway comes next to Webb Creek Road near U.S. 321.
- Eliminate some of the recommended areas for vegetation maintenance along site 3C. This would still allow the retention of some good views but reduce the amount of area to constantly maintain.
- Establish a planting and revegetation plan (beyond the initial grassing of slopes) involving native hardy tree species such as Virginia pine, red maple, black locust, sweetgum, hackberry, redbud, and several native shrubs. Apply this to all cuts and fills recognizing the relationships between elevation, slope, and substrate condition. Plant in cuts and fills using nuts and seeds gathered from nearby trees to speed up the recovery process. Monitor survival, growth, and pest plant invasion so corrective actions can be effectively implemented. Replanting can be expected for many areas. Allow the use of herbicides to control exotic pest plants so native plants can get well established (and shade out further pest plant invasions).
- Examine the layout of terrain closely at the top parking lot on Webb Mountain to determine if less forest could be cleared.
- Eliminate site 6A. Although the view is excellent, it is very narrow and somewhat duplicated at site 7A.
- Consider eliminating the development of site 7C (Cosby Creek near exit ramp). The site is close to public roads and development, would be somewhat crowded and congested, and is subject to disturbance from the widening of SR 32 and a new exit ramp.
- Assess the height of trees at all sites considered for aesthetic develop. The vegetation maintenance estimates were based on trees being 25 meters tall. It is likely the trees are not this tall at many sites. If this is so, the maintenance line can be moved closer to the parkway and thereby reduce the area of vegetation maintenance. Further, in some areas it may be appropriate to thin forests rather than totally clear them. A detailed inspection should be conducted to determine if forest clearing and maintenance can be reduced.

### 5.8.4 Potential for Interpretive Resources

Subjects for interpretation at aesthetic sites are local history, local structures, aquatic habitats, geology, identification of mountains, forest ecology, wildflowers, geology, floral and faunal ecology, Indian culture, seasonal changes, hydrology, local religion, local stone wall construction, and many other topics. These interpretative subjects can be highlighted appropriately across 8 to 11 sites with more than one topic per site. Self-guided tours, especially at 1A, 2A, 3C1, 5A, and 7C would be appropriate.

Sites identified for development have included consideration of cultural, environmental, and other interpretive subject material in their location and design. However the details of the subject matter have not been developed.

### 5.8.5 Potential for Views of Streams, Valleys, and Distant Views Not Evaluated

Initially, 38 sites were identified as having at least some potential for viewing or interpretive development. Many were eliminated because views were very short, looking across a small valley

into a close, opposing ridge. These could potentially offer opportunities for additional development for special studies and interpretation. The present development plan has a mix of distant panoramic views and close encounters with trees, streams, and fields. These could be expanded at a later date to meet park management goals.

## 5.9 CULTURAL RESOURCES

Consideration should be given to screening the parkway in such a way that the Tyson McCarter Place is not visually impacted from construction and operation of Section 8B.

Placing the parkway on the eastern side of Big Ridge would avoid visual effects to the Lansford Barn. Placement of the location of the barn on the conceptual design sheets would help identify the potential visual effects of the parkway.

The location and boundary of Sutton Cemetery should be placed on the conceptual design sheets. The cemetery should be protected and access to the public should be maintained.

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