

The U.S. Department of Energy's
National Renewable Energy Laboratory

General Development Vision—2003

A 25-Year Framework for Developing
NREL's Campus at South Table Mountain
and the National Wind Technology Center

November 2003



*Creating a "living
laboratory"—
a world-renowned,
high performance
research campus,
exemplifying
sustainability*



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Site Planning Working Group

The working group oversaw and guided the planning process. Members included the following:

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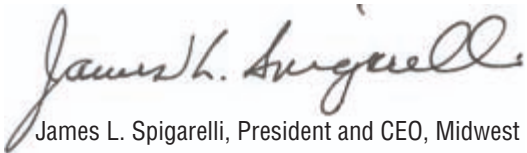
Foreword

Imagine a future where a building's "skin" generates its own electricity; where the by-product of automobile exhaust is water; and where utilities generate a significant amount of a community's power from wind. These are among the many energy technologies being researched and developed today at the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) in Golden, Colorado.

While NREL researchers work on exciting alternative energy technologies for the nation, they also believe in "walking the talk" in their own backyard. NREL's long-term vision is to develop a world-renowned, high-performance research center at South Table Mountain that showcases energy technology innovation and leadership and embraces the best in energy and ecological conservation practices.

The 25-year site vision is the first step toward development of such a center. It proposes incorporating leading-edge renewable energy and energy efficiency technologies, as well as environmentally sound energy and water efficiency practices, into NREL's buildings and the surrounding environment. The plan sets goals for land development and building design that will maximize resource efficiency, minimize waste and help NREL achieve its energy mission.

As one of Colorado's foremost scientific institutions, the National Renewable Energy Laboratory's commitment to clean energy not only attracts leading technology businesses and high-quality jobs to Colorado, it sets the standard for the wise use of natural resources. The Midwest Research Institute, Battelle and Bechtel — NREL's managing partners — are proud to be part of an era in which NREL-developed technologies will become the crown jewel of its South Table Mountain research center.



James L. Spigarelli, President and CEO, Midwest Research Institute



Preface

During the 2002 celebration of NREL's first 25 years of operation, we looked back at the numerous accomplishments of our exceptional staff and the technological progress, but we also looked forward to the next quarter century with great anticipation. One of the Laboratory's finest assets is the several hundred acres of land at South Table Mountain in Golden, Colorado, and at the National Wind Technology Center, which the Department of Energy has entrusted to us. As we continue to grow and face new research challenges, we may be limited by available space. We decided that now is the right time to seize the opportunity to clearly establish a vision of the future development of this valuable asset.

This document represents the culmination of the planning process that I set in motion in May 2002. The process began with a set of goals and values that were jointly developed by NREL's Site Planning Working Group and the Executive Managers. The planning process engaged staff and managers from throughout the laboratory. It involved DOE and NREL stakeholders, along with members of our Design Advisory Board, in a series of design workshops. It also included conversations with local governmental officials and key community stakeholders.

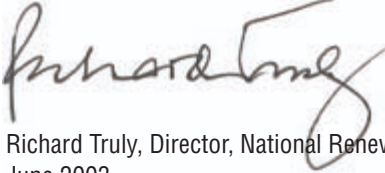
In order to meet the overall needs of NREL, the plan was able to strike a number of challenging balances, including—

- Preserving a highly visible commitment to sustainability, while providing a safe and secure campus where security is as transparent as practicable;
- Identifying potential locations for future high-quality research facilities as well as facilities to house administrative staff in productive and efficient space;

- Emphasizing pedestrians and alternative modes of transportation on the campus, while still providing adequate space for parking and vehicles; and
- Compactly siting facilities to maintain the valued campus open space, given a pattern of incremental funding that tends to favor small buildings.

Many organizations will look to NREL as a leader as we incorporate the concepts of sustainable design in the context of an overall campus general development. This vision is intended to serve as a model to others as we develop our research campuses to be cutting edge, environmentally sound, and high performing.

Finally, a special thanks to NREL's Nancy Carlisle, whom I asked to lead this effort, and to all those who worked so hard to support her in producing this vision of the future.



Richard Truly, Director, National Renewable Energy Laboratory
June 2003





Chapter 1: Objectives and Approach

1.1 Objectives

The National Renewable Energy Laboratory (NREL) is the only national laboratory dedicated to supporting the mission of the U.S. Department of Energy's Office of Renewable Energy and Energy Efficiency (DOE EERE). That mission involves strengthening America's energy security, environmental quality, and economic vitality in public-private partnerships that enhance energy efficiency and productivity and bringing clean, reliable, and affordable energy technologies to the marketplace. NREL's complementary mission is to develop renewable energy and energy efficiency technologies and practices, advance related science and engineering, and transfer knowledge and innovations to address the nation's energy and environmental goals.

From its beginnings in 1977 as the Solar Energy Research Institute, NREL has been modestly but steadily developing campuses on two DOE-owned sites west of Denver, Colorado: South Table Mountain (STM) and the National Wind Technology Center (NWTCC). On May 15, 2002, NREL Director Richard Truly called for a long-term site development vision for both sites. More than 150 NREL staff members and stakeholders were involved. The resulting General Development Vision will serve as a framework for site development for the next 25 years, enhancing NREL's role in the community and its role in the growth of the Denver metropolitan region.

This General Development Vision was developed to meet the following expectations:

- Present a single, unified NREL vision for the future of our sites that captures people's imaginations.
- Demonstrate vision, innovation, and leadership for the Laboratory for the next 25 years.

- Reflect and communicate the values of our organization, which include—
 - Excellence in research and development (R&D) of science and technology, and
 - Sustainability in our operations, which means minimal environmental impacts, maximum cost-effectiveness, and beneficial impacts on our staff and neighbors.
- Ensure a linkage between NREL's future mission requirements, site usage, and optimal development of our physical facilities.
- Strengthen the rationale for NREL's capital budget by defining an overall context for individual buildings and facilities.
- Create a campus environment that enhances the staff's productivity and attracts top researchers and professionals.
- Provide input to future environmental assessments.
- Strike a balance between potentially conflicting design values.
- Encourage collaboration and discussions among NREL Directorates, staff members, and other stakeholders.

As DOE's premier laboratory for renewable energy, NREL is tasked to develop energy efficiency and renewable energy technologies and practices, advance related science and engineering, and transfer knowledge and innovations to address the nation's energy and environmental goals. Consequently, we have determined that using principles



Figure 1-1. NREL's Solar Energy Research Facility

of sustainable design is the most effective way to manage the Laboratory and excel at our mission.

In this document, we use the word *sustainable* in two ways:

- In terms of resource efficiency, the word means maximizing the efficient use of all our resources, minimizing waste and pollution, and serving as a positive force that reflects economic, environmental, and community responsibility.
- In terms of site development, the word means creating a place that honors the local climate, topography, vegetation, and materials as well as the mission of the Laboratory.

A place that is rooted in its context is unique and meaningful to people. When people value a place, it will be sustained.

1.2 Approach

A seven-person Site Planning Working Group—which included representatives of Executive Management, NREL's four major Directorates and the Environment, Safety, and Security Office—was formed to oversee the planning process. The Working Group selected a site-planning consulting team through a competitive process. The following key inputs to this document were developed:

- **Expectations, assumptions, goals, and strategy.** An overarching set of shared values for the development of our campus was developed jointly by the Site Planning Working Group and NREL's Executive Managers. Assumptions and expectations as to the outcome of the process are summarized in Chapter 2 and described in more detail in Appendix A.
- **Staff priorities for the NREL campus.** Meetings were held with staff from each NREL Directorate in order to understand the ways in which our facilities are currently used and perceived, as well as to highlight strengths and areas for improvement. The priorities for the STM site are

listed in Chapter 2, those for the NWTC are in Chapter 4, and they are also described in Appendix B.

- **Characterization of NREL's future strategic directions.** We reviewed DOE strategic plans for each Energy Efficiency and Renewable Energy program at the Laboratory. We used these plans as the basis for projecting the levels of funding, research directions, and generic types of facilities that will be needed for the next 25 years. These provided a basis for quantitative projections as to the sites' occupants, parking needs, and the types of research facilities that will be needed. See Chapter 3 for a summary for the STM and Chapter 4 for the NWTC summary.
- **Site issues analysis.** Issues addressed for the STM site included parking and circulation, density, image, security, energy, and sustainable design. The analysis is summarized in Chapter 5.
- **External factors impacting the sites.** External factors included global issues, our community, and the ways

in which the workplace of tomorrow and advances in technologies will impact our operations. They are summarized for the STM in Chapter 6 and for the NWTC in Chapter 4.

Finally, as the culmination of a year-long study, the South Table Mountain and National Wind Technology Center visions for development were completed. The development process also involved holding on-site design charrettes in December 2002 and February 2003, and holding more than 20 topical meetings with key stakeholders.

Public presentations on the vision for the site were held at the February and May 2002 Design Advisory Board meetings to solicit feedback. They also were shared with NREL staff at the 2002 NREL Staff Awards and Expo. Presentations were given at several other forums, and many NREL staff members had an opportunity to provide input. The resulting development strategy for the STM site is presented in Chapter 3. The NWTC strategy is presented in Chapter 4.



Figure 1-2. Aerial View of NREL's Visitors Center with the SERF in the Distance



Chapter 2: Goals and Projections

2.1 Planning Assumptions, Goals, and Priorities

By using renewable energy, demonstrating sustainable design and environmental stewardship, and generating worldwide interest in renewable energy and energy efficiency technologies, NREL's goal is to "walk the talk" of its mission. As a reflection of its commitment to sustainability, NREL will strive for a cohesive, pedestrian-friendly campus featuring predominantly low-rise buildings (75 feet or less), some mixed-use development, consolidated parking, and preserved and enhanced open space.

A full set of goals, values, and assumptions for site planning is in Appendix A. Listed below are general assumptions about our future missions and programs.

- Over the next 25 years, our mission will be to develop renewable energy and energy efficiency technologies and practices, advance related science and engineering, and transfer knowledge and innovations to address the nation's energy and environmental goals.
- The STM site will continue to support biological, chemical, physical, and multidisciplinary scientific and engineering R&D very much like the way it does today. Specific programs are likely to change, however, in response to the successful completion of some mission elements, new opportunities, and changes in federal direction.
- The NWTC site will continue to support scientific and engineering R&D for wind, distributed energy resources (DER), and similar programs.
- Staff work patterns will change as a result of alternative work schedules, telecommuting, job sharing, greater needs for physical and cyber security, and the continued evolution of communication technologies and information systems.

- Because we value social interaction and believe that physical proximity fosters creativity and leads to innovation, over the next 25 years all NREL staff members who work on site will be accommodated with adequate space on DOE property, without the need for remote (nonadjacent) leased space.
- The proportion of staff on the regular payroll to on-site students and subcontractors will stay about the same as it was in 2002. On-site industry partners will remain proportional to total projected work-for-others efforts.
- Currently, about 1100 people work at NREL in facilities on the STM campus and in the Denver West Office Park. In recent years, our population growth has averaged about 3% per year. This planning effort is based on evaluating scenarios that project up to 2,500 employees working on the STM site by the year 2027.
- Currently, about 90 people work at the NWTC. The planning effort for the NWTC is based on evaluating scenarios that project approximately 160 employees working on the NWTC site by 2027.

We have characterized growth in terms of a desired near-term to mid-term (approximately 10-year) build-out and a long-term (25-year) build-out. The time frame for construction is speculative and dependent on funding. The near- to mid-term phase is based on a build-out of the facilities that NREL has currently designed or discussed as needed (see also Section 2.3).

This document offers a vision to guide the development of our sites, regardless of the time frame. The overall goals of the development framework are to—

- Provide the maximum capability to support excellence in state-of-the-art R&D, including efficient administrative services.

- Support safe, healthy, efficient, and secure operations while minimizing the visibility of security measures to maintain a campus atmosphere consistent with NREL's education activities and outreach to our stakeholders and the public.
- Demonstrate the best principles of sustainable site development, buildings and structures, and Laboratory operations.
- Clearly convey NREL's image of excellence in R&D and sustainability.
- Maintain positive relations with our immediate neighbors and take advantage of mutually beneficial relationships and projects with the metropolitan and regional communities.

Staff priorities for the STM campus were determined in a series of staff workshops that identified eight priority items; they are listed here and described in more detail in Appendix B. These priorities are very consistent with our goals for the campus.

1. The campus should reflect NREL's mission and sustainable values.
2. NREL should consolidate on one campus (except for the specialized activities at the NWTC).
3. NREL should preserve and enhance the natural environment.
4. The circulation of pedestrians should be improved.
5. Buildings on the campus should be more cohesive and integrated visually.
6. Parking should be consolidated, and alternative transportation should be used on campus.

7. There is a need for more common space and for informal, interactive, indoor and outdoor gathering spaces.

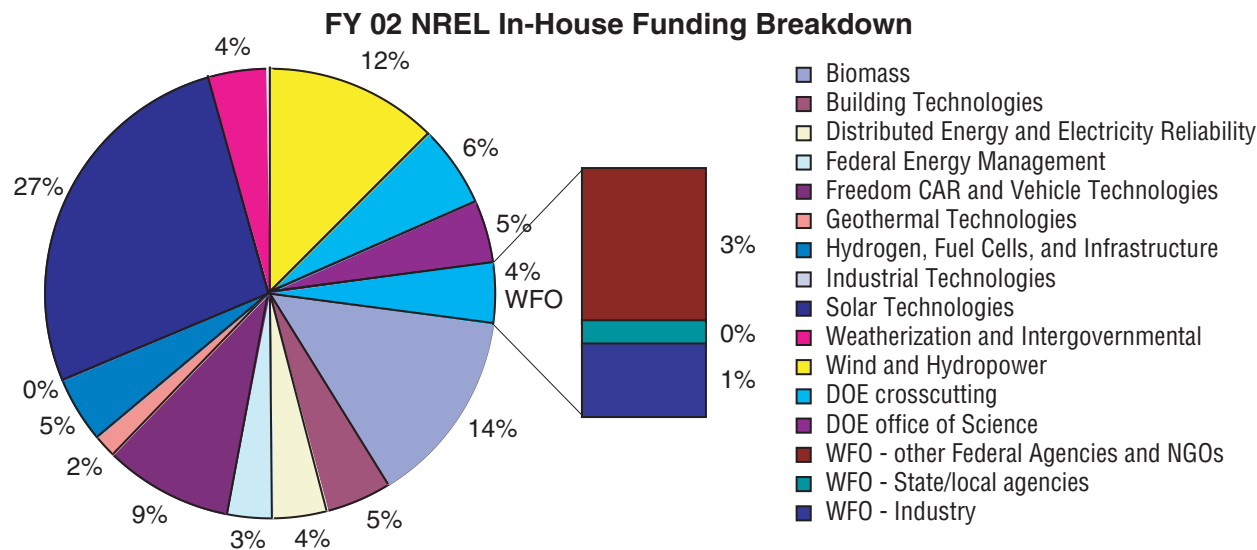
8. NREL's visibility with the public should be enhanced.

2.2 Growth Projections

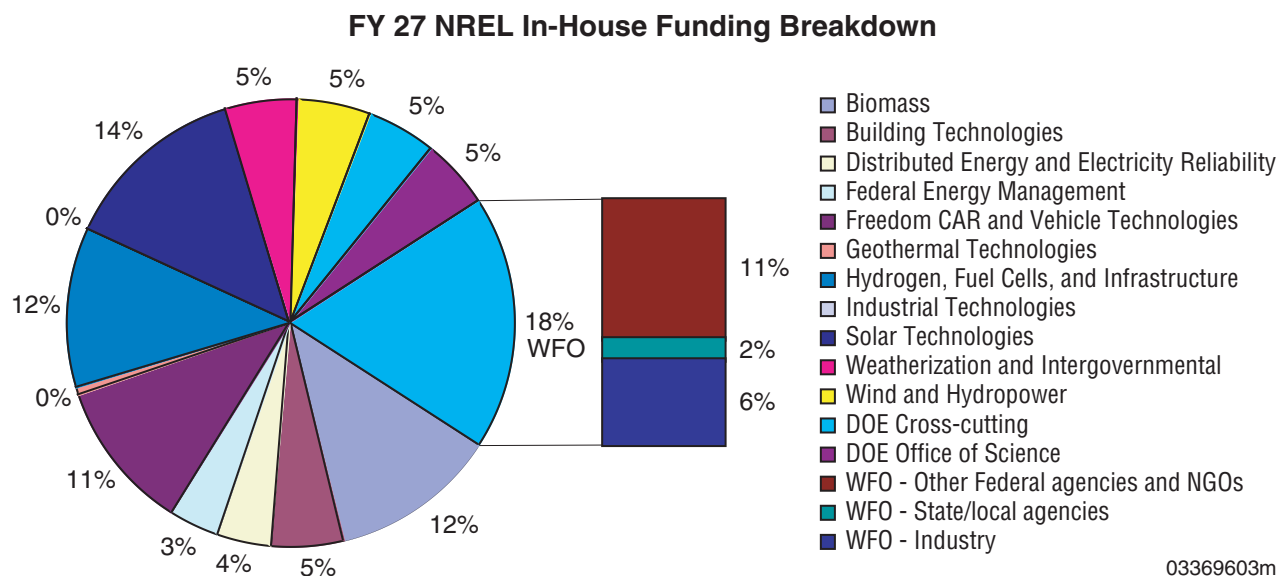
More than 90% of the support for NREL activities is provided by the DOE Office of Energy Efficiency and Renewable Energy (EERE). This funding is dependent on an annual budget process culminating in appropriations by the U.S. Congress. EERE has strategic plans for future activities, multiyear program plans, and major initiatives such as FreedomCAR that are launched by the Administration.

The 25-year planning horizon represents at least three presidential administrations, numerous congressional elections, and no doubt many geopolitical changes. History provides us with some information about funding patterns over time, and these translate directly into numbers of NREL staff while indicating the variability of the democratic process. During its first 25 years, NREL grew to the current staffing level of about 1100 people; growth has been at least 3% per year during the past 5 years.

We evaluated growth scenarios in the 3%–5% range and selected the 3% scenario as the basis for this plan. This would result in a population on the STM site of approximately 2500; NREL anticipates moving all staff in leased buildings in the Denver West Office Park to this site. regardless of the specific time frame for growth, one of the major reasons for developing the site plan is to provide a context for decisions on the eventual build-out of the STM site. For the NWTC, similar projections show that the staff could increase from about 90 today to about 160 employees by 2027 because of the specialized nature of anticipated activities.



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Figure 2-1. In-House Funding Breakdown for FY 2002 and Projections for 2027

It is also necessary to look beyond a simple staff count to project the types of laboratory facilities that will be needed in 25 years. These will include high-bay test laboratories as well as wet- and dry-bench and computer laboratories. For this reason, NREL has also projected growth in funding over the next 25 years by program.

Program data were taken from multiyear plans in support of fiscal year (FY) 2004 budget requests. For each program, we estimated growth for three periods of time: for the next 5 years, for 5-15 years, and for 15-25 years. Beyond the next 5 years, however, the quality of our data is poor. Therefore, some estimates are based on the general themes of the EERE strategic plan. For each program, approximate current in-house funding (excluding subcontracted tasks) was identified, and future growth rates were postulated. These were translated into equivalent people, assuming constant FY 2002 dollars, so that people and funding are proportional.

The charts in Figure 2-1 show the funding breakdown for FY 2002 and the funding projected for FY 2027 by program. A high rate of growth in work for others (WFO) clients compensates for the lack of specific information about new programs in the out-years. This is likely to be a logical direction for NREL as technology moves from basic to more applied research and on into private-sector product development with support from NREL specialists.

2.3 Buildings

The following is a summary of the program assumptions used for the 25-year planning horizon. They are described in three categories: Existing Buildings, Near- to Mid-Term Buildings (potential construction projected through 2014), and Long-Term Build-Out (potential construction projected from 2015 to 2027).

Existing Buildings. Existing buildings on the STM/Denver West Office Park site in 2002 included—

- 323,766 ft² in six research buildings on the STM site (approximately 400 staff members),

- 191,787 ft² in leased space at Denver West Office Park (approximately 600 staff members), and

- 136 acres of developable land.

Table 2-1. Potential Near- to Mid-Term Buildings

Facility	Lab. Buildings (ft ²)	Admin. Buildings (ft ²)	Lab. Bldg. Staff (no.)	Admin. Bldg. Staff (no.)
Science and Technology Facility	71,000		55	
Administration Building to accommodate staff now in leased space, plus common spaces		275,000 (1)		650
Bioenergy Research Facility (this is an expansion of the FTLB) — Phase 1	28,500		98	
Bioenergy Research Facility — Phase 2	27,400		72	
Bioenergy Research Facility — Phase 3	29,000		60	
Thermal Test Facility expansion	10,000		10	
Hydrogen/ Fuel Cell/ Transportation Laboratory	58,000		60	
Solid-State Research Facility (east of S&TF)	40,000		40	
West End Research Facility (renovation of former Shipping and Receiving Building)	– 0 –		10	
Renewable Fuels and Lubricants Laboratory	14,000		10	
Computational Sciences Facility	15,000		15	
Shipping and Receiving Facility (new building at east entrance)		20,000		15
Total for Laboratories	292,900		430	
Total for Administrative		295,000		665

(1) This equals space for 650 employees at 375 gross square feet (GSF)/person plus an added 30,000 GSF for reconfigurable meeting rooms, other types of interaction spaces and/or expansion to the Visitors Center. We currently lease 191,787 ft² at Denver West Office Park.

Near- to Mid-Term Buildings. The near- to mid-term estimate of buildings includes those that appear in existing NREL planning documents or that have been discussed internally as a need over the next 10 years. The administration building complex would be needed in order to move staff out of leased facilities. Near- to mid-term buildings are shown in Table 2-1.

Near- to Mid-Term Infrastructure. Chapter 7 discusses next steps planned for the STM campus, including infrastructure development. It identifies the inner loop road, pedestrian pathways, and drainage improvements as near-term infrastructure improvements. A current need, however, is to expand parking areas for the Visitors Center. Once additional buildings are built on the East Campus, developing the east quadrangle, as discussed in Chapter 3, will be a high priority.

Long-Term Build-Out. The long-term build-out program should accommodate 2500 people, according to a 3% growth model. The ratio of administrative personnel to laboratory personnel at NREL is 53%: 47%. “Administrative personnel” refers to staff who require only an office (no lab) to do their work. Specific buildings are not yet defined except for the commons buildings. These centrally located facilities will house the NREL library along with the other functions described in Chapter 3. In terms of infrastructure, the service road (the outer loop described in Chapter 3) will have to be completed and a section of the existing road widened. Additional small chemical storage and waste disposal buildings will also be needed, and all quadrangles, landscaping, and perimeter security elements will be completed.

Table 2-2 summarizes the build-out according to time frame. The total floor space needed for both lab and administrative space is 1,671,875 ft².

Table 2-2. Summary of STM Build-Out by Time Frame

	Lab. Staff (no.)	Admin. Staff (no.)	Lab. Space (ft ²)	Admin. Space (ft ²)
Existing	400	0	323,766	0
Near- to Mid-Term	430	665	292,900	295,000
Long-Term	345	675	558,334	201,875
Build-Out	1,175	1,325	1,175,000 ⁽¹⁾	496,875

⁽¹⁾ The ultimate space needed to accommodate staff assumes 375 ft²/person for administrative staff and 1,000 ft²/person for lab staff.



Chapter 3: South Table Mountain Development

3.1 South Table Mountain Site History and Description

The STM site is a 327-acre parcel of land containing 136 acres that can be developed. It is located on the “toe,” side, and top of South Table Mountain in unincorporated Jefferson County, Colorado, near the town of Golden. It is a unique site—a place where the natural and man-made worlds intersect. The northern half of the site includes the mesa slope, with its pristine hillsides, rock outcroppings, and deep drainage channels. The southernmost part is surrounded by neighborhoods, and busy commercial areas are nearby. The site is surrounded on three sides by areas of residential and commercial development, increasing growth, and rising real estate costs; all can have an impact on NREL’s mission, activities, and future development.

In 1999, 176.78 acres were placed into a conservation easement adjacent to other open space owned by Jefferson County in exchange for 25 acres of developable land south of the STM site; these are included in the 136 acres that can be developed. Another 16 acres of the site are restricted because of access and utility easements. A condition of the land exchange is that, if improvements are not started on the 25 acres before the end of the 25-year period that begins in 1999, the county has 5 years to exercise an option to encumber the property under a conservation easement.

Figure 3-1 is a map of site conditions in 2003. Currently, the STM site is only partially developed. In 2002, about 400 people and most of NREL’s R&D activities were housed in two major buildings on the site: the Solar Energy Research Facility (SERF) and the Field Test Laboratory Building (FTLB). The site also contains several smaller research buildings,

such as the Thermal Test Facility (TTF) and the Alternative Fuels User Facility (AFUF).

The STM site supports all R&D areas except wind energy. The site includes low-bay and high-bay laboratories, process development areas, and pilot-scale facilities. There is space

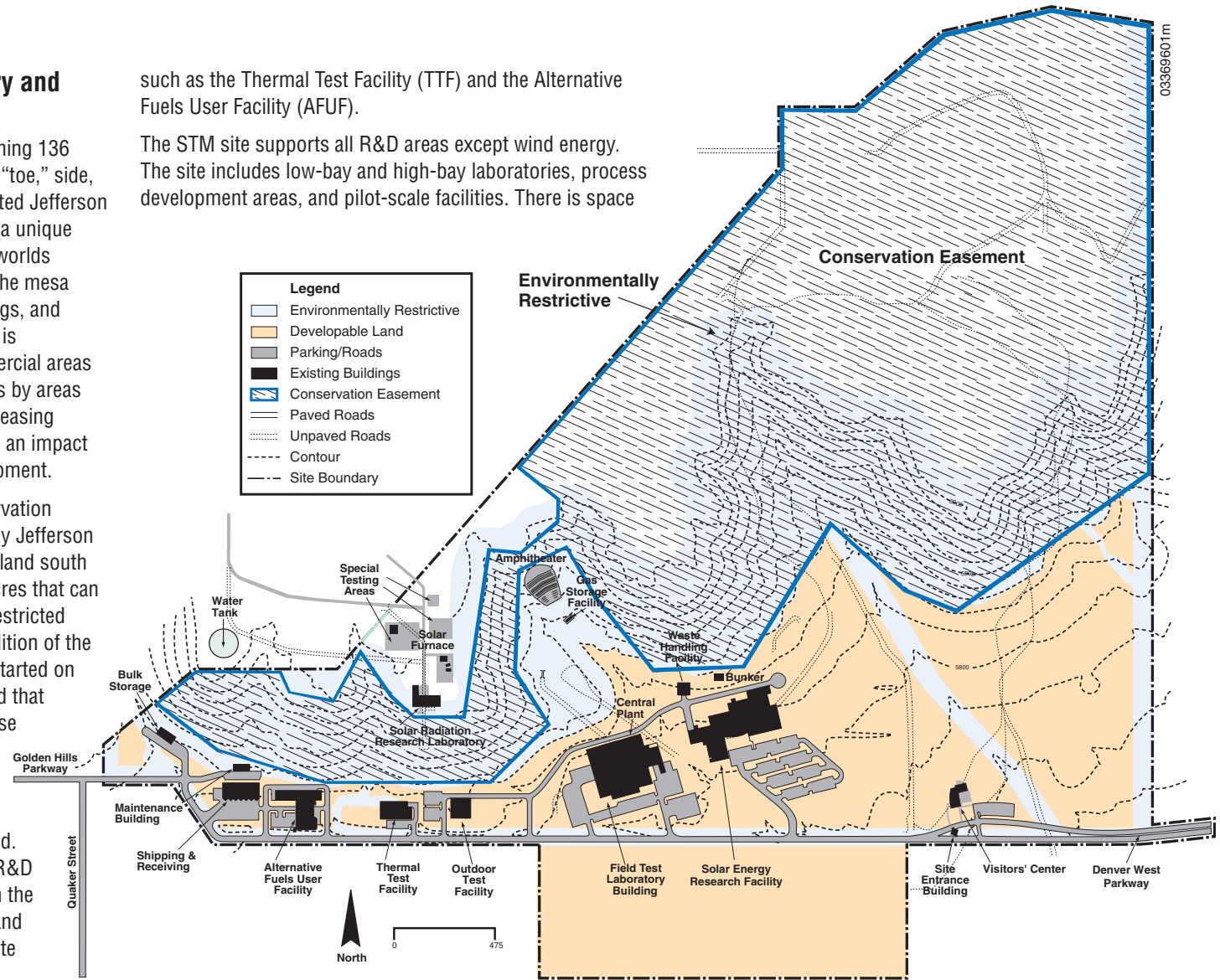


Figure 3-1. STM Site Conditions in 2003

Table 3-1. NREL Facilities in 2002

Location	Size (ft ²)	Occupants (no.)
South Table Mountain Campus	323,776	450
Denver West Office Park (leased)	191,787	650
Joyce Street Facility (leased)	56,000	0
ReFuel Facility (leased)	4,576	3
DOE Golden Field Office and Denver Regional Office (currently co-located with NREL)	35,000	125 ⁽¹⁾

⁽¹⁾ This includes federal employees, contractors, and temporary employees.

for R&D and support staff working on programs that involve chemistry, biology, physics, thermal sciences and engineering, vehicle engineering, outdoor and field testing, and interdisciplinary activities. The STM site also houses several research support facilities, including a Visitors Center, Site Entrance Building, Shipping and Receiving, and Maintenance Building. There is currently a total of 323,776 ft² of building space at the site.

Near the STM site in the Denver West Office Park (Denver West), NREL leases 191,787 ft² of space. The leased space houses most of NREL's administrative and support staff as well as some R&D program staff; it contains less than 15,000 ft² of laboratories. In 2002, 660 staff resided in leased space in Denver West. The Joyce Street Facility (56,000 ft²) and the ReFUEL Facility (4,576 ft²) constitute other leased spaces in the vicinity of the STM site. DOE's Golden Field Office and Denver Regional Office currently are co-located with NREL in Denver West Office Park in approximately 35,000 ft² of leased space (Table 3-1).

The 136 acres of land that can be developed is located as follows: approximately 100 acres at the toe of the slope to

the mesa (north of Denver West Parkway), 25 acres south of Denver West Parkway, and less than 10 acres on the top of the mesa. The altitude of the site varies between 5750 ft and 6050 ft above sea level.

The mesa slope, which is in the conservation easement, has a grade greater than 20%, which prohibits construction; the slope is unstable when disturbed. It includes a rock fall zone, steep slopes, and major drainage ways. The Mesa Top has poor soil conditions and a shallow depth to bedrock, making construction difficult and expensive. Water, natural gas, and electrical service are accessible to the Mesa Top, but sewer facilities are not. The Mesa Top is accessed via about 1 mile of unpaved road on an easement. Only low-impact activities are performed on the Mesa Top; these involve a minimum number of people and low, unobtrusive buildings.

Because the entire STM site is visible to the surrounding community for several miles, NREL is sensitive to the concerns of its residential neighbors. The Laboratory seeks to ensure that research facilities have an acceptable appearance and that research activities on the Mesa Top have minimal visual impact. There are no new facilities planned for the Mesa Top at this time.

3.2 Land Use

The goals of the General Development Vision, as outlined in Chapter 2, are embodied in the philosophy of land use and site organization at South Table Mountain. In the 25-year planning horizon, the land use plan depicts development sites to support just under 1.7 million square feet (ft²) to house an NREL staff of 2,500, including personnel currently located off site in Denver West leased space. The development sites are organized in three primary zones: East Campus, Central Campus, and West Campus. The development sites are intentionally clustered so that buildings can be close together to create a pedestrian-friendly environment.

Buildings will be within easy walking distance of each other, with pleasant open spaces between the buildings. By concentrating the development, we can anticipate that the section of property east of the current Visitors Center will remain undeveloped in the 25-year planning horizon, and undisturbed open space will be preserved. Additional building sites are available in that section of property for development beyond a site population of 2,500.

The land use plan is shown in Figure 3-2. The following is a description of each development zone.

East Campus. The East Campus has been designated as the "visitor interaction" portion of the site. One of the staff priorities listed in Chapter 2 is to increase NREL's visibility to the public. This land use plan directly reflects that priority by suggesting building sites on the East Campus that have public access. Uses directly related to the public include an expanded Visitors Center, a conference center, and an NREL museum. These facilities will be located outside the security zone and will feature entry monitoring with a sign-in registry. The facilities will extend north of the existing Visitors Center, forming a public edge to the STM site.

Laboratory buildings, including the planned Science and Technology Facility, will be around the edge of the east quadrangle. The buildings will be oriented so that visitors could have escorted access to some of them to learn about research activities through displays and examples. NREL research would thus become more accessible and visible through an element of public outreach.

Research functions grouped on the East Campus could include solid-state R&D, surface science, photovoltaics, nanotechnology, computational science, solid-state lighting, and discovery areas. An administrative complex development site will be south of the east quadrangle. It will probably be the location of the Director's offices and other administrative functions that have a public orientation.

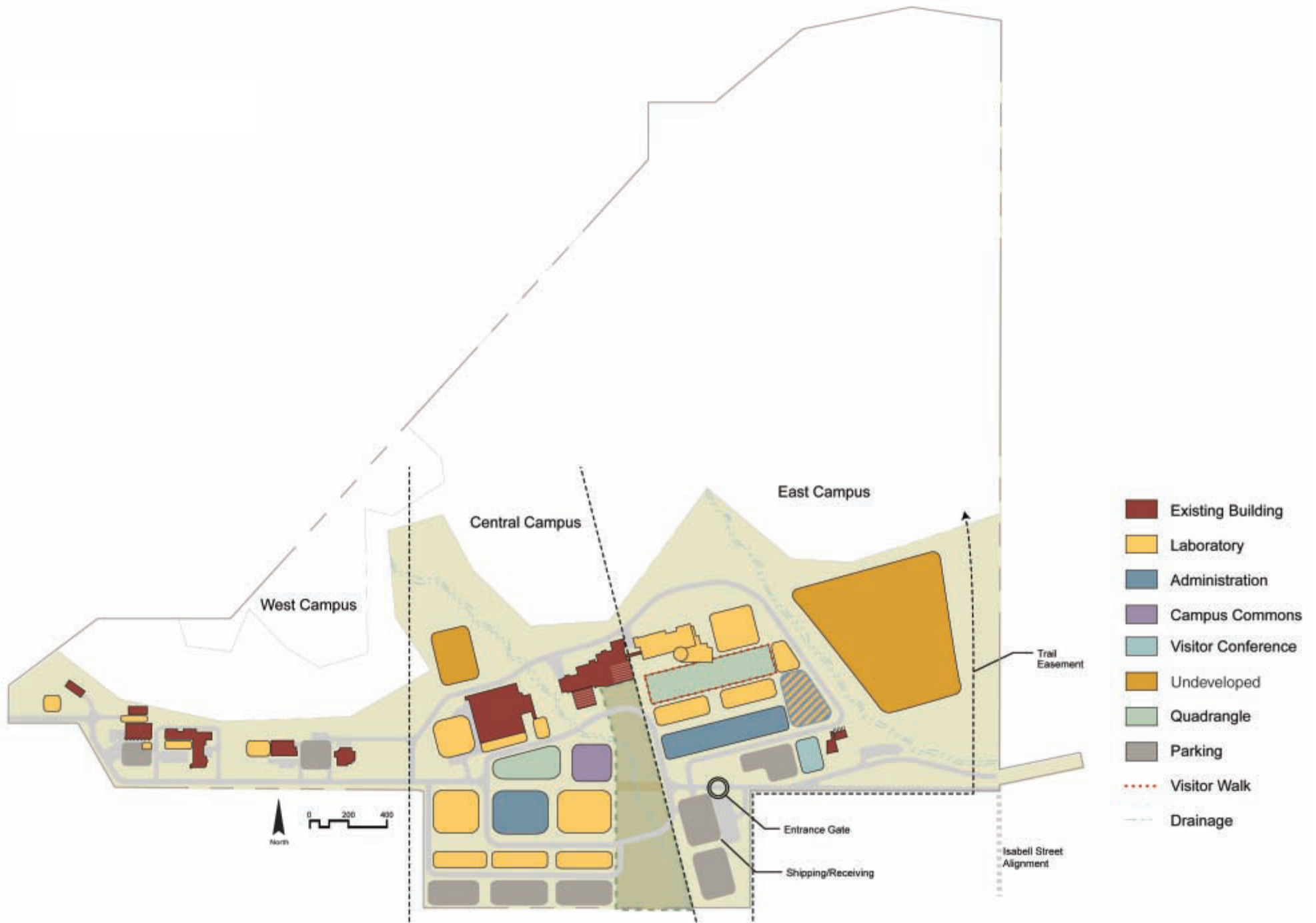


Figure 3-2. Land Use



Figure 3-3. View from the East End of the Campus Looking West

Figure 3-3 illustrates the view from the east end of the campus looking west.

Central Campus. The Central Campus will be the heart of research activities at South Table Mountain. Anchored by the SERF and the FTLB, the Central Campus will contain five additional laboratory building sites and a site for an administration building. Research areas such as biomass, fuel cells, hydrogen, energy storage, and transportation are likely candidates for additional facilities in this zone.

The administration building will contain internal campus functions such as accounting and planning. Additions to the FTLB are also being considered. At the core of this development zone is a site for a Campus Commons building, centrally located to provide common staff services such as a cafeteria, meeting rooms, a wellness center, and the like.

West Campus. The West Campus is envisioned as an infill development area with sites dedicated to additions to existing laboratory buildings. Because this area is relatively narrow, future development opportunities are somewhat limited. Building sites include additions to the Thermal Test Facility, the Alternative Fuels User Facility, and the current Shipping and Receiving building. Additional sites are south of the existing Bulk Storage building at the far west end of the campus. The west end will be well-suited for expanding outdoor test areas if building additions are not planned.

The following criteria apply to the future development of the West Campus:

- Additional facilities and growth that support research affinities

- Facilities that have a low density of personnel
- Facilities that have a low impact on adjacent residential development (e.g., low noise impact, little to no after-hours usage, preservation of site lines to the mesa, low light levels)
- Smaller buildings that work with the existing topography, easements, and drainage.

In addition to the current property, an adjacent parcel at the extreme west end of the campus, south of NREL property, is currently leased by the National Forest Service. If this land becomes available, DOE has first right of refusal. If it is acquired, it could be developed. The location lends itself to a central plant facility that could supply all or a portion of the NREL campus with energy based on renewable technologies.

3.3 Transportation

Roadway Network. The Transportation Plan depicts a strategy for the development of an internal roadway network and the location of parking areas. The roadway plan is based on a loop organization. An outer loop runs around the perimeter of the central development area. The northern portion of the loop is an extension of a service road that currently runs north of the FTLB and the SERF. The southern portion extends south along the east and west property lines of the former Camp George West property; it then runs east and west between the laboratory building development pads and the parking areas at the southern edge of the property.

The outer loop is primarily intended to be a service and parking area access road. The inner loop runs south of the FTLB and SERF buildings and between laboratory and administrative office sites on the southern half of the property. This roadway is primarily intended to be a pedestrian and internal shuttle route to connect the various facilities on campus. The plan suggests that Denver West Parkway be eliminated through the center of the site. Because of the large number of utilities running under the

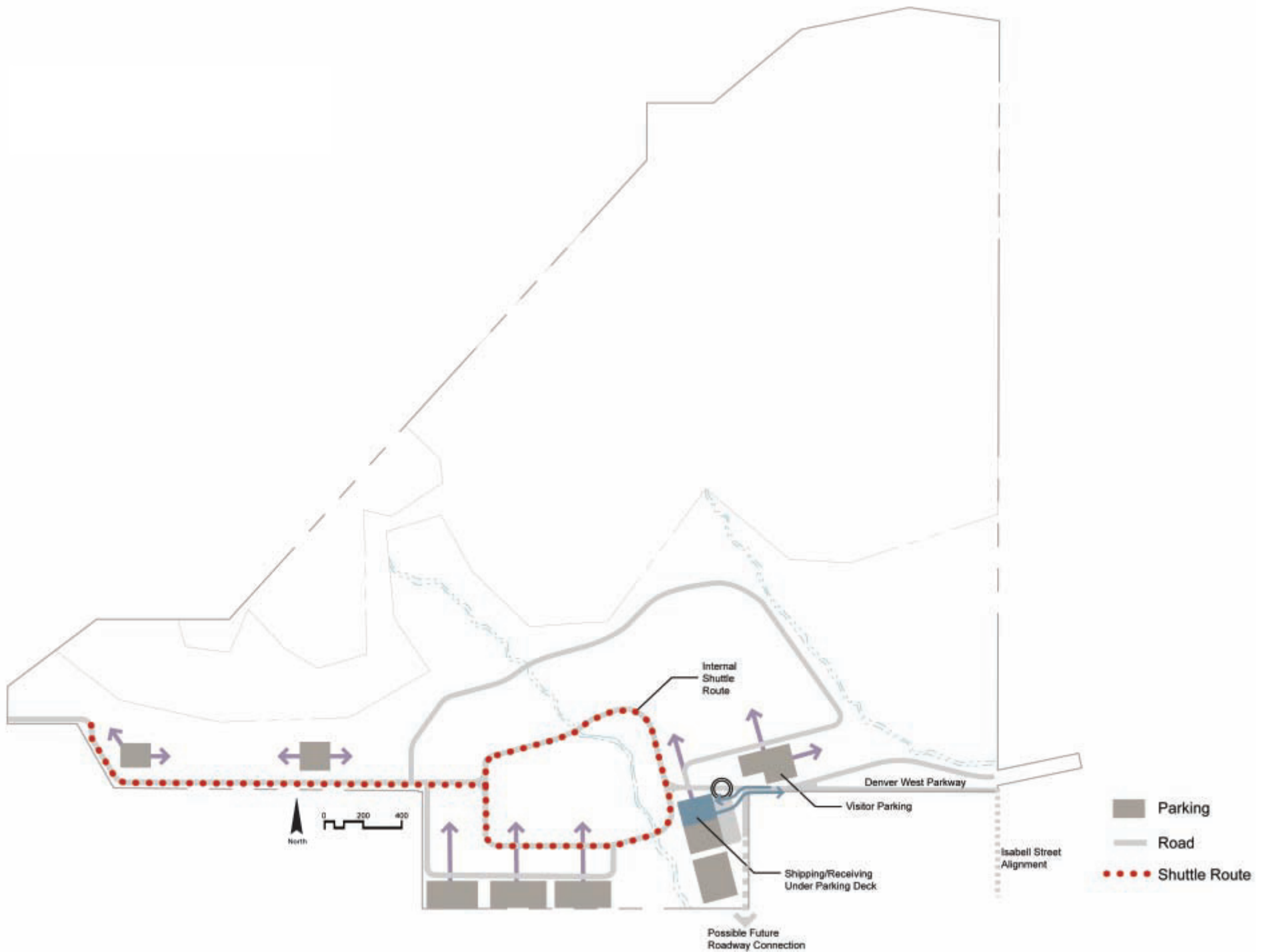


Figure 3-4. Transportation

road, the right-of-way will continue to be an easement. Over time, this easement should be converted to green space. The transportation plan is shown in Figure 3-4.

Site Access. Currently, the primary entrance to the site is on the east side via Denver West Parkway. There is another gate at the west end, but it is used infrequently. As development increases and site access becomes congested at one location, additional roadway connections to the regional transportation network could be developed.

Additional connections to the campus could include an extension of Isabell Street to the north to connect to Denver West Parkway. This would provide access from the south via Colfax near the Colorado Mills shopping development. Also, roadways could be extended from South Golden Road to the north on the east and west sides of the office park in the former Camp George West property. If the east road is developed in the future, the site entrance station and security checkpoint might be relocated west to coincide with an intersection at Denver West Parkway. This would allow easy security access to the Shipping and Receiving facility and permit additional facilities beyond the Visitors Center to be outside the security zone, if desired.

Parking. An overall goal for site development calls for parking areas to be reduced over time. Although it may be impractical to disallow parking on the campus, the goal is to move in that direction. Therefore, there will be incentives to encourage employees to reduce automobile commuting and use alternatives to a “one person, one car” commute. These incentives could include the following:

- Providing food service and other amenities on site to reduce the need to drive off campus during lunch
- Providing covered bicycle storage and locker facilities to encourage bicycle commuting
- Providing an on-site vehicle pool for employees to use for off-site trips during the day

- Coordinating airport shuttle/carpool arrangements
- Providing shuttle service to Colorado Mills for lunch-hour trips
- Providing better pedestrian connections between campus buildings and from Denver West to the main campus
- Creating a “guaranteed ride home” program.

Proposed on-site parking areas are described in the 25-Year General Development Vision. To reduce the circulation of on-site vehicles, parking will be collected in several parking reservoirs on the campus. On the East Campus, parking will be in two primary locations: the Visitors Center and the area to the east of Camp George West. Visitor parking will be added just west of the Visitors Center. This lot can either supplement or eventually replace the current surface lot east of the Visitors Center. A large intercept parking areas could also be located on the east edge of the former Camp George West property. This would serve employees working in East Campus facilities.

On the Central Campus, parking areas will be at the southern edge of the former Camp George West property. These lots will be accessed from the outer loop road and serve the development areas in the Central Campus. Because of the relative remoteness and small employee population of the West Campus, parking will be accommodated in existing and modified surface parking lots there.

Parking areas will be completed in phases. Initially, surface parking lots will be built to accommodate the parking needs associated with new development. Then, as the campus population increases, surface lots can be converted to parking structures. The topography of the campus lends itself to two-level decks that could be accessed from grade at both levels, providing an efficient, cost-effective way to add capacity. Fully developed parking structures with two-level decks could accommodate approximately 1,500 cars on site. To further reduce campus parking, surface lots on the

Central Campus can also be redeveloped over time with new buildings.

One of the major inefficiencies identified on the current campus is the remote location of Shipping and Receiving in relation to the main entrance gate. Therefore, the Shipping and Receiving facility will be relocated from the west end of the campus to the east side of the former Camp George West property. Placing the new facility closer to the east gate will allow incoming freight to be intercepted at the entrance to the campus, improving security and efficiency. The circulation of most delivery vehicles would thus be limited to a small corner of the campus with little impact on the internal roadway system.

The central Shipping and Receiving facility will receive all incoming deliveries, including U.S. Mail. NREL staff can then use campus vehicles to pick up and deliver parcels, mail, and so on to and from Shipping and Receiving and the various campus buildings. Liquid gas shipment vehicles can continue to circulate to various tank farms throughout the campus, however.

Transportation and Staff Priorities. The transportation plan supports four staff priorities identified in Chapter 2. One priority is that parking should be consolidated and alternative transportation used on the campus. This goal is manifested in the transportation plan. Aggregating parking and providing an internal shuttle system allows the NREL site to be more environmentally friendly, which reflects NREL’s mission of sustainability, another staff priority. This is also a major goal of this General Development Vision.

As employees walk, bike, or use the internal transit system to move between facilities, gasoline usage and on-site pollution will be reduced. An alternative fuel transit system will promote sustainability and be an effective demonstration of alternative fuel technologies. During peak morning and afternoon commuting times, a shuttle can be used to transport employees from parking areas to buildings. During

off-peak hours, the shuttle can transport visitors and groups in escorted tours of the Laboratory.

Additional priorities include preserving the natural environment and improving the circulation of pedestrians on campus. Consolidating and limiting parking areas preserves land, both for building development and for open space. Employees will also be encouraged to walk throughout the campus. Thus, the pedestrian environment will be designed to be pleasant and to take advantage of the natural beauty of the locale.

3.4 Open Space and Landscape

Open space and landscape are critically important parts of NREL's future development. While set against the backdrop of the dramatic mesa of Table Mountain, the site is currently a series of disconnected buildings in a harsh, highly exposed landscape. The topography slopes up from the plains to a broad, flat mesa. The few natural drainage ways (arroyos) from the mesa are marked by riparian woodland species, in contrast to the open grasslands of the adjacent slopes. Seasonal winds along the front range of the mountains can be strong. And in summer, the sun can be hot in this arid climate. Although the wind and the sun are two natural resources integral to NREL's mission, they must be mitigated through the landscape design to make the campus inviting.

Three staff priorities deal directly with the development of open space as the building density of our campus increases. These priorities state that the natural environment should be preserved and enhanced, pedestrian circulation should be improved, and more outdoor gathering spaces should be available. Although the STM site's natural environment is beautiful, the current landscape is quite austere. Through thoughtful building orientation and placement as the campus develops, we can create a new natural landscape and open space areas that are more conducive to pedestrian movement, gathering places, and staff interactions.

The open space plan includes several concepts that integrate future development. The three main components are the campus foreground, major campus quadrangles, and pedestrian linkages. In addition, woven throughout the open space network is the requirement for storm-water management. The open space plan is shown in Figure 3-5.

Campus Foreground. The NREL campus has a dramatic setting. Although the SERF is an imposing building, it is somewhat dwarfed by the vastness of the mesa slope behind it. Prairie grass dominates the hillside, and mountain mahogany propagates in the relative dampness of the arroyo channels, making the mesa slope a good natural backdrop for the campus. Similarly, the property east of the current Visitors Center is a gentle slope of native grassland, which forms a nice foreground for the campus. The open space plan recommends maintaining these areas of natural, undisturbed vegetation. The eastern open space area could be developed over the long term, beyond the 25-year planning horizon, but it should remain undisturbed until then.

Campus Quadrangles. The campus buildings are organized around three major open spaces or quadrangles. On the East Campus, a linear open space defines the east quadrangle. This open space is bordered by a walkway that provides access to various laboratory facilities surrounding the quadrangle. The walkway could be covered with a trellis that could become a field of photovoltaic panels, to enhance an interpretive experience for the campus. At the west end of the east quadrangle, an overlook provides a view of the rest of NREL's campus. Landscaping in the quadrangle could consist of xeriscape demonstration gardens based on principles of sustainable development. A view of the east quadrangle looking east is illustrated in Figure 3-6.

The Central Campus contains two other major quadrangles. The central quadrangle runs south from the SERF to the community park bordering the southern property line.

Although security requirements prevent the campus from opening directly to the park, this open space provides a strong visual link to the park and beyond to Interstate 70. The view from the interstate to the SERF can be preserved by this open space connection. A view of the campus from I-70 is shown in the model of Figure 3-7. One of the primary drainage arroyos meanders through this open space as it makes its way south toward Lena Gulch.

The FTLB, the Commons Building, and the Administration Building south of Denver West Parkway can border the second major quadrangle in the Central Campus. With the Commons Building at the apex of this open space area, the commons quadrangle functions as an outdoor gathering area for NREL employees, either for organized events or for casual outdoor meals or recreation.

Pedestrian Linkages. One staff priority states that the circulation of pedestrians on our campus should be improved. Most of the development plan, which places building sites closer to each other than they are now, is on a grid. This allows spaces between development sites to be designed as a network of pedestrian walks leading between facilities and to the Commons Building at the center of the campus. This network will lend a "village" character to the site development, fostering casual interactions between employees and providing a much more habitable environment.

The staff pathways must be pleasant and protected from the wind. Amenities such as benches and shaded seating areas can be provided along these pathways, as well as pedestrian-scale lighting. In addition, the internal loop road can be designed to accommodate both pedestrians and a circulator shuttle system.

Another linkage needed is public access to the mesa trail system. Trails should be developed along the east edge of the former Camp George West property, across Denver West Parkway, and up to the mesa in a dedicated easement along

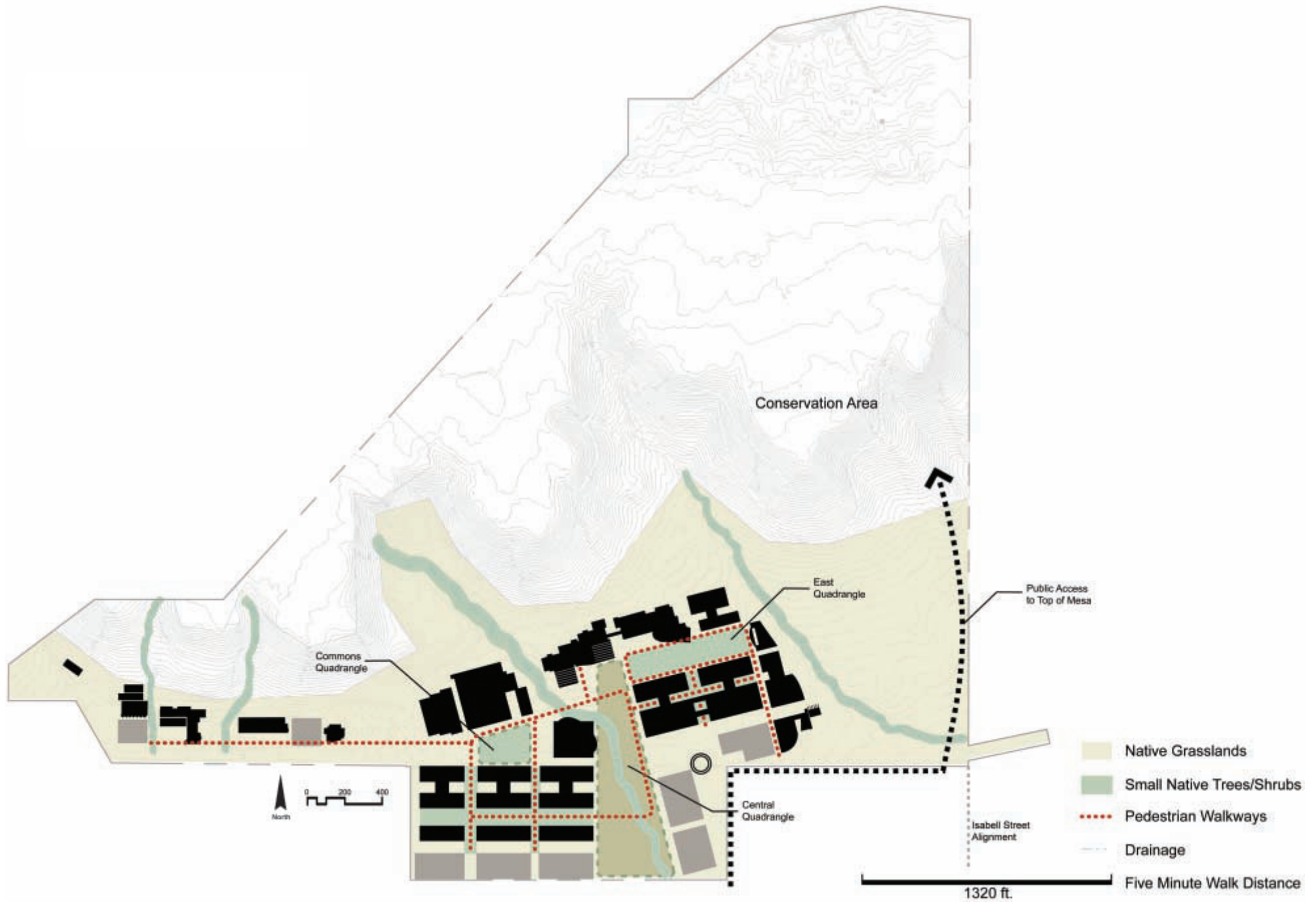


Figure 3-5. Open Space

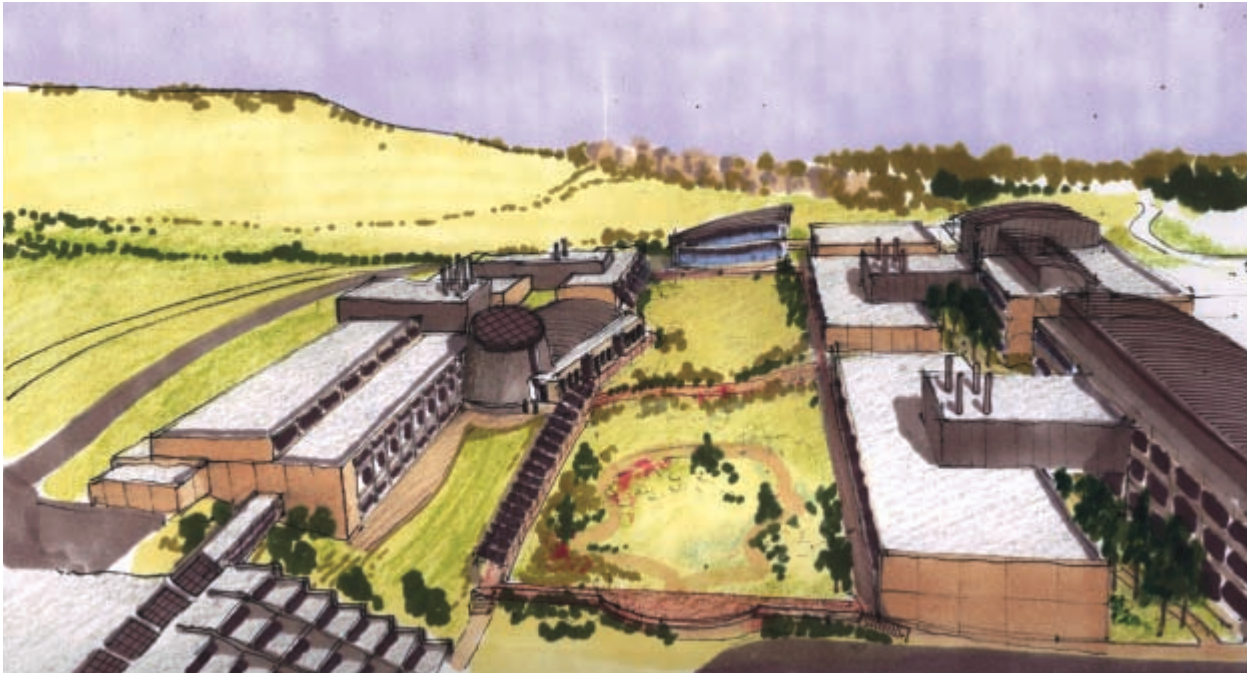


Figure 3-6. View of the East Quadrangle Looking East

the eastern side of the NREL property. And safe passage must be provided across Denver West Parkway. In the future, it may be possible to run the trail along the existing drainage area in the residential neighborhood just east of the former Camp George West property and south of Denver West Parkway, connecting it to the east easement along a much more pleasant path.

Landscape Context. Surrounded by residential neighborhoods, a historic military campus, growing urban development, and the natural open spaces of South Table Mountain, the NREL campus has two faces. One looks toward the mountain with its open space and native plant communities. The other looks to the south to homes, parks, and regional commercial and office complexes. At the western edge of metropolitan Denver, this area shows the

result of some conflict in people's understanding and expectations of the landscape.

The NREL plan actually identifies two types of landscape, both critical to the success of the campus, where the landform and vegetation will be restored to their native character (open prairie) and where small riparian oases are protected from the weather. The mountain-side plants must be native to the site, but the oasis plants could come from a broader palette of local riparian and pine plant species. Oasis areas include courtyards, quadrangles, and pedestrian linkages in the core of the campus core. They will be irrigated primarily by detained storm-water or recycled water, or both. It is important that the construction budgets for each new campus building include an element for landscaping improvements consistent with this plan.

Storm-Water Management. As we develop our site, greater amounts of impervious surfaces will mean less opportunity for rainwater to infiltrate directly into the ground and more opportunity for surface runoff, known as storm water. Storm water contains sediment and other contaminants that have a negative impact on water quality downstream. Detention, or temporary holding of storm water, is an important



Figure 3-7. View of the Built-Out Campus “Modeled” from I-70

sustainable design practice for our campus. It provides a means to slow down the rate of flow so water can be released from our site at the same rate that it would be released under natural conditions.

Currently, water retention strategies fall into a gray area in terms of Colorado water law. These strategies involve holding water for longer periods of time and reusing the water for some function such as site irrigation. If and when this is clarified in the courts, we would like to consider storm-water retention on our site, as well.

The local Urban Drainage Flood Control District (UDFCD) developed a preliminary storm-water management plan for the Pleasant View Area watershed. The plan identifies three significant drainage basins on our STM site that must be considered in site design, both overall and individually. These three basins (west, center, and east) are shown on the open space plan (Figure 3-5). Additional information on storm water management are in Appendix C. The UDFCD plan recommends creating channels or improvements for the center and east drainage channels, including numerous drop structures. According to the plan, additional detention is not required for either basin if overall development of the site is at or below anticipated development for this area (approximately 30%–50% impervious). The current master plan is below this anticipated development rate, and additional detention is not likely to be required.

The UDFCD plan indicates a 14-acre-foot pond planned for the east drainage basin. This was proposed because of the lack of outfall infrastructure for storm-water conveyance under Denver West Boulevard. NREL has not made a commitment to the UDFCD to build this pond, however.

Instead of planning for one large regional pond, we believe that we can achieve the UDFCD objectives by including a requirement in the plan for each new NREL building that, within the east basin, provisions are made to plan for and

use such landscape features as planted infiltration basins and trenches, porous pavement, and grassy swales to filter the runoff, along with localized detention ponds to slow down the runoff. This more localized approach to storm-water management offers several advantages to NREL:

- It will not only slow down storm-water runoff but also improve the quality of water leaving our site,
- The swales and planted basins will support added plant growth on the campus, and
- Land that would otherwise be needed for a regional detention pond can be used for a higher purpose.

3.5 Utilities

The Xcel Energy overhead 13.2-kilovolt (kV) electrical distribution line enters the site from the west end of Denver West Parkway to single-point metering at the center of the site on the south side of the Parkway in front of the FTLB. The STM site has an underground 13.2 kV high-voltage distribution system that is configured in three loops to provide high voltage to various STM site buildings. The capacity of this loop is designed to accommodate NREL's needs for the foreseeable future.

Xcel also supplies natural gas to the site. Consolidated Mutual Water Company provides water, and Pleasant View Water and Sanitation provides sewer service. Qwest provides telephone and electronic communications for the STM site. The fiber optic data and communication cables run in two 5-inch conduits along Denver West Parkway.

NREL has a central boiler and chiller plant in the FTLB that serves that building and the buildings along the western end of the campus through an underground pipe that runs along the north side of the buildings. Another central plant is located in the SERF. It is designed to serve the planned Science and Technology Facility, as well.

As the site develops, additional services and utility corridors will be required to provide the fire protection, heat, power, communication, and domestic services needed. Two options can be considered to meet these increased demands: a corridor-style layout of utilities, or an additional central plant (or plants) to provide power and heat to the new buildings through tunnels.

In a corridor system, the utilities are grouped together, typically under a road or walking path to serve all the buildings and labs. A corridor system allows each building to act as an individual entity, without relying on other facilities for services. Each building would then require a mechanical room to house controls and allow for upgrades and maintenance.

A central plant is one alternative to the corridor system for supplying heating and cooling to the campus. With one or more central plants, heating and cooling would be controlled and maintained in fewer locations and piped to facilities through tunnels. Although a similar corridor-style layout of utilities would be required, the security of the control systems could be monitored more closely, and maintenance of the heating and cooling source could be done at fewer locations. A diagram showing suggested future utility corridors is shown in Figure 3-8.

3.6 Near- to Mid-Term Development of the STM Site

It is somewhat difficult to predict a specific time frame for the development of the STM campus. Initial development efforts should focus on the East Campus in order to begin creating a pedestrian-friendly environment and the genesis of a campus village. This can be followed by development of the Central Campus.

Several elements of the East Campus that can be developed in the early phases of expansion include new meeting and

conference facilities, an administrative office complex, a Science and Technology Facility, a Computational Science Facility, and a few other important R&D facilities. As for the Central Campus, the most likely location for a new Hydrogen/Fuel Cell/Transportation R&D building is the northwest corner of the former Camp George West property.

Additional near- to mid-term development should include infill research facilities on the West Campus and relocation of the Shipping & Receiving function to the eastern edge of the Camp George West property. Infill development would include transportation and vehicle engine testing and research in a remodeled Shipping and Receiving building, additional space for buildings research, and a new biorefinery complex. The new Shipping & Receiving facility and added meeting and conference facilities should be accompanied by the development of additional parking to serve East Campus needs. Taking advantage of the topography, parking could be developed on the roof of the Shipping & Receiving building, which would be accessed directly from Denver West Parkway. The near- to mid-term build-out plan is shown in Figure 3-9, and the long-term build-out is shown in Figure 3-10. See also Chapters 5 and 6 for a detailed discussion of the major issues involved in creating a development plan for the STM site.

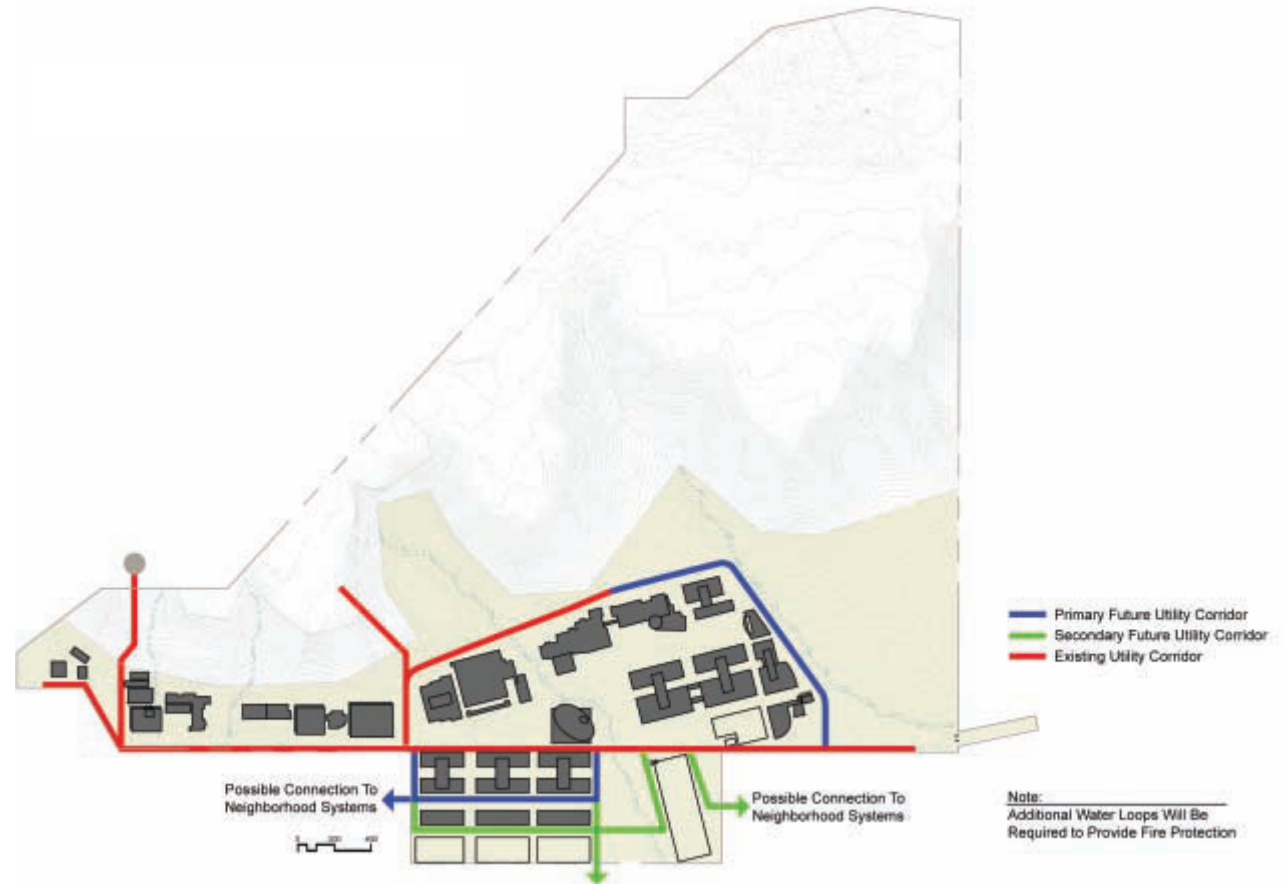


Figure 3-8. Future Utility Corridors

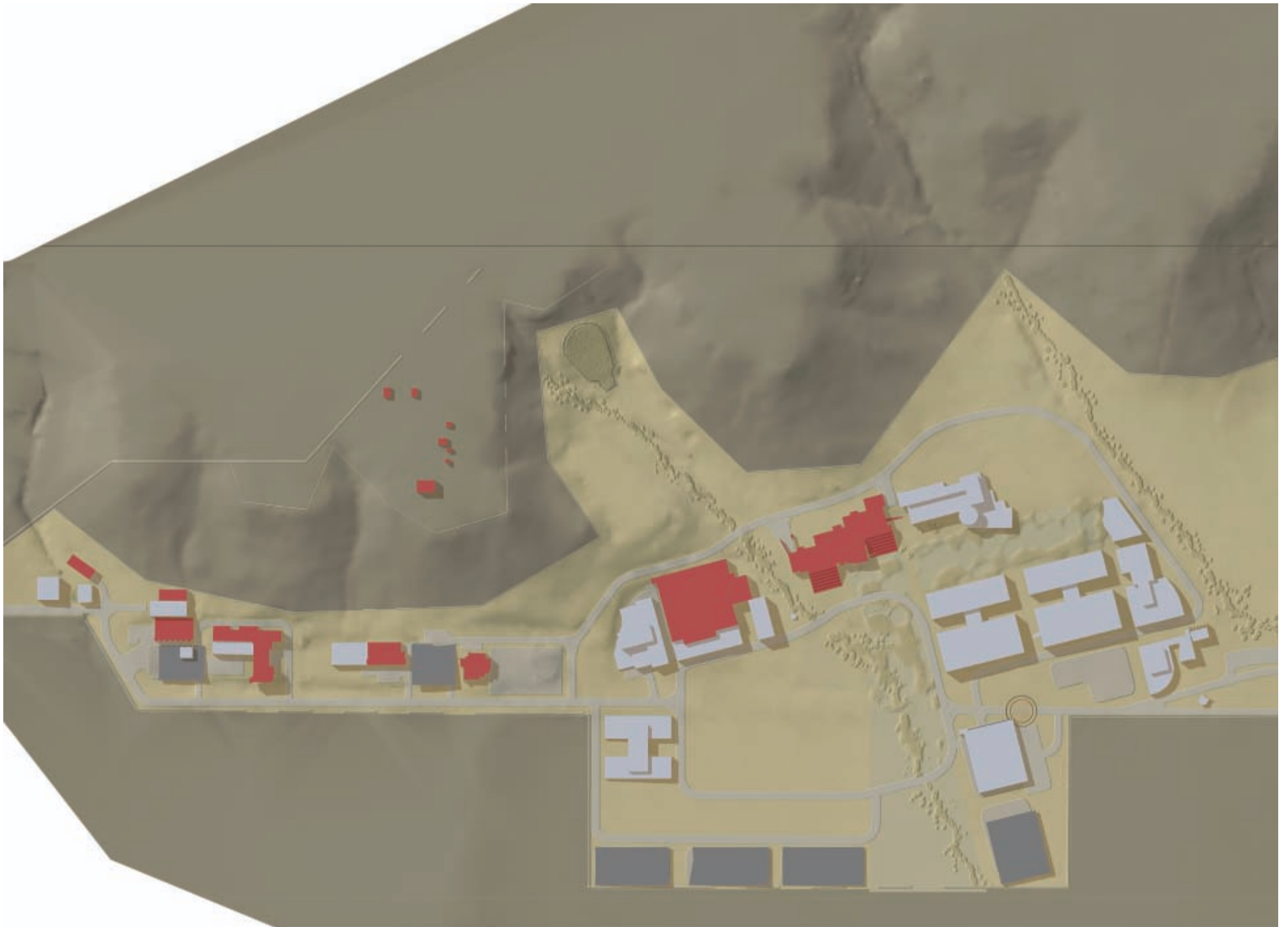


Figure 3-9. Near- to Mid-Term Build-Out

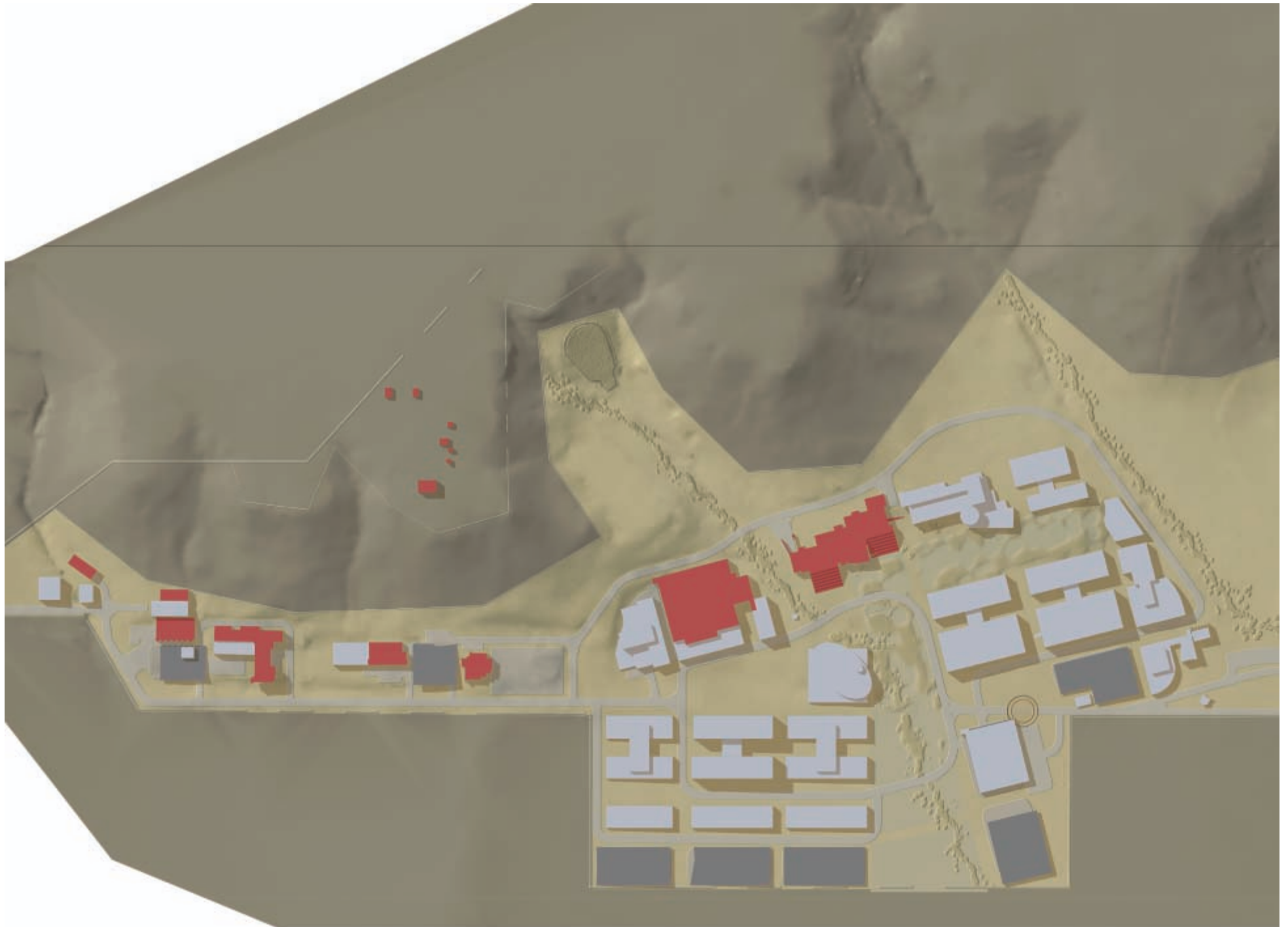


Figure 3-10. Long-Term Build-Out



Chapter 4: National Wind Technology Center Development

4.1 NWTC Site History and Description

The 305-acre National Wind Technology Center site is about 20 miles north of Golden, Colorado, in unimproved, unincorporated Jefferson County, adjacent to DOE's Rocky Flats Environmental Technology Site (RFETS). Most developed land at the NWTC is used for outdoor field tests of wind turbines; direct access to wind from Eldorado Canyon is needed for these tests.

The site is ideally suited for a wind research facility because it is subject to intermittent, extremely high-velocity winds, and the site's wind resource is well characterized. It is not well-suited for wind power production, however, because the wind patterns are not consistent. In addition to R&D in wind energy, the site supports NREL's R&D in hybrid power technologies and distributed energy resources.

The NWTC site was transferred from the Rocky Flats Plant to NREL in 1993. No radiological operations were conducted on this site, and there are no radiological contamination issues. The site is hydrologically upslope and upwind of the RFETS. DOE is the owner of the surface rights of the site; however, the subsurface mineral rights are under private ownership. While the land is basically flat and accessible, currently there are no water, gas, or sewer services.

In 2003, 25 acres from the Rocky Flats Buffer Zone were transferred to the NWTC. The National Defense Authorization Act for FY 2002 authorized the conversion of the RFETS to a wildlife refuge and transfer of the land. This transfer increased the size of the NWTC from 280–305 acres.

4.2 Staff Priorities for the NWTC

A staff workshop was held at the NWTC as part of the planning process. Seven priority items for site planning were raised at the NWTC workshop, as follows:

1. **Make sustainability a focus.** A workshop attendee commented that the NWTC clearly wants to “walk the talk.” One way to do this is to use electric and hybrid vehicles for on-site transportation.
2. **Preserve the beautiful setting.** One of the most important aspects of the site is the setting.
3. **Use life-cycle costs when designing new buildings.** Life-cycle costs should be considered in planning to include operations & maintenance (O&M) costs over an extended period of time. This has not been done in the past.
4. **Extend the connection between the NWTC and the STM site.** We should look for ways to bridge the two campuses and seek a way to share resources. Creating places at the STM site where NWTC staff can work remotely and installing centrally located video connections at both campuses were suggested.
5. **Improve the human environment.** One suggestion was to create some inviting, informal, shaded (and protected from the wind), interactive outdoor spaces.
6. **Improve accessibility.** Suggestions focused on exploring ways to make the site more accessible by alternative modes of transportation.
7. **Improve the site's image.** The NWTC campus is austere. Image improvements will make the campus more inviting to the public and will be welcomed by staff, as well.



PIX10015

Figure 4-1. Experimental Turbine at the NWTC

4.3 External Factors

Two external factors could have an impact on the NWTC site over time. They include—

1. Adjacent mining operations and subsurface mineral rights issues, and
2. The conversion of the RFETS to a wildlife refuge.

The aggregate mining facilities west and southwest of the site are composed of surface excavations, material conveyors, rail lines, and processing facilities. Two companies, TXI and LaFarge, operate on separate but contiguous sites between Highway 93 and the project site's western boundary. Mineral Reserve, Inc.'s aggregate mining operation is located south of the site. A DOE agreement with the mining company for a moratorium on mining was recently nullified by the court. Working with the mining companies so that we both can achieve our objectives will be an ongoing issue.

The second issue, conversion of DOE land to a wildlife refuge, could provide NREL with greater opportunities to increase our visibility and educate the public about renewable energy. There could also be opportunities for shared exhibits or for a visitor or educational center near NWTC property.

4.4 Site Issues and Analysis

In consideration of future uses of the NWTC site, the DOE Wind Program is expected to establish viable research activities supporting the development of large, low-wind-speed turbines for most of the next decade. After that, it is possible that commercial development of wind energy will be transferred to the private sector, except for ongoing incremental research at a significantly reduced funding level for NREL. At the same time, the site's unique testing facilities and staff capabilities will probably be in demand to support the testing, verification, and problem-solving needs of the

U.S. industry, and it is likely that industry funding will replace a large portion of current funding from DOE.

In light of this vision of the future, a major part of the acreage at the NWTC will continue to be reserved for wind research. A relatively small space will be made available for other program activities, such as electrical interconnection research related to distributed generation technologies.

Constraints on the development of this site include the following:

- NREL/DOE does not own the mineral rights under the property, although no significant claims are anticipated.
- There are self-imposed conservation easements, predominantly on the west side of the site.
- The site has no permanent water supply. Negotiations are under way with Xcel Energy to extend a natural gas pipeline into the NWTC site.

Areas are still available at the NWTC for wind equipment. Building sites for future development are also available in various locations between existing facilities and on both the north and south sides of the driveway entrance. Safety zones around the turbines and wind shed boundaries restrict development elsewhere on the site.

4.5 Planned Buildings and Infrastructure Needs

Current Conditions. The NWTC site is partially developed. It houses about 90 staff in 56,086 ft² of space in several small buildings and trailers.

Near- to Mid-Term Buildings. This will include buildings that appear in existing NREL planning documents or that have been discussed internally as needed over the next 10 years, through 2014. These are shown in Table 4-1.

Table 4-1 Near- to Mid-Term Buildings for the NWTC

Facility	R&D Buildings (ft ²) ⁽¹⁾	Occupants (no.)
DER Systems Interconnection Test Laboratory	11,000	10
DER Hybrid Systems Test Laboratory	10,000	10
Blade Preparation Shed	11,000	0
70-m Structural Blade Test Facility	25,000	25
10-MW Dynamometer	12,000	
Addition to Building 251, and renovation of the former switchgear building to house staff ⁽¹⁾	10,000	20
Total	79,000	65

⁽¹⁾ We define administrative buildings as buildings housing administration functions only. Since all staff at the NWTC are performing or supporting R&D, the Building 251 renovations are listed as improvements to an R&D building.

In addition to the proposed buildings listed in Table 4-1, both large and small wind turbine test facilities and infrastructure improvements are planned.

Planned Test Facilities. Turbine test facilities include the installation of up to three megawatt-class turbines and up to 20 additional test sites for smaller machines generating less than 1 MW. Foundations for the megawatt-class turbines could require excavations measuring about 75 ft on each side. These turbines, which will be much larger than turbines currently being tested, will require a spacing of about 2,310 ft and towers more than 400 ft high. Currently, the largest turbine being tested has a tower 140 ft high.

The rotor diameter of the blade on the large new machines is approximately 350 ft, in comparison to 140 ft for the largest turbine currently on the site. A typical turbine test site comprises a turbine, one or more small test buildings to house equipment, and several ancillary towers for meteorological equipment, video equipment, lightning protection, and other items.

In addition, an outdoor test area is planned for DER technology development. The outdoor area will allow field testing of advanced design technologies, including photovoltaics, wind, microturbines, fuel cells, concentrated solar power, energy storage, combined heat and power, modular biomass, and electrical distribution equipment.

Infrastructure. Many improvements are planned for the infrastructure. These include electrical upgrades to accommodate larger research equipment; extending the natural gas line from Highway 93; upgrading and extending telecommunications; upgrading the existing domestic water and sewer system; upgrading the fire protection system; upgrading and modifying on-site roads, parking areas, and the site entrance; and implementing security improvements and modifications.

Long-Term Build-Out. The assumed planning scenario for this effort is that the NWTC is likely to grow from its current staff of 90 to approximately 160 people by 2027. This assumes that all wind R&D staff members, about one-third of the staff members working on distributed energy applications, and about 20% of staff supporting WFO, including industrial participants, would work at the NWTC primarily because of the site's testing facilities.

At this point, the assumption is that one additional mid-sized laboratory building and perhaps a small visitors center will be built beyond the buildings and facilities identified as being part of the near- to mid-term build-out. Table 4-2 lists building needs for the 25-year time frame.

4.6 Master Site Development Strategy

As the NWTC operates primarily as a wind research site, additional building development will be limited to the extreme northern portion of the site because of the safety area and wind fetch required for the turbines. It is possible, however, to expand the buildable area approximately 100 ft south of the existing east/west road that runs through the site. Therefore, the master plan suggests relocating the road to the southern development limit, providing more contiguous land for building development north of the road to the property line. Building site areas are indicated on the plan and are generally clustered in four areas. The site plan is shown in Figure 4-1.

At the east end of the site, there is space for an additional building or buildings just west of the current proposed new road. This is an ideal location for a visitors center depicting the site's research activities and the natural features and wildlife of the area as well as exhibits related to NREL research conducted at South Table Mountain. Currently, a relatively high number of visitors tour the NWTC, so a visitors center would help to raise public awareness about NREL's work and capitalize on the public's interest in this site.

North of the reconfigured road is a site for additional building development. This site is relatively flat up to the existing drainage arroyo. Because of the high exposure and intense winds of the site, it would be preferable to have the buildings surround parking and open space areas to help protect pedestrians.

The area now surrounding Building 251 is another opportunity for facilities development. New buildings could shelter parking areas and open space from the predominantly northwest winds there, as well. This development could become the administrative core of the campus, expanding on uses within Building 251.

Table 4-2. Summary of NWTC Build-Out by Time Frame

	Lab. Staff (no.)	Lab. Space (ft ²)
Existing	90	56,086
Near- to Mid-Term Build-Out	65	79,000
Long-Term Build-Out	5	15,000
Ultimate Build-Out	160	150,086

Continuing west is the site for the proposed Multimegawatt Test Facilities, which include the Blade Testing Facility and the Dynamometer Building. Further west is an open area just north of Building 254. This area is planned for expansion of distributed power generation research activities, either in outdoor test areas or in enclosed facilities.

West of Row 1 is a conservation management area that should remain undeveloped, because it is located in the wind fetch for the turbines. The 25 acres added onto the southeast side of the property will provide the NWTC with space to test the next generation of megawatt-class turbines.



Figure 4-2. NWTC 25-Year General Development Vision



Chapter 5: STM Site Issues and Analysis

Several issues concerning the STM site were studied and analyzed in depth as the General Development Vision evolved: transportation and parking, density, image, security, the energy design strategy, and sustainable design practices. Below is a description of each issue.

5.1 Transportation and Parking Issues

Parking is a major factor in determining land use for the STM site at full build-out. If we assume the full site population of 2500 people, and each person has a car, 20 acres of the site would be required for surface parking for all the cars. However, a means of alternative transportation will have to be established if on-site parking is limited.

The cost of providing parking was estimated to range from \$1,000 to \$2,000 per space for surface parking; \$10,000 per space for above-ground parking; \$15,000 per space for the first level of underground parking; and \$20,000 per space for each additional level of underground parking.

During the design process, the working group evaluated three primary parking schemes: dispersing the parking areas throughout the site, consolidating most of the parking in one location on the edge of the site, and intercepting cars before they reach the site. These alternatives are shown in Figures 5-1, 5-2 and 5-3.

Intercepting the cars outside the site would make the campus almost car-free, much like most university campuses. Campus transportation could then be handled through a shuttle system and well-developed pedestrian linkages. Although this is the most environmentally sensitive solution, it sacrifices a certain amount of employee convenience. In addition, a site for the parking facility would have to be developed with an outside land owner, complicating implementation.

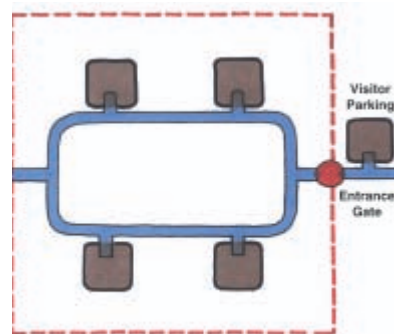


Figure 5-1.
Distributed Parking

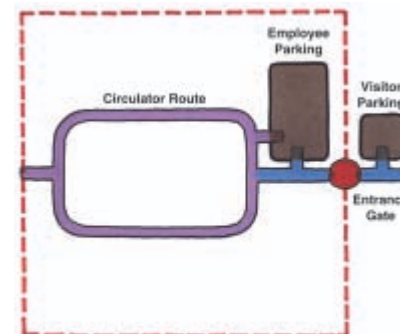


Figure 5-2.
Internal Intercept Parking

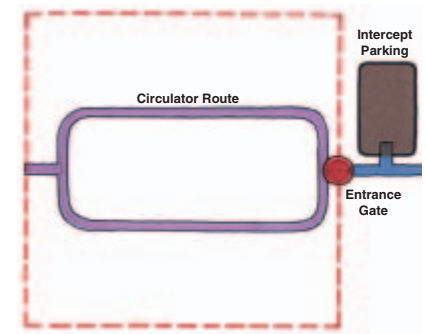


Figure 5-3.
External Intercept Parking

Consolidating parking within the site captures many of the first option's benefits, including the creation of a more pedestrian-friendly environment. A shuttle would be required to transport employees and visitors from the parking areas to the facilities around the site. By locating the parking reservoirs on site, NREL could control the timing and character of the parking development.

Parking lots at the site are currently dispersed and located next to the buildings they serve. This alternative could be the model for future parking development as well. Although it is convenient, allowing vehicle traffic throughout the campus runs counter to the creation of a pedestrian-friendly place. It also increases the potential for pedestrian-vehicle conflicts. Dispersed parking (and thus more on-site driving) is inconsistent with the goal of encouraging sustainable development on campus, and it consumes natural resources unnecessarily.

Two primary traffic circulation schemes were also evaluated in the site design process (see the diagrams in Figures 5-4 and 5-5). The first is a combination service road and circulator road. This alternative puts service vehicles and employee/visitor circulation on the same road. The roadway network is efficient, but it could become congested as service vehicles and shuttle/employee vehicles try to access the same system.

The second circulation scheme is a split roadway system. Separating service and shuttle routes can eliminate conflicts. In addition, the shuttle route can then be used as a pedestrian pathway without concern about service vehicles.

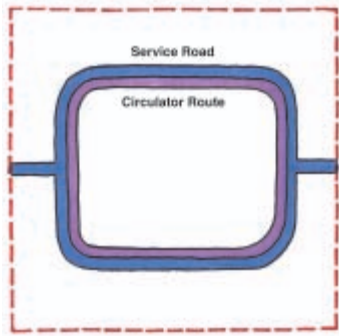


Figure 5-4. Combined Roadway System

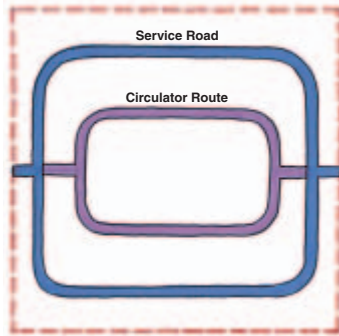


Figure 5-5. Two-Loop Roadway System

Either laboratories or offices could be located on each development pad. One pad could support three office module footprints, each having 15,000 ft² of space and multiple stories. A single development pad could thus accommodate either three office modules, two lab modules and one office module, or one lab module and two office modules. The modules could be stand-alone buildings or, preferably, connected buildings. The proposed land-use plan (see Chapter 3) is based on this module approach. Three office modules—each one four stories high—on one development pad could accommodate about 480 staff members in 180,000 ft². At three stories, the modules could accommodate 360 staff members in 135,000 ft². Each development pad could be built as one or more buildings or phases.

Because NREL staff highly value the open space on our site, the plan includes large pockets of pleasant (rather than harsh) outdoor spaces designed for people, and including sufficient shelter from the elements. At full build-out, the plan includes 62% of outdoor space throughout the area suitable for development. The open space plan is described in Chapter 3, Section 3.4.

5.3 Image

A staff priority in the master planning process is to enhance NREL's visibility with the public. Greater visibility could help NREL achieve its mission by increasing the public's awareness of who we are and how we add value to the community, building and strengthening community relationships. Greater visibility also fosters partnerships

5.2 Density

Density is a contentious issue. On the one hand, because NREL receives most of its funding in small increments, only small facilities have been built on the STM site in recent years. However, continuing to build in this manner will result in a sprawling campus as well as inefficient use of land and other resources. This will not achieve the cohesive sense of place desired by the staff. It is also not consistent with our goal of creating a sustainable, pedestrian-friendly campus.

On the other hand, although taller buildings and more dense development result in smaller building footprints and less impact on the land, tall buildings cost more to build. In order to balance these competing issues, we propose the use of "development pads," the largest measuring 300 ft x 300 ft, which will allow for more compact and modular yet flexible development. Development pads allow NREL to lay the site out in a grid. They provide flexibility by allowing more building as money is available and adding modules over time. And they would bring some uniformity to the campus. The key is to reach agreement on the design of a standard building module for labs and offices.

For planning purposes only, office module dimensions were set at 300 ft long by 50 ft wide, to meet the requirement that all such space will be 100% daylit. Lab modules were assumed to have a slightly different shape but to still fit on a 300 ft x 300 ft pad. A standard lab module was assumed to be about 86 ft wide (shown at approximately 100 ft) and configured in a manner similar to that of the SERF, which features a pedestrian corridor adjacent to the long axis of a lab, a service corridor, another lab section, and a second pedestrian corridor. A development pad for a lab—assuming two lab modules, one building module, and a height of three stories—would accommodate 185 staff members in 185,400 ft² (see Figure 5-6)

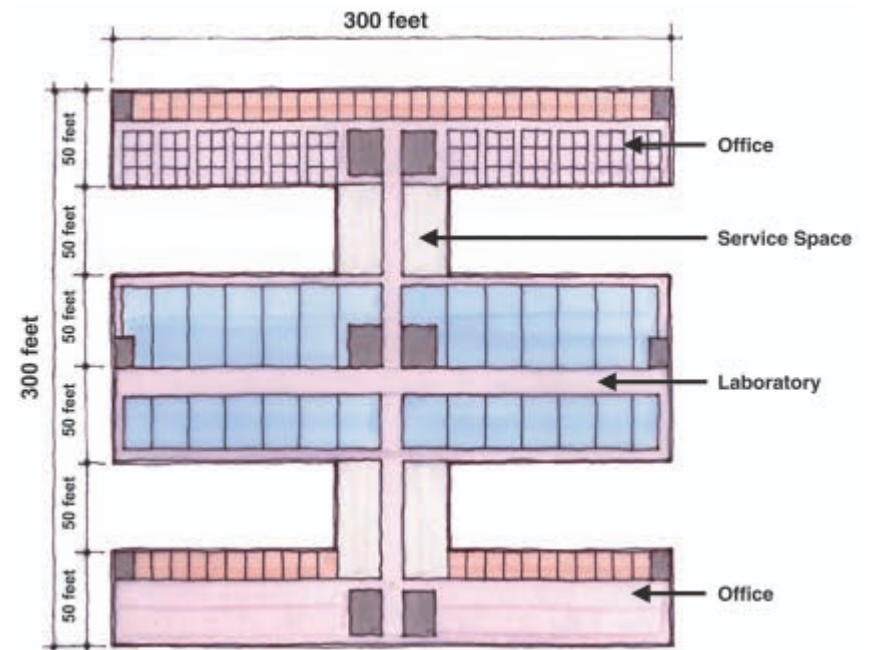


Figure 5-6. Development Pad

with other organizations and companies having similar objectives. This could help to diversify our funding base and reduce the vulnerability caused by single-source funding. However, it will be a challenge to integrate this goal with current goals for heightened site security.

The plan incorporates several ideas to strengthen NREL's relationship with the public, including—

- Added meeting and conference space serving the Visitors Center. The current Visitors Center receives about 12,000 visitors per year.
- East Campus buildings constructed around the east quadrangle. Ways to use a this quadrangle to enhance the interpretive experiences of escorted visitors are explained in Chapter 3, Section 3.3.

The east quadrangle will incorporate human-scale uses of renewable energy technologies, such as using PV panels on canopy entrances to buildings or as shading elements for walkways; small demonstrations of wind power and other technologies; interactive solar displays; signage describing sustainable practices on our campus; and wind blades or other historical artifacts from the past incorporated into a contemporary sculpture.

An enhanced image and stronger relationships with the community would allow NREL to serve as more of a catalyst or “economic development engine” that spurs greater local business development in the field of renewable energy.

5.4 Security

The future of security at NREL is highly dependent on national security policy. Because NREL is part of the DOE national laboratory system, the NREL site must respond to the levels of security precautions mandated by the U.S. Department of Homeland Security.

Two levels of security are envisioned for the STM site. The lowest level will be for areas accessible to the public, and

will most likely be limited to the expanded Visitors Center, conference center, and NREL Museum. This level requires signing in and receiving a badge, but an NREL escort is not required. The relocated Shipping and Receiving building will have an entry outside the badge access zone for pickups and deliveries. The next level will be badge access for staff, escorted visitors, and tour groups.

To balance the need for public visibility with the need for increased security, we propose that the east quadrangle be part of the site tour. These areas will allow escorted visitors to go beyond the Visitors Center and into the main part of the campus. As mentioned earlier, these will be areas in which escorted visitors can see and interact with exciting displays of renewable energy technologies.

NREL Security managers recommend that the perimeter of the entire NREL site be fenced. The fence does not need to be highly visible, but it should follow the property line. There should also be signs on the fence displaying regulations pertaining to access to the property.

They also recommend that vehicle barriers be placed at the entrances to new buildings. In addition, parking areas should be at least 90 ft from front entrances. And areas of possible concealment, such as shrubbery beds, should not be right next to a building.

Currently, access to the STM through the west gate is limited to those who use the Mesa Top facility and emergency vehicles. If more use is anticipated, the gate should include a manned security station. In fact, any new vehicular site entrance will need to be equipped with a manned security station.

5.5 Energy Design Strategy

Our energy strategy for the NREL campus is as follows: conserve first, use renewable energy on site, and buy green power.

Conserve First. Energy conservation is the most cost-effective way to reduce energy use. All new buildings on the NREL campus will be designed to be at least 30% more energy efficient than Federal standards require. They will also be designed to achieve at least a silver rating under the U.S. Green Buildings Council's “Leadership in Energy and Environmental Design” (LEED) rating system, and the goal will be to achieve a gold or platinum rating.

One way to promote energy efficiency through building design is to ensure that all new office buildings are 100% daylight. In the General Development Plan, building footprints reflect natural daylighting principles. A 30- to 40-ft-wide building section is an ideal depth for daylighting, and the long sides of the buildings are the north and south elevations. All the buildings will be designed to take advantage of natural lighting, so that electric lighting systems can be dimmed or turned off during the day.

Use Renewable Energy on Site. We will incorporate renewable energy technologies on our campus for demonstration and displays and to meet power needs, where appropriate. Alternatively fueled vehicles should be the norm for shuttling people on site. And photovoltaics and solar thermal systems will be incorporated into buildings both for demonstration purposes and to meet certain power needs. Power-generating systems can be located primarily on roofs.

Site planning should emphasize a strong pedestrian environment. The site could be a demonstration of sustainable design, with interpretive areas featuring sustainable techniques such as storm-water management, low-water-using landscaping, and similar features. Pedestrian walkways could include photovoltaic sunshades, not only to protect pedestrians from the elements but also to provide an interpretive example of solar energy R&D.

Hydrogen research and applications are becoming a more prominent and visible part of the NREL mission. As such, the General Development Plan should include space for a

hydrogen fueling station that could be used in application research as well as for fueling an on-site vehicle fleet. Hydrogen could also be used to power the first administration building. Developing a central hydrogen energy plant on site could be considered for a later phase of development.

Buy Green Power. In 2003, 10% of the power NREL has been purchasing is generated from renewable sources (“green power”). Our goal is to purchase sufficient green power from our local utility to supplement on-site renewable energy generation. Thus, renewable resources could be meeting 100% of NREL’s energy requirements by 2025-2030.

5.6 Sustainable Design Practices

Sustainable design is a key element of this plan. As part of our overall site planning goals, assumptions, and strategies (see also Appendix A), we established sustainable design strategies for drainage and water, site circulation, parking, and building design, as noted earlier in this chapter. This plan is consistent with the goals of the Sustainable NREL program.



Chapter 6: STM External Issues

6.1 Key Assumptions and Drivers

Many things could happen in the next 20 years that would make NREL look quite different from our vision of the Laboratory and its campus. Possible events include an unforeseen expansion or contraction of NREL's role as a national laboratory, a fundamental shift in the global balance of power, obsolescence of the internal combustion engine, and many more. Nevertheless, to formulate a development plan, we must proceed on the basis of our best current estimates and assumptions.

We made these two key assumptions about the future:

1. There will be a future, and NREL will have a role in it. Although many of the technologies NREL is working on today will probably become well-established in the marketplace over the next 25 years, we believe that NREL will continue to develop and manage an R&D portfolio that emphasizes renewable energy and energy efficiency.
2. Technology will continue to evolve much faster than people will evolve. Twenty years from now, computers will no doubt look and function much differently than they do today. People, on the other hand, will still walk upright, breathe air, consume food and water, and require sleep. So, while the rapid evolution of technology will bring about new ways of doing science and create different expectations about work, the rate of change will be tempered by human requirements for things like social interaction at the water cooler, hands-on experimentation in the lab, or even the ability to stand up from your desk and immediately take a walk outside.

Part of this chapter is reactive, i.e., it describes external factors that will shape our future. Part of it is proactive, i.e., it reflects our desire to see the Laboratory move to a more

sustainable, people-centered campus that reflects and enhances our mission of renewable energy and energy efficiency research and development.

External factors that we believe will impact NREL's growth and development over the next 25 years include global issues, neighborhood issues that will change NREL's physical surroundings over time, and workplace issues caused by changes in technology and in the patterns and processes of research.

Four key drivers could shape those environments:

1. **Geopolitical drivers**—the mix of developed and developing countries and their desire or need for energy, as well as the relative stability (or instability) of the world order
2. **Public policy drivers**—the relative importance of the Laboratory and its mission among national priorities, as well as expectations about renewable energy and energy efficiency as viable alternatives to traditional sources of energy
3. **Growth drivers**—the impact of more people, roads, vehicles, homes, and businesses on our campus
4. **Technology drivers**—how technology will change the way we work, what we work on, and how we think of work.

For site planning, we looked at the drivers from the standpoint of how they would affect the layout of the campus. Geopolitical and public policy drivers were

thought to have great potential to impact the role of the Laboratory, and they help to answer the questions, "Will there be an NREL in the future, and if so, what will its role be?" Growth-related drivers were discussed more with regard to the surrounding environment, e.g., traffic around the site(s), population densities, expectations of local neighborhoods, and so on. The discussion of technology drivers was more focused on their impact on the way people will work and "do science." In other words, technology will have a social and cultural impact as well as a scientific and technological impact.

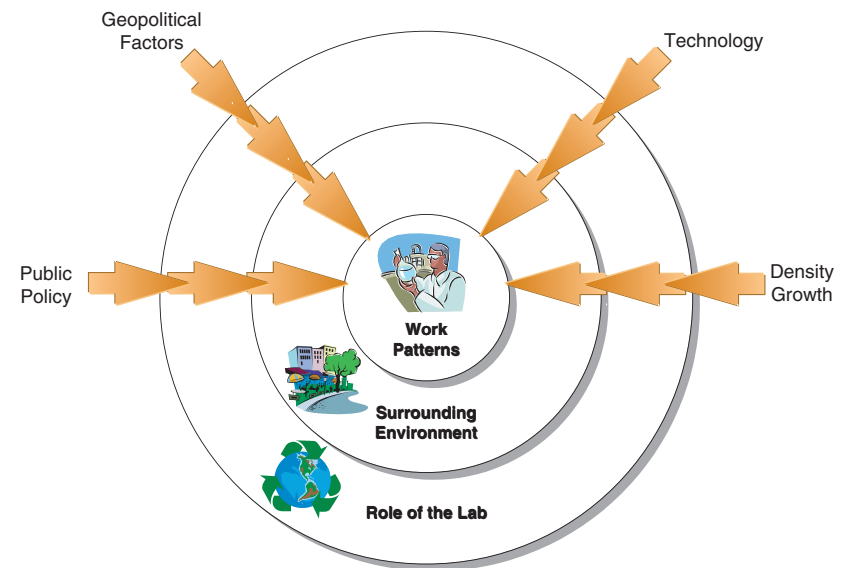


Figure 6-1. Diagram of Environments and Drivers

6.2 Global and National Issues

Drivers that will accelerate the demand for energy in general and renewable energy in particular include these:

- Developing countries will increase the global demand for energy
- Energy independence will be accepted as part of national policy

- Conflicts in other parts of the globe may lead to increases in the cost of conventional fuels.

Public policy factors that will result in greater interest in renewable energy and in the role and mission of NREL include these:

- Increasing desire for clean energy
- New breakthroughs in renewable energy research

- The level of Federal funding available for renewable energy research and NREL's role.

6.3 Neighborhood Issues

The South Table Mountain site is currently in unincorporated Jefferson County. The site is also included in the planning districts of two nearby cities: Lakewood and Golden. Although the federal government is not constitutionally obligated to follow local planning, zoning, and other rules, the Laboratory strives to work with the community and honor its desires wherever possible. As mentioned in Chapter 3, NREL's STM site is surrounded by a wide variety of neighbors to the south, east, and west. To the south and west of the STM site is the community of Pleasant View, a small, unincorporated area of Jefferson County. Homes back up to NREL's fence on the south. Also on the west, the lower part of STM abuts property owned by the State of Colorado and leased by the U.S. Fish & Wildlife Service. Just west of the Mesa Top is undeveloped property owned by the Coors family, who also own the Coors Brewing Company. To the east of the site is the Denver West Office Park, which includes numerous office buildings and an apartment complex owned by Denver West Property Management.

During the site planning process, we met with representatives of many of our neighbors and looked for opportunities to partner with them to achieve shared objectives. We spoke with representatives of the following organizations:

- The Pleasant View community
- Denver West Property Management
- Jefferson County Planning Department
- Jefferson Economic Council
- Jefferson County Open Space
- City of Lakewood
- City of Golden



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Figure 6-2. Aerial view of the Outdoor Test Facility (OTF), Thermal Test Facility (TTF), and Alternative Fuel Users Facility (AFUF) in the West Campus.

- The Regional Transportation District (RTD)
- Colorado School of Mines

Our discussions with these groups are described in Appendix D.

During the planning process, we discussed several ideas for further exploration that would involve collaboration and working together with our neighbors.

- **Access to our site.** As the population of our site continues to grow, developing multiple ways to access the site will become more important. These options were described in detail in Chapter 3, Section 3.2.
- **Off-site parking.** A key goal for this document is to reduce the parking ratio on our campus. In Chapter 3, Section 3.2, we recommend planning to accommodate 1500 cars as well as continuing to explore options for reducing this number. Off-site parking is one option.
- **Technology enterprise zone.** Several other DOE National Laboratories have worked with their local and state governments to create technology enterprise zones near their campuses. These are areas in which local governments encourage businesses and industrial partners to co-locate to take advantage of the personnel and equipment resources of the Laboratory. Others in the locality also benefit from the economic development created by the National Laboratory. This would also provide NREL with a way to advance the commercialization of renewable energy technologies.

6.4 Work Patterns

Changes in technology can be anticipated that will alter the way we work and influence the types of facilities that we work in. These will also reinforce the need for flexibility in the design of our buildings and facilities. We will need to be able to respond quickly to change to meet the future needs of the Laboratory.

In the field of research and development, computational science is emerging as the “third leg of science,” a complement to theoretical and applied science. What this could mean for NREL is that less space will be needed for wet and dry labs, and more space will be needed for computer labs, in comparison to the configurations of our facilities today. This might also reduce the amount of space needed for chemical storage and fume hoods, as more and more experiments are done “virtually” via computers. And it could translate into a need for more computer bandwidth and more computer storage space.

Another trend could be increasing online collaboration with remote partners. This could allow people to participate in meetings from separate rooms. Networks for experiments will be “always on, always connected.” These trends have important implications for how we plan future office, lab, and meeting space.

In terms of non-lab functions, as our ability to connect remotely and telecommute increases, staff will be represented by a mix of on-site and off-site employees. Employees will be working at all hours of the day and night, based on their needs, so 24-hour access 7 days per week will be necessary. With increasing needs for security, “smart badges” may also become prevalent. Smart badges could enable dynamic access control, authentication as to owner, and other features.

All these trends will have an impact on office space. There will be a greater need for shared, temporary, and reconfigurable space. This will, in turn, have an impact on phone numbers, computer information, and workspace ergonomics and require increased security and biometric authentication techniques. Because advances in technology will change the way we work and do science, our long-range vision should take the following into consideration:

- Ensure ready access to wiring so that we can plan for and enable easy “replumbing” of our information technology

infrastructure every 5–7 years (e.g., voice and data networks).

- Assume and plan for two types of networks: a ubiquitous wireless network that supports a high degree of accessibility (always on, always connected), and an “industrial-strength” wired network that supports increased security requirements and facilitates the rapid movement of large amounts of data. It also includes planning for data storage and some degree of backup or redundant systems.
- Plan for a wireless infrastructure (access points) connected to the wired infrastructure. Important considerations are how to design the fabric so that it has seamless coverage and the ability to heal itself.
- Increase the use of reconfigurable space. Larger spaces with movable walls that can be reconfigured into smaller rooms (e.g., training rooms, conference rooms, and visitor demonstrations) will provide greater flexibility.
- Enable people to become more mobile on site. With the prevalence of wireless networks and the use of remote wired connections to the NREL computer system, people will be less and less tied to conventional office space. Therefore, even though we are planning offices and labs today using a constant ratio of space per person, the amount of space needed per person will most likely go down. Physical labs will still require proximity to offices, however, but more labs will be controlled and accessed remotely.
- Plan for greater security (both physical and cybersecurity) over time that will be visible at the edges and transparent in the middle. We assume that all access to buildings will be monitored, and security will be integrated among various buildings and local agencies. Our planning challenge is to balance security with openness and accessibility.

- Support round-the-clock access to NREL. Access to food and showers on site would thus be desirable amenities.
- Understand that “the best science happens in the cafeteria.” Throughout the planning process, this is a concept that we heard repeatedly; it is important to enhance ad hoc collaborations. Many staff members advocate the idea of a kind of “student union” on campus. This would provide the kind of informal interactions at the heart of the campus in which novel ideas can emerge. Casual, informal meeting spaces throughout our buildings are also desired.
- Recognize the importance of our neighbors. There are many opportunities to partner with others in businesses that could support NREL, such as food service on or near the campus, a day care center, and visitor housing that incorporates sustainable technologies. In communities surrounding other national laboratories, local jurisdictions have partnered with the private sector to create opportunities to commercialize technologies developed at the labs in “technology enterprise zones.” A technology enterprise zone could spawn private-sector growth in energy-related businesses, industries, and research that will support NREL’s mission. In this way, NREL could become a major force for economic development in the community, and DOE and NREL could reap the benefits of greater private-sector commercialization of our technologies.



Chapter 7: Next Steps

The 25-Year General Development Vision should be a working document that provides a road map for future facility development. Often, however, master planning documents cease to have application after they are published, and the planners' vision and aspirations end up collecting dust on a shelf. Therefore, it is important to suggest some immediate steps to take after publication that will further the goals outlined in this document. Although they are not all-inclusive, here are six significant steps we can take now to reach our eventual goal.

1. Develop design guidelines.

The General Development Vision provides an overall framework for future development, helping to guide decisions on building placement and overall infrastructure construction. But the actual character of the development—such as landscape design, pedestrian walkway design, and building architecture—is not defined by the plan. To fully realize the vision of a sustainable, human-scale, walkable campus, more definition is needed.

Design guidelines can define landscape materials and application, pedestrian and vehicular paving design, site furnishings and amenities, parking lot design, lighting, signage, and graphics. In addition, building architecture can be defined in terms of orientation, site interface, building materials, massing, and so on to ensure compatibility with sustainable design practices and the overall site master plan. A key aspect of the design guidelines is establishing a standard set of building modules so that space needs can be optimally met.

Action plan:

- Review NREL's existing design guidelines and standards for site and architecture and development of new guidelines, as appropriate.

2. Develop the Near- and Mid-Term infrastructure.

Much of the infrastructure can be developed as specific building projects are implemented. However, some capital projects should be started independently. More detailed plans need to be developed for such projects as the internal loop road, pedestrian pathways to help connect various parts of the campus, and drainage improvements throughout the campus. A full utility plan and implementation steps need to be developed.

Landscape improvements could be put in place in early phases of development so they would reach maturity before later development phases. Parts of the roadway system should be constructed to establish service and circulator system patterns in anticipation of development when it occurs. Some parking lots may need to be built to begin the transition to a different transportation system. This task would involve working closely with NREL's Site Operations Office.

Action plan:

- Define a roadmap of infrastructure development projects.
- Create an implementation strategy for design and construction.

3. Optimize the location of functions.

Many detailed items require further study to determine their optimal location on our campus. These include the need for

centralized or distributed locations for functions such as machine shops and the stockroom, the location of the physical library, and the number and location of additional chemical storage facilities. Further study will also help in planning proximate locations for researchers who need similar labs or equipment.

Action plan:

- Continue to integrate physical planning with NREL strategic planning.

4. Develop a new transportation and parking culture.

The 25-Year General Development Vision suggests a reduction in the parking ratio over time. Current on-site campus parking provides approximately one parking space per employee. The Vision represents parking that provides one space for every two employees. This reduction in the ratio has to be accompanied by incentives and alternatives to encourage employees to leave their cars at home. To begin this effort, policies need to be formulated that address this goal.

Several ideas have been postulated within the body of the plan. These ideas and other incentives have to be explored and policies implemented to reduce the need for personal automobiles on campus. In addition, ideas should be explored concerning the types of vehicles to use on the shuttle loop. Bicycles, golf carts, vans, and hydrogen-powered buses have been suggested, along with other types of vehicles.

Action plan:

- Develop transportation and parking alternatives with implementation strategies.

- Examine potential NREL policies and incentives to support alternatives to the personal automobile as a commuter vehicle.

5. Develop programs for non-research facilities.

The 25-Year General Development Vision identifies several buildings that are non-research-oriented. These include administration buildings, an expansion to the Visitors Center to include conferencing facilities, shipping and receiving, and the Campus Commons building. Many if not all of these projects may be candidates for third-party financing development. As such, the buildings will require further definition before a third-party private developer can assess their feasibility for development.

The first step in definition is to create programs for the various facilities, specifying overall size, space requirements, and staff capacity. The programs can then be used to define square footage and costs and to create a financing strategy for constructing the buildings.

Action plan:

- Define buildings to be programmed.
- Prepare facilities programs for the buildings.

6. Continue to participate in ongoing off-site development planning.

NREL's site is situated in an area of metropolitan Denver that is undergoing a transformation. The recent opening of Colorado Mills, a major regional shopping center, has invigorated development in the Denver West area, and more redevelopment is likely to occur. The Regional Transportation District (RTD) has completed an Environmental Impact Study for a light rail line that will run just south of the site, roughly along the U.S. Highway 6 corridor to the Jefferson County government center. As plans for the light rail line

move forward, transit-oriented development plans are also being formulated in nearby areas, such as the Denver Federal Center. If NREL's projections for growth over the next 25 years come to fruition, NREL itself will be a major economic generator not only in Lakewood, Golden, and Jefferson County but in the entire state, as well. In addition to the potential growth, NREL has budding partnership opportunities with institutions such as the Colorado School of Mines that involve education as well as joint development.

Jefferson County, in cooperation with Golden and Lakewood, is currently undertaking an urban planning study of the west metro area, including the NREL site. The planning area contains a wide mix of existing uses, ranging from government installations like NREL to office, retail, industrial, residential, and open space. In particular, just south of the NREL site is Camp George West, an area controlled by the state. This area has direct frontage along the highly visible Interstate 70 corridor. The area presents a potential opportunity for private redevelopment with industries and research companies in concert with NREL's mission.

Action plan:

- Monitor and participate in the Jefferson County and RTD planning process for the Denver West area as a significant stakeholder in the region.



Appendix A: Goals, Values, and Strategies

As an organization we want to “walk the talk” to inspire world interest in renewable energy and energy efficiency (RE/EE) technologies, demonstrate sustainable design, and be a model for environmental stewardship. A cohesive and pedestrian-friendly campus, with predominantly low-rise buildings (less than four stories), possibly some mixed-use development, consolidated parking and preserved and enhanced open space could be an ideal reflection of NREL’s commitment to sustainability. To reach this conclusion, the site planning participants relied on a set of planning goals, assumption and strategies, as shown below.

What are the expectations for the outcome of the site planning process?

- Present a single, unified NREL vision for the future of our sites that captures people’s imagination.
- Demonstrate vision, innovation, and leadership for the Laboratory’s direction for the next 25 years.
- Reflect and communicate the values of our organization:
 - 1) Excellence in R&D for science and technology development, and
 - 2) Sustainability in our operations: minimal environmental impact, maximum cost-effectiveness, and beneficial impacts on our staff and neighbors.
- Ensure linkage between future mission requirements, site usage, and appropriate physical facilities.
- Strengthen NREL’s capital budget rationale by defining an overall context for individual buildings and facilities ⁽¹⁾.
- Create a campus environment that enhances staff productivity and attracts top performers.

- Inform future environmental assessments.
- Strike a balance between potentially conflicting design values, and encourage collaboration and discussion between NREL Directorates, staff, and other stakeholders.

What are the assumptions about NREL as an organization that influence our planning?

1. Over the next 25 years, our mission will be to develop renewable energy and energy efficiency technologies and practices, advance related science and engineering, and transfer knowledge and innovations to address the nation’s energy and environmental goals.
2. The STM site will continue to support biological, chemical, physics, and multi-disciplinary scientific and engineering R&D similarly to the way it does today, although the specific programs are likely to change in response to successful completion of some mission elements, new opportunities, and federal direction.
3. The NWTC will continue to support scientific and engineering R&D for wind, DER, and similar programs.
4. Staff work patterns will change as a result of telecommuting and job sharing, increased physical and cyber security, and significant evolution in communication technologies and information systems.
5. Because we value social interaction and believe that teamwork leads to innovation, over the next 25 years all NREL staff who work on site will be accommodated with adequate space on DOE property, without the use of remote (non-adjacent) leased space.
6. The numbers of students and subcontractors on site will stay in about the same proportion to NREL payroll staff

- as in 2002. The industry partners on site will remain proportional to the total work-for-others efforts projected.
- 7. Estimates indicate that our population (occupants needing a dedicated office or cubicle) will grow in the range of 3% to 5% per year, subject to such trends as telecommuting, sabbaticals and visitors, and other changes. Compared with our July 2002 occupancy, a 3% growth rate means a population of approximately 1,600 in 10 years, and 2,500 in 25 years at the STM site. For the NWTC, the population is projected to increase from the current population of 90 to 160 over the next 25 years.
- 8. The percentage of NREL’s funding coming from work for others will grow over time.

What are the goals of the site plan?

1. Provide maximum capability to support excellence in state-of-the-art R&D, including efficient administrative services.
2. Support safe, healthy, efficient, and secure operations while minimizing the visibility of security measures to maintain a campus atmosphere consistent with NREL’s image.
3. Demonstrate the best principles of sustainable site development, buildings and structures, and laboratory operations.
4. Clearly convey NREL’s image of excellence in R&D and sustainability.
5. Maintain positive relations with immediate neighbors, and take advantage of mutually beneficial relationships and projects with metropolitan and regional neighbors.

What are some strategies and options for addressing goals?

1. Provide maximum support for excellence in state-of-the-art R&D, including efficient administrative services.

- Provide for an appropriate mixture of large R&D buildings (>100,000 sf), smaller R&D buildings (10,000 – 90,000 sf), specialized smaller buildings (<10,000 sf), and adequate outdoor test space.
- For the purpose of master site planning, provide facilities on the STM and NWTC sites to accommodate all future staff, including those housed in Denver West (DW) buildings 15, 16, 17, and 27, as well as adequate meeting and conference space (2).
- Plan for a generally modular or incremental approach to building out the site.
- Design flexibility into all building and outdoor test facilities to meet changing needs or functions in labs and expandability to meet increases in lab requirements.
- Provide exterior shaded nodes, walkways, patios, for casual staff interactions, transitions from inside to outside, and to encourage interaction between people from different parts of the organization.
- Plan to accommodate staff that primarily telecommutes to work with shared or non-assigned workstations and work areas, needing less space per person than current standards (3).

2. Demonstrate the best principles of sustainable site development, buildings and structures, and laboratory operations.

Strategies for a sustainable site:

- Meet or exceed environmental regulations (4).

- Clearly document conservation management areas and follow development guidelines for these locations.
- Minimize soil disturbance.
- Integrate the design of buildings adjacent to the mesa with the slope.
- Minimize footprint of buildings over 10,000 sf by designing them to be at least two stories high wherever possible.
- Develop an appropriate recycling center for items to be commercially recycled off site (5).
- Develop appropriate areas for storing R&D materials and equipment (piping, tanks, etc) that could legitimately be reused at the Lab in the future (i.e., shield from public view, protect storm water from contamination by the materials, etc).
- Re-establish vegetation in disturbed areas.
- Evaluate site planning options using both life cycle costing and some level of life-cycle assessment, which would include some costs that are traditionally difficult to quantify such as environmental impact, impact on worker retention and productivity, and community impacts.

Drainage/water:

- Maintain existing surface drainage patterns wherever possible.
- Harvest rainwater/storm water and gray water for landscape plants selectively located to humanize building entrances and outdoor gathering spaces, in compliance with local codes.
- Provide landscaping throughout the site that is xeriscaped and appropriate for the climate and site conditions with minimal watering while providing shading and human comfort (6).

Site circulation:

- Design the site to maximize walking, bicycling, (including appropriate storage lockers/racks) and use of alternative vehicles on campus.
- Develop a vehicular circulation system on our sites to offer a pattern of connectivity (e.g., a primary and secondary road system) rather than just one major road, and consider options in site analysis that involve curving the main entrance road to create a more pleasing sense of campus and support the use of pedestrian, bicycle and small, low-energy on-site vehicles.
- Provide/develop electric vehicle charging and alternative fuel filling stations (for government-owned vehicles) on our sites.
- Develop a pedestrian circulation system on our site for connecting all facilities and to provide access to recreational trails.

Parking:

- Develop creative parking solutions (such as locating a significant fraction of the parking at the periphery of the site, using a parking garage, parking under buildings, and/or shared parking with neighbors, and/or consolidating parking facilities). This will strengthen our image, reduce the visibility of parking, improve sustainability by minimizing run off, and seek win-win solutions with neighbors.
- If allowed at all, consider preferential parking near buildings for alternative vehicles.

Strategies for sustainable building design:

- Design all new buildings on our campus to be at a minimum of 30% more energy efficient than the Federal standard 10 CFR 435 as per NREL guidelines (dated April 2002) (7).

- Design daylighting systems in all new buildings to control the amount of natural light into a building permitting artificial lights to dimmed or turned off during the day.
- Design all new buildings on our campus to achieve a minimum of a silver rating using the Leadership in Energy and Environmental Design (LEED) rating system developed by USGBC.
- Purchase green power and install on-site renewable energy generation to contribute 100% of NREL's energy requirements at both the STM and NWTC sites in the 2025-2030 time frame or earlier if feasible. On-site renewable applications at STM will be primarily building integrated. The potential application of greater use of on-site renewable energy systems at NWTC will be analyzed under the Sustainable NREL program in order to determine a near term percentage goal for on-site renewable energy at NWTC.
- Use materials in building construction that will support wireless computer technology in the future, and wire all new buildings for smart controls so that devices can be turned off when no occupants are around.
- All new building designs will include site and major process load metering and energy management control systems.

3. Clearly convey NREL's image of excellence in R&D and sustainability.

- Develop a unique campus appearance and image that will be cohesive and will help to attract world-class researchers.
- Create a campus appearance and image that will inspire staff and visitors to support NREL's mission and technologies, and take ideas back to their own buildings and facilities.

- Provide on our site (possibly near the edge for easy access), or on adjacent private property, a public facility that exemplifies sustainability and integrates NREL technologies into the building's architecture in a way that gives a positive impression about the viability of these technologies and their potential to integrate into beautiful buildings. Possibilities include an education center, conference facilities, and VIP lodging.
- Our South Table Mountain site will include energy and education facilities to serve an expansion commensurate with growth at the lab in visitors annually from today's level of about 10,000 per year.
- Keep the SERF building as our campus icon and maintain its visibility from major viewpoints (including I-70).

4. Support safe, healthy, efficient and secure operations. Minimize the visibility of security measures to maintain a campus atmosphere consistent with NREL's image (4).

- Co-locate administrative functions with R&D on the South Table Mountain site, and include a minimal amount of satellite administrative functions at the NWTC site.
- Use leased space for warehousing and to meet temporary needs.
- Provide an informal gathering spot located centrally on campus that is viewed by staff as a place to meet or work remotely from one's office.
- Provide a wellness center on campus.
- Ensure that visitors can easily identify the entrances to our sites and major buildings and find their way around campus.
- Co-locate functions wherever feasible to increase efficiency, taking into account functional affinities.

- Enable and support public use of the conservation easement areas on STM while preserving necessary security measures.
- Provide increased site access on STM in the future, such as safe and secure employee vehicular access via the STM's west gate, and pedestrian access via a south gate.

5. Maintain positive relations with immediate neighbors, and take advantage of mutually beneficial projects with local and regional neighbors (8).

- No new facilities are planned for the Mesa Top at this time.
- Minimize the impact of NREL operations (light, noise, visual impacts) on adjacent neighbors through the use of landscaping, setbacks, and/or physical barriers as necessary.
- Locate buildings with appropriate concern for neighbors.
- Improve the connectivity of our site within the greater fabric of the Denver West community. For example, evaluate a pedestrian and bicycle link from Denver West Shopping Center, to/through DW Marriott, etc., so the community can access the Mesa Top and our staff can access the shopping areas without cars. Also, evaluate options with developers of the adjacent ball fields such as shared food service or parking; insure that daycare services are provided close to NREL.
- Evaluate options for the future use of sites currently on the historical register.
- Provide easy access to bus stops and other transportation links to the community in the future (including a Denver light rail link for 2008).

Footnotes:

1. Implementation of this strategy is consistent with Sustainable NREL Financial Responsibility goal.
2. This Master Site Planning process is a primary activity of the Sustainable NREL Strategic Management Framework “Campus” Implementation Strategy.
3. Implementation of this strategy is consistent with Sustainable NREL “Transportation” Implementation Strategy,
4. Activities will be consistent with Environmental Management System (EMS) requirements and Sustainable NREL “Environmental Management” Implementation Strategies.
5. Implement consistent with Sustainable NREL “Recycling” Implementation Strategy.
6. Implement water efficiency measures consistent with Sustainable NREL Water Efficiency Management Plan.
7. We will also consider zero energy building design principles where feasible.
8. Outreach activities with the community will be implemented consistent with Sustainable NREL “Public Responsibility” Implementation Strategies.



Appendix B: Identified Staff Priorities

The planning group held workshops with staff from each Directorate to gather feedback throughout NREL regarding their perceptions of both the STM and NWTC campuses today and how they could be changed in the future. Four workshops focused on the STM campus; one focused on the NWTC campus. Each workshop included about 10 representatives from within a Directorate. Individuals were selected to represent a diverse cross-section of staff in terms of length of service at NREL, job type and level, and a balance of males and females.

- 1. The campus should reflect NREL's mission and sustainable values.** In discussions of this topic throughout the workshops, the following themes emerged: staff believe that it is important to give the impression to the public that we use renewable energy ourselves and are not wasteful. The visual impression that we present is important; we should convey to others that we do research and help to commercialize renewable energy. Sustainable values include not only energy efficiency but also resource efficiency, water efficiency, and the use of alternative modes of transportation.
- 2. NREL should consolidate on one campus (except for the NWTC).** This was favored by staff from all Directorates for many reasons; for example, because it is a way to increase productivity, save money, unify the mission, and promote a common purpose. Other reasons cited were that consolidation would allow for better pedestrian circulation; promote sharing of resources; allow us to have a central gathering space; leave more open space; could improve communications and help break down the "silos" of different research functions; promote a collegiate culture, i.e., on one campus, people will share a more common purpose, feel they are part of a place, and experience more "ownership" in the workplace. To some staff, leased spaced conveys a lack of permanence.

- 3. NREL should preserve and enhance the natural environment.** Workshop attendees value the natural setting at the STM and feel fortunate to have it. In almost all cases, the natural environment was cited as one of the most valued aspects of our campus. Smaller building footprints and consolidation of development on the site are good ways to preserve open space. The view was expressed that we should not "sprawl" when we develop the site. Staff expressed the desire that we try to make the outdoor environment pleasant to use, with selected landscaped areas, transitional zones (between the indoor and outdoor environments), and usable outdoor environments (such as shaded patios). We should also preserve and enhance fauna and preserve the views.
- 4. The circulation of pedestrians should be improved.** With a more consolidated campus, this would be more feasible. It is currently not done because of the distance and time involved and the lack of sidewalks. Walking rather than driving, and allowing visitors to NREL see that staff use walkways, are integral to our sustainable values.
- 5. Buildings on the campus should be more cohesive and integrated visually.** A common theme at the workshops was that our site appears to be more of a collection of buildings, and it does not "feel" like a campus. Staff expressed the perception that our buildings currently "seem to mirror our organization, that we are siloed, we lack connections." A campus with a central point of focus for staff such as a common gathering area, a hierarchy of spaces, and continuity among colors and materials (despite a variety of building mass and form) would appear more cohesive and well-integrated.
- 6. Parking should be consolidated, and alternative transportation should be used on campus.** In two groups, these were listed as separate items; in other cases, these items were subsets of the value to improve

pedestrian circulation. Under this item, points made included the fact that a whole hierarchy of alternative vehicles—such as bicycles, electric carts, and shuttles—should be considered for our campus. Surface parking lots in front of the buildings are not only unattractive, they also increase rainwater runoff. In almost all workshops, participants proposed moving at least some parking lots out of the direct line of sight of major buildings and consolidating parking in one or more locations on campus.

- 7. There is a need for more common space and for informal, interactive, indoor and outdoor gathering spaces.** The idea of informal, interactive spaces came up in various ways at each workshop. The overriding reason cited for this type of space was to advance NREL's mission by enhancing creativity and productivity. Many people said that informal interaction improves morale and promotes the kind of shared mission and high-quality science that results when people work together. Having one central gathering space as the focal point or "heart" of the campus was also a popular idea. The gathering space was viewed as a "student union" type of space with informal meeting rooms, a cafeteria, and space where NWTC and DC staff can work when on campus.
- 8. NREL's visibility with the public should be enhanced.** Suggestions included making our facilities more welcoming and separating the facilities for the public from the research facilities, where security is a greater issue. One staff member emphasized the importance of an impressive campus this way: "Our research is so important, but I'm afraid that it will not bring us half the notoriety as a cutting-edge, environmentally sound, high-performing campus. (That) may be the best teaching and outreach tool that we can offer the public."



Appendix C: Storm-Water Management

The Urban Drainage Flood Control District (UDFCD) developed a preliminary storm-water management plan for the Pleasant View Area watershed. As part of this plan, calculations were made to compare the impervious areas in this plan to the assumptions used in the development of the UDFCD plan (referred to below as the Master Drainage Report. The UDFCD plan was analyzed for the drainage basins in its jurisdiction. Figure C-1 shows the drainage basins that apply to NREL's South Table Mountain campus.

Basin 93

Area = 17.28 acres

Master Drainage Report:

Assumed existing impervious area = 17%
Assumed future impervious area = 40%

25-year Development Plan Build-Out:

Actual existing impervious area = 23%
Proposed future impervious area = 38%

Basin 94

Area = 35.2 acres (detention areas are existing)*

Master Drainage Report:

Assumed existing impervious area = 13%
Assumed future impervious area = 47%

25-year Development Plan Build-Out:

Actual existing impervious area = 20%
Proposed future impervious area = 18%*

Basin 95

Area = 99.2 acres (detention areas are proposed)**

Master Drainage Report:

Assumed existing impervious area = 14%
Assumed future impervious area = 37%

25-year Development Plan Build-Out:

Actual existing impervious area = 1%
Proposed future impervious area = 16%

Basin 59

Area = 32 acres

Master Drainage Report:

Assumed existing impervious area = 20%
Assumed future impervious area = 50%

25-year Development Plan Build-Out:

Actual existing impervious area = 0%
Proposed future impervious area = 38%

* Master drainage report assumes existing detention ponds remain.

**Master drainage report requires detention of 14.5 acre-ft.

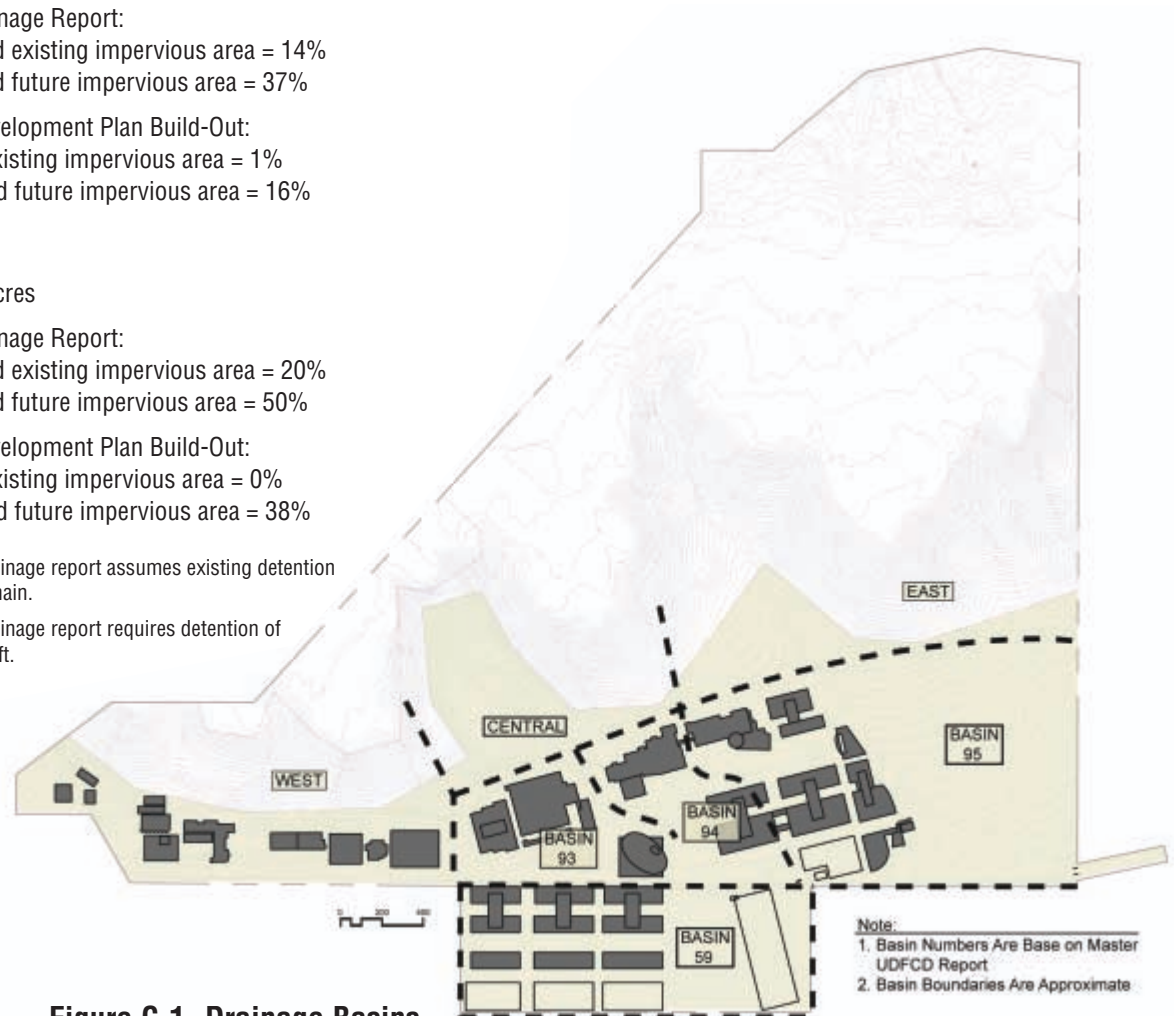


Figure C-1. Drainage Basins



Appendix D: Summary of Discussions with NREL Neighbors

Pleasant View

The Pleasant View Community, particularly the homes nearest to the STM site, will continue to be an important external influence on NREL's site development plans. The neighborhood is represented through a metropolitan district containing between 1500 and 1800 households. By actively seeking their input through NREL's Design Advisory Board, community meetings, and responsiveness to occasional complaints, NREL has developed a positive relationship with Pleasant View. This neighborhood group is viewed as an important ally in developing NREL's site plan.

The Pleasant View community is currently planning a recreational park just south of the NREL site. Construction will begin in 2003. The park will include three baseball fields and two multi-use fields. Access to the park will be from Old Golden Road. A parking lot for the recreation area is planned and also will be used by the public to access the Jefferson County Open Space trail system planned for South Table Mountain.

Denver West

The 450-acre Denver West Office Park, located on both sides of Interstate 70 (I-70) at Denver West Marriott Blvd., consists of both commercial and residential development. The park contains office space totaling 2 million ft². Office Buildings 26 and 27 are the ones nearest to the NREL STM site. Also next to the STM site is a high-end apartment complex. Access to the STM is through this office park area on the west side of I-70.

The following factors are of interest in NREL's planning efforts:

- Denver West's office development sites are almost completely built out. However, about 200 acres of land owned by Denver West remain available for development in the area.
- Three building sites within the office park on the north side of I-70 represent a potential of up to 250,000 ft² of office space.
 - Behind Buildings 26 and 27 is an old "trailer park," one of two buildable sites left for Denver West to develop. The management company says the site could accommodate a 105,000-ft² building there. Another site near Building 64 could accommodate a 66,000-ft² building. Office space is planned for both areas.
 - The Boston Market building at the corner of Denver West Parkway and Denver West Marriott Blvd. could expand by 70,000 ft².
- During the fourth quarter of FY 2002, construction of a self-storage complex was completed along I-70 west of the Jefferson County Schools building (Building 27), and south of the STM site. The widening of Colfax Avenue from Youngfield Street to I-70 has been completed, as has the new interchange at 6th Avenue and Indiana Street and the Denver West Marriott/Cole Blvd. intersection.
- There is room for the Denver West Marriott Hotel to double in size, but we are not aware of any plans to expand at this time.
- Denver West plans to install a fiber optic conduit network through its office complex and could easily extend the network to NREL's STM site.
- A trail system is planned throughout the Denver West property, linking the property on the east and west sides of I-70. The goal is to connect the South Table Mountain and Green Mountain trails. These trails would provide pedestrian access for NREL employees, because the alignment is expected to be along Isabell St.
- There are no plans to open Isabell Street from Old Golden Road to Denver West Parkway. This would be one additional access point to the STM if it opened, but it goes through the Pleasant View neighborhood and Denver West property.
- Residents of the Denver West apartment complex have been invited to NREL community meetings, but have not attended any; our conclusion is that renters do not have the same level of interest in our site planning as homeowners do.
- Denver West has recently completed a large retail complex at Colfax and Denver West Marriott Blvd. Its immediate impact on the nearby neighborhoods and office park is a significant increase in traffic. More retail expansion is planned.
- There are no plans for day-care facilities nearby, according to Denver West management.
- Denver West development may provide some options for off-site visitor handling and or parking. Though we have been told that Denver West prefers to put office buildings on its remaining development sites, it might be possible to investigate whether there is an opportunity to develop the sites in partnership, to meet NREL's needs as well as those of Denver West.

South Table Mountain Landowners/Jefferson County Open Space

NREL shares the Mesa Top with the Coors family, which owns a significant amount of land west of Quaker St.; with the Colorado State Patrol, which has a vehicle training area to the northwest; and with Jefferson County Open Space.

- DOE provided Jefferson County Open Space with a conservation easement of 177 acres on the Mesa and an easement to the east of STM property for trail access to the Mesa Top. There are no firm plans at this time to build trails through the easement or on top of the Mesa. However, the county has defined the current “social” trails on the Mesa. In recent discussions with NREL, Jefferson County Open Space officials had no time frame for building official trails but indicated that within a few years, as the Pleasant View recreation park is completed, trails will need to be established. They will include trails through the easement on NREL’s lower STM property, across the main road into the STM site.
- Interactions with the Colorado State Patrol have been minimal, although the State Patrol’s training track is near NREL’s Mesa Top facilities.

Jefferson County/City of Lakewood/City of Golden/Regional Transportation District

Jefferson County is in the process of updating its Comprehensive Plan for the County. They are currently running a public review process on the plan. NREL’s 25 year planning scenarios are of interest to them. Currently, the planning boundary between Golden and Lakewood runs along Denver West Parkway, which splits the NREL property between two planning jurisdictions. The City of Lakewood is currently working with the Denver Federal Center on a public/private-sector development at that site.

NREL also met with representatives of the Regional Transportation District (RTD) and provided comments on the RTD West Corridor Light Rail Draft Environmental Impact Statement. We commented because we are supportive of the West Corridor Light Rail line connecting Golden and Denver and want to work with organizations and agencies offering our employees and visitors more alternative travel options to and from our site.

Colorado School of Mines (CSM)

NREL and CSM have a good relationship with respect to adjunct professors. And CSM is interested in building a more collaborative relationship with NREL. Areas in which our interests coincide include these:

- Technology Transfer and Business Incubators — Both NREL and CSM are interested in partnerships to attract the attention of a broader range of potential users of the technology that we develop. We are both interested in supporting spinoff companies.
- Enterprise Zone — Both organizations would be supportive of efforts to encourage private-sector energy companies to locate near our campuses in Jefferson County and to strengthen our public/private relationships.



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