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Wildland Fire Risk at SRS

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Abstract

Wildland fires can affect SRS nuclear facilities. This paper describes this risk and offers several recommendations to reduce the wildland fire risk. Based on this review, it appears that the existing US Forest Service, SRS Fire Protection, and Emergency Preparedness programs provide an adequate framework for ensuring an adequate fire risk. However, since the frequency is 0.007 fires/year, which is slightly below the threshold for anticipated, additional management attention is warranted in reducing the present risk. This is significant because preventive programs are primarily administrative (prescribed burns, fire suppression, etc.) and have been observed to fail at other DOE facilities[1]. Additionally, building features, which typically mitigate severe fire events, may not be available if facility services (water, electricity, etc.) are damaged.

This paper quantifies the frequency of wildland fires at SRS and describes existing programs at SRS that limit the risk of such events. While propagation of a wildland fire directly to the hardened nuclear facilities is not expected, a wildland fire would be expected to cause fires in multiple non-hardened structures and equipment. These fires then have the potential to propagate to the nuclear facilities. Three facilities (HB-Line, SRTC and RBOF) have been used as examples in demonstrating how current authorization basis documents encompass the wildland fire risk.

Introduction

The Savannah River Site (SRS) encompasses approximately 310 square miles. It is 12 miles south of Aiken, SC and 15 miles southeast of Augusta, GA. Features include Carolina bays, sandhills, abandoned agricultural fields, swamps, and 2 major man-made lakes. Approximately 80 percent of the site is forested. The Savannah River forms the west boundary of the site. The local land along the borders is similar to that of the site. There are seventeen operating areas on the site ranging in activity from nuclear material handling to facility administration. The locations of these areas are shown in Figure 1 and account for about 12 percent of the site area.

The forests at SRS are defined by the tree species that are present. The major conifer species are longleaf and loblolly pines; deciduous species include sweet gum, maple, birch, oak and hickory. The fire risk in these forests is strongly influenced by the understory growth and the litter (leaves, pine needles, etc). Where such material is allowed to collect, the fire risk can become significant. Thus, where forests are managed, the wildland fire risk is dominated by facility construction materials.

Fires involving the forests surrounding the operating areas have the potential to spread to the structures in the operating areas. This can occur by flame progression (incremental movement of fire across open grass), thermal radiation from the fire front and spotting. At SRS spotting, which occurs when flaming brands loft from the fire, land on downwind combustibles, and cause ignition, is considered the most likely propagation mechanism. Such spotting is common within one half mile of a wild fire and can occur at greater distances. These spot fires can occur on structure roofs, materials stacked adjacent to buildings or internal to the buildings if drawn in by ventilation systems. Once one structure ignites in an operating area there is potential for multiple structure ignitions by spotting or thermal radiation exposure from the first involved building.

The US Forest Service manages the natural resources at SRS. Part of this effort includes managing the forests to reduce the fire risk to acceptable levels. This is accomplished by prescribed (controlled) burning, thinning, fire break construction and fire suppression. While most of the land at SRS is subject to prescribed burning, there are several limitations. These include: (1) Limits on burning where radioactive contamination exists (7 percent of the site), nonmanipulative ecological research set asides (9 percent of the site) and avoidance of locations where objectionable smoke or visual damage from previous controlled burns have occurred. The majority of this latter category exists near the operating areas. Thus, all of the operating areas have at least one nearby forest that has not recently been prescribed burned to reduce the fire risk. SRS is actively working to reduce the risk in these areas.

External Fire Events

External fires are those fires that originate outside of a facility and include structure exposure fires, vehicle fires and wildland fires. External fires can be a threat to the nuclear facilities at SRS. The threat can be neighboring structures, transport vehicles or forest fires. At SRS, structure exposure fires and some vehicle fire scenarios have been explicitly included in the fire frequency calculations, which are documented in the Authorization Basis Documents with additional detail provided in the Fire Risk Analyses (FRAs). For scenarios that evaluate single facility events, the consequences do not exceed those calculated for the internal fire events. The screening criterion for assessing a building's susceptibility to exposure fires in a FRA is separation of less than three times the spacing required by NFPA 80A[2] (without crediting fire walls or sprinklers). In addition, NFPA 80A recommends that the required separation be increased if no fire department response is expected. Based on this criterion and the bounding scenarios analyzed for internal fire events, all nuclear facilities at SRS were eliminated from further consideration. These scenarios would not have accounted for spotting as a means of fire propagation.

Forest fires have typically not been evaluated as a separate accident event in facility Authorization Basis (AB) documents. In cases where they were evaluated in the Hazard Analysis, they have sometimes been classified as Beyond Extremely Unlikely[3]. The section below reviews the AB for three SRS facilities as it relates to fire. All of these facilities are postulated to have the potential for very severe fires. An FRA was prepared on each, thus both consequence and frequency estimates are available.

Facility Authorization Bases

RBOF - The Receiving Basins for Offsite Fuel (RBOF), Building 244-H, is a steel frame structure with metal siding that covers a water basin for nuclear fuel storage. The incipient fire frequency for this structure and its exposures is 0.22 fires/year. A severe fire dose at RBOF is not expected to exceed 0.53 mrem for an offsite individual. The exceedance frequency for this event is 6.5E-3 fires/year. Structure exposure fires account for 1.1 percent of this frequency. If the fire causes the structure to collapse, there is a potential for a criticality. The exceedance frequency for this event is 6.5E-5 per year[4].

SRTC - Building 773-A, which houses laboratory and administrative functions, is in A Area[3]. While the structure is equipped with a nuclear grade ventilation system and sandfilter, during a severe fire the building windows are postulated to break, allowing contamination release directly to the environment. The postulated incipient fire frequency for this building is 0.81 fires/year. The incipient fire frequency for exposure to Building 773-A is 0.51 fires/year. When operator intervention, combustible controls, building design features and fire protection programs are credited the frequency for a fire causing a dose exceeding 0.5 rem is 7.8E-3 fires/year. Structure exposure fires account for 13 percent of this reported frequency[5].

HB-Line - HB-Line is constructed on the roof of H Canyon, Building 221-H. Both are reinforced concrete structures that share a common ventilation system. Ventilation air from these structures travels underground in a concrete duct to a sandfilter, exhaust fans and subsequently out through a stack[6]. The incipient fire frequency for the HB-Line facility is 0.11 fires/year. This includes the frequency for fires in the office and support structure which abuts the reinforced concrete structure of HB-Line (0.007 fires/yr). The frequency of the most severe fire postulated* for HB-Line is 2.4E-5 events/year. This fire involves all of the building nuclear material with the exception of that in the vault. The office and support structure accounts for 31 percent of this frequency[7].

For the three example facilities, incipient fires are anticipated (frequency > 1.0E-2 per yr). The frequency of severe fires ranged from 2.5E-5 to 7.8E-3 fires/yr. This frequency range, which is three orders of magnitude, is very facility dependent. Thus, in evaluating the wildfire risk for individual facilities, the actual building construction and protective features must be considered.

Forest Fires

Since 1978 SRS has experienced approximately 12 wildland fires/year. (See Table 1). Most of these fires are controlled by the SRS Forest Service before they cause significant damage. Prior to 1978 the average frequency was 20 fires/year (1954-1977)[8]. The actual fire frequency is dependent on the weather conditions and vegetation moisture content, which varies from year to year. In completing a risk analysis, it is considered more appropriate to evaluate the risk based on severe fire conditions being present, rather than being based on a nominal fire frequency. Thus, the analysis starts with a postulated frequency for severe fire conditions and assuming one demanding fire occurs every 10 years. The probability of successful control by the forest service is taken as 0.95 (1:20); a value based on interviews with the USFS. Thus, the frequency of a severe, uncontrolled wildland fire would be 0.005 fires/year. This frequency is considered to include those fires that initiate off-site and propagate to SRS.

Where such material is allowed to collect, the fire risk can become significant. The *Standard for Protection of Life and Property from Wildfire*[9] suggests a method to categorize the fire hazard from such fuels. Locations where understory growth and litter has been allowed to accumulate are categorized as Fuel Model O (conifers) and Fuel Model R (deciduous). The slope hazard rating for these two models on level land (< 20 % slope) is high and low respectively. In conifer forests that are managed to reduce understory growth and litter accumulation, Fuel Model P should be used. The slope hazard rating for this model on level ground is low. When the slope hazard rating is low, the overall wildfire severity rating is dominated by the building roof combustibility, which affects the likelihood of fire propagation by spotting.

In evaluating the wildland fire risk, the areas where minimal fire management practices are occurring must be considered. There are unmanaged parcels of land near all of the operating areas, with some of the highest loadings near A, B, F and H areas. These heavy loadings have been allowed to accumulate to avoid the generation of smoke near the nuclear and administrative facilities. The result is the highest

* The HB-Line BIO[6] presents a frequency of 1.0E-4 per year. This higher value does not account for some protective features and programs that are not covered by Technical Safety Requirements. The 2.4E-5 value is considered a best-estimate frequency and more appropriate for considering the actual facility risk.

hazards exist near the locations of greatest potential consequences. To account for this nonuniformity the initiating frequency would normally be adjusted upward, however this adjustment is considered to be offset by the corresponding fraction of fires that initiate remote from the operating facilities.

An alternate frequency estimate can be generated from the data in Table 1. In 46 years (1954-1999) SRS has not experienced a major wildland fire event that affected a nuclear facility. Based on this data the frequency of such an event would be 0.01 fires/year (0.5 events/46 years). The two frequency values are considered to establish a range of potential solutions. The logaverage to these values is 0.007 fires/year. This will be considered the nominal frequency that an SRS operating area is placed at risk from a wildland fire. For a particular area being placed at risk (e.g., H-Area) the frequency is taken as one-third of this value (0.002 fires/year) based on the arrangement of the site and the location of the high risk forest areas. In terms of overall site risk, the 0.007 fires/year frequency with a potential for multiple buildings being damaged, appears to be excessive. As discussed above, the individual building risk must be evaluated using facility specific information.

<u>RBOF</u> - When evaluating the wildfire risk to RBOF, an estimate can be developed by scaling the existing FRA results. Not every wildfire near H Area will cause ignition of RBOF. The likelihood that a fire will propagate by spotting is taken as 0.25. Thus, the wildland fire frequency would be:

1. $$F = \frac{6.5E-3\frac{\text{fires}}{\text{year}}}{0.22\frac{\text{fires}}{\text{year}}}(0.25)\left(0.002\frac{\text{wildfires}}{\text{year}}\right) = 1.5E-5\frac{\text{fires}}{\text{year}}$$

which is extremely unlikely. The corresponding frequency of a criticality event would be 1.5E-7 per year and thus would be Beyond Extremely Unlikely (BEU). {Note: Credit for the SRS Fire Department actions are already included in the fire frequency estimates.}

<u>SRTC</u> - Because of the size of Building 773-A, roof construction and exposures, a fire is assumed to occur during any severe wildfire event that affects A Area. The wildfire frequency corresponding to the unlikely random fire consequence is

2. $$F = \frac{7.8E-3\frac{\text{fires}}{\text{year}}}{0.81\frac{\text{fires}}{\text{year}}+0.51\frac{\text{fires}}{\text{year}}}\left(0.002\frac{\text{wildfires}}{\text{year}}\right) = 1.2E-5\frac{\text{fires}}{\text{year}}$$

Since this is extremely unlikely, the existing AB envelope (e.g., a fire causing a dose exceeding 0.5 rem with a frequency of 7.8E-3 fires/year) is considered to bound the wildland fire risk. However, the existing Hazard Analysis[3] indicates a BEU frequency.

<u>HB-Line</u> - Direct ignition of HB-Line by a wildland fire is judged BEU, however indirect ignition requires numerical evaluation. If a fire ignites the office and support structure (0.25 probability), it is possible for a fire to propagate into HB-Line (0.003)[7]. Thus, the frequency of a wildland fire causing ignition in HB-Line operating facility if there is nominal credit for the SRS fire department (0.3) would be:

3. $$F = \left(0.002\frac{\text{wildfires}}{\text{year}}\right)(0.25)(0.003)(0.3) = 4.5E-7\frac{\text{fires}}{\text{year}}$$

Thus, for well-constructed buildings like HB-Line, which have very few fire exposures, fire involvement is considered BEU, however response to blackout conditions as discussed below should be considered. The wide variation in building response is strongly dependent on the building construction. Where the building is constructed of non-combustible material (e.g., reinforced concrete) the potential for wildland fire damage is very low (possibly BEU). If combustible or limited-combustible materials are used, involvement of specific buildings is unlikely or extremely unlikely depending on the housekeeping around the building and the actual materials involved[10].

Multiple Fires and Other Effects

One of the forest locations with greatest fire hazard is north of Road 1 near A Area. This area has not been prescribed burned for about 25 years, since reservations were expressed by site management about the condition of the forest after the burn. The scenario discussed below is similar to those that can be generated for other operating areas. If a fire were to occur on the west end of this region, a moderate wind (~20 mph) could readily move this fire towards A Area. Under extreme conditions, spotting in A area would be expected about 1 hour after the fire starts. These spot fires would be primarily grass fires, however they could involve trailers, automobiles and waste containers. The SRS Fire Department would be expected to control many of these fires, however because their staffing is limited, some spot fires may not be successfully contained. Thus, it should be expected that some structural damage to trailers and similar buildings will occur. In addition, once these auxiliary buildings ignite, propagation to the major buildings (703-A, 773-A, etc.) can occur.

Smoke in the area will be heavy and is expected to impair area evacuation. Under the most extreme conditions full area evacuation may not be possible. Elevated smoke levels may exist for several days after the fire, however entry by emergency personnel (SRS Fire Department or Forest Service) should be possible in 1 to 6 hours depending on the radiological contamination concerns and the number of buildings affected. Damage to the area infrastructure may be extensive. Stabilization to allow the return of all general duty personnel (administrative support staff, researchers, design personnel, etc.) may require more than 1 week. Evacuation would be further complicated in some locations were a wildland fire to subsequently involve other operating areas (e.g., E, F, H, S areas). This would put additional demands on the limited available resources.

A wildland fire can be expected to damage the electric transmission and communication equipment outside operating areas. In addition, the smoke and spot fires in the operating areas may disrupt the emergency power systems, water systems (fire, domestic, process) and security systems. Diesel generators, which might start after loss of primary power could be irreparably damaged by smoke and fire gases. In addition, since many have a limited fuel supply, they may fail to run for the entire event period (~ 3 days). In some situations it might be prudent to disable the generators to ensure they can be manually started after conditions are stabilized. Unless dictated in the emergency plan, blackout conditions (no power, lighting or ventilation) should be assumed in evaluating the wildfire risk.

Where ventilation systems continue to operate (i.e., primary or secondary power does not fail), smoke will be pulled into the process building. This smoke can be expected to load filters (e.g., HEPA, diesel air filters, etc.), some to the point of pluggage. Where pluggage occurs or the fans loose all power, building ventilation will cease. This will allow the uncontrolled migration of contamination. Because of uncertainties in smoke loading and filter damage, full changeout of all filters following a severe wildland fire should be considered. While sandfilters may experience some increase in pressure drop under severe smoke loading, their overall performance is not anticipated to be adversely impacted.

Programmatic Impacts

Most site programs will be disrupted following a severe wildland fire. Most buildings in the affected operating area will require cleaning to remove residual smoke damage. Painting may be necessary. Computers in the trailers and offices may require servicing. Reestablishment of full communications and security systems may take one month. Thus, access to much of the site's electronic media will not be available in the affected areas. The loss of vegetation along the area perimeter will allow water erosion damage to the patrol roads. This will have a negative impact on security patrols and emergency response equipment. Erosion prevention and road repair will place an increased demand on the site maintenance infrastructure for about 4 months.

Radiological Consequences

The radiological consequences from multiple-facility involvement will be higher than would be expected from a single facility event. However, the peak radionuclide concentrations would not be expected to occur at the same time. The random nature of the release mechanism (i.e., fire ignition and propagation) would preclude a simultaneous release. Therefore, the consequences would increase because of exposure duration, rather than increases in the exposure concentration. Should multiple building evacuation be expected, it would be reasonable to require down-wind evacuation both in terms of direct fire risk and radiation exposure. Since the radiological consequences for such events are expected to develop over multiple hours, such evacuations are plausible if adequately planned.

An additional consideration in looking at the radiological consequences is that the AB doses are typically bounding. Such bounding values will not be expected at all facilities during the same event. It might be appropriate to consider the worst-case facility at the bounding dose, and the neighboring facilities at a fraction of the bounding dose. This would simplify the screening process in evaluating the risk of multiple facility involvement.

Preventive and Mitigative Controls

SRS has multiple administrative programs, design features, and emergency response programs that prevent or mitigate the potential for a wildland fire to damage a nuclear facility. These programs are conducted by the Department of Energy, the US Forest Service, WSRC and WSI.

Administrative Programs

In areas where the US Forest Service conducts prescribed burns the wildland fire risk is minimized. In addition, thinning programs and fire breaks further reduce this risk. When prescribed burns are being conducted, the work controls ensure that all stakeholders are notified and the risk of unmanaged spread is controlled to an acceptable level (e.g., ensure low wind, good ground moisture). The US Forest Service is also responsible for maintenance of secondary roads outside of the operating areas. This maintenance ensures timely fire suppression efforts and effective emergency evacuations.

Administrative programs conducted by WSRC that mitigate the wildland fire risk include facility housekeeping and trash removal. Without these programs the likelihood of ignition of operating area structures will increase significantly. In addition, programs to ensure timely fire department access into and through operating areas (e.g., control of road closures) improves the effectiveness of the SRS Fire Department in protecting structures during a wildland fire.

SRS has a policy that requires all new construction to be noncombustible or limited combustible, where appropriate[11]. Where such materials are used, the likelihood of spotting is substantially reduced. In addition, SRS mandates the use of automatic sprinklers in all new structures that have a floor area greater than 5,000 ft. sq. and requires separation between structures complying with NFPA 80A. These two features also substantially reduce the fire risk. Budgetary constraints and cost effectiveness initiatives have resulted in consideration of using combustible building materials and reducing sprinkler protection. Wildland fire risk has not been routinely considered in evaluations of this nature however, this shortcoming is being addressed.

Emergency Response Capabilities

The emergency response to wildfires at SRS, which are not affecting an operating area, are conducted per WSRC Manual 6Q15.2, EPIP 6Q-123[12]. This procedure assigns the management of such events to the SRS Forest Service. WSRC personnel serve in a support role to assist the SRS Forest Service during such events. If an area evacuation were necessary, it would be conducted per the emergency response procedure applicable to that area. The corresponding emergency procedure to implement when a wildland fire is affecting one or more operating areas is uncertain.

The SRS Forest Service is responsible for wildland fire protection at SRS. Their training is primarily wildland fire fighting. Most service members are not qualified or equipped for structural firefighting. As with the SRS Fire Department, the primary mode of operation is rapid deployment to contain and extinguish wildfires. During a severe wildfire, if additional resources are required, requests can be made for assistance from the South Carolina Forestry Commission or mutual aid from the surrounding CSRA region.

The SRS Fire Department is responsible for structural fire protection at SRS. Their capabilities are described in the *Baseline Needs Assessment*[13]. The minimum on-duty staffing is 18 persons, with an allowance for personnel involved in events involving off-site travel. Their training is primarily interior structural firefighting. They are provided with annual training that allows them to support SRS Forest Service fire suppression efforts. The primary mode of operation is rapid deployment to control a structural fire with the limited manpower. During a severe wildfire, when additional resources are required to suppress spotting in the operating areas, additional resources can be requested. These resources would come from an all-Call of off-duty SRS personnel and a request for mutual aid from the surrounding CSRA region. For most situations the complement of 18 should be adequate. However, for a severe event as described for SRTC, additional resources will be needed. The expected timing for response of these resources is less than 2 hours, but is greater than the expected development time for the event.

The WSI helicopter has been assisting the SRS Forest Service in responding to wildfires. The aerial view provided by the helicopter decreases the response time and improves the effectiveness the SRS Forest Service. In addition to this, there is an ongoing effort to formalize coordination between SRS Forest Service, SRS Fire Department, SRS Emergency Response Operations staff, and WSI. During a severe wildland fire, which threatens an operating area, these organizations will need to function as a coordinated team with a consistent set of goals under a single incident command system.

In evaluating the availability of additional resources, the possibility of concurrent demands must be expected. During very dry periods (i.e., droughts), the risk of wildland fire increases substantially. This increased risk would be expected to result in multiple fire ignitions per day in the Southeast United States. If this were to occur, the availability of mutual aid, both structural and wildland firefighters, will be very limited. There is the potential that no additional resources will be available.

Recommendations

1. A New Issue (NI) related to wildland fires should be initiated. (This was completed on 13 June 2000[14].) Authorization Basis documentation should be reviewed for locations where the wildfires are considered Beyond Extremely Unlikely. Where identified, these conclusions should be reviewed based on the results of this paper.

2. Forest locations with a high or moderate fire hazard (those where routine prescribed burns are not being conducted) need to be evaluated for fire potential. Walkdowns should be conducted to identify these locations. A plan should be developed to manage these fire risks through burning, thinning, improved access and fire breaks.

3. The need to ensure that construction materials are noncombustible or limited-combustible should be reemphasized. Where combustible construction exists, it should be removed as soon as practical. Where combustible storage presents an exposure hazard to buildings it should be removed or protected. Walkdowns should be conducted to identify these locations.

4. The administrative programs that limit wildfire fire risk (e.g., prescribe burning, area housekeeping) should be considered during the functional classification process. Where appropriate, these programs should be categorized as Safety Significant or Safety Class.

5. Where possible, prearranged facility responses, with accompanying drills, should be developed to reduce the possible consequence of a wildland fire. These responses might include disabling emergency generators, moving radioactive material into more robust containment, and removing unnecessary combustibles from process buildings.

6. A prearranged agreement should be developed to address a wildland fire that threatens one or more SRS operating areas. Drills should be conducted to ensure the successful implementation of this agreement.

Conclusions

There is an unlikely potential that a wildland fire at the Savannah River Site would severely affect one or more operating areas. While it is not expected that the radionuclide consequences would exceed the envelopes established in the individual authorization basis documentation, multiple source releases could occur. This possibility will be addressed in the appropriate emergency action guides.

The existing US Forest Service and WSRC Fire Protection programs form a good foundation for limiting wildland fire risk [15], however there are several practices that should be evaluated. (1) Areas that have not been prescribe burned within the previous 10 years should be burned or some compensatory protective measures implemented. (2) The use of combustible construction materials in operating areas should be reviewed. (This implies a facility walkdown.) Where identified, a plan should be developed to adequately address the risk. (3) The emergency response organizations that must respond to a wildland fire, which threatens an operating area, should drill regularly to ensure effective fire control capabilities.

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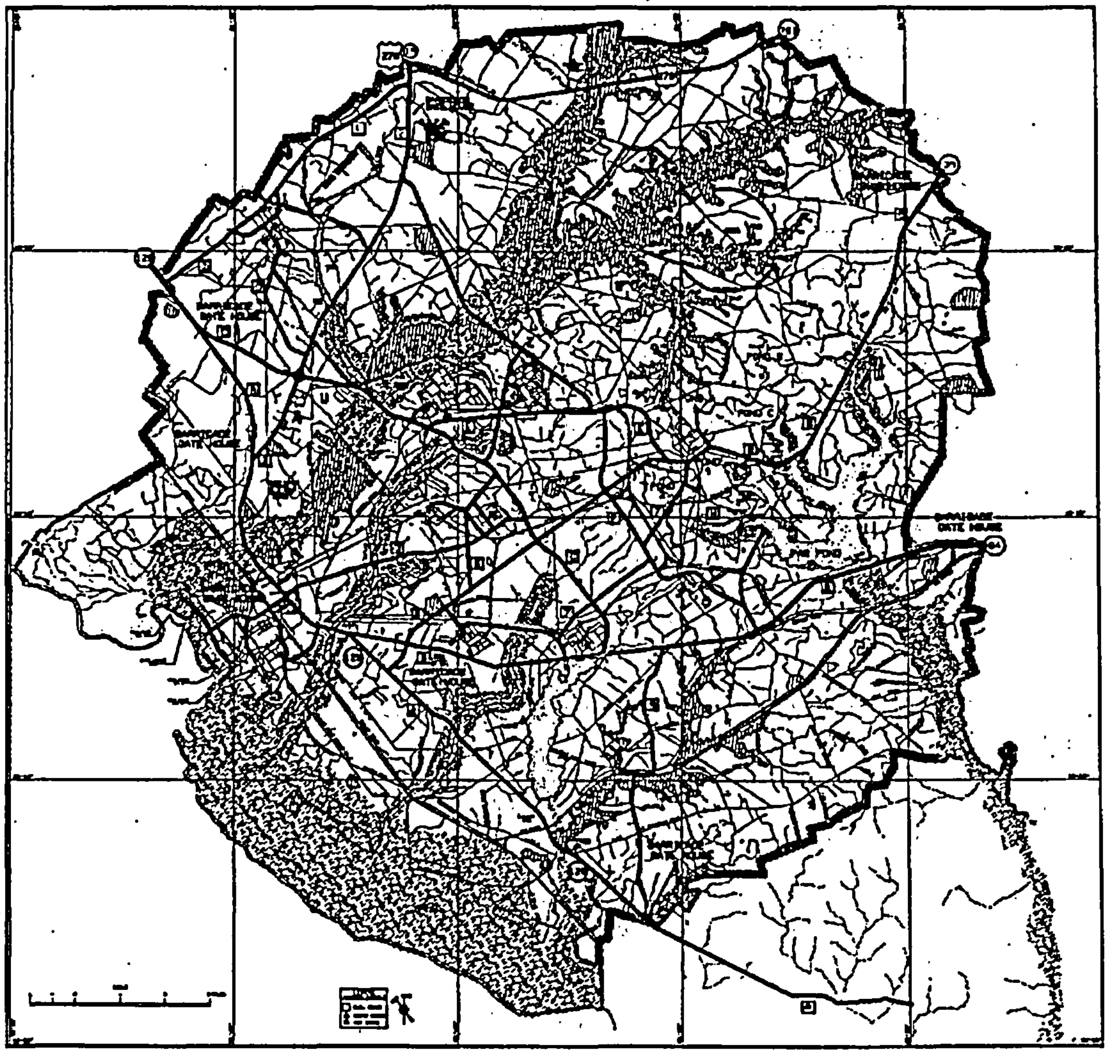

Figure 1 , SRS Roads, Areas and Features

Table 1.--SRS Wildland Fire Experience[8]

Year	Number of fires	Acres burned
1978	32	251
1979	11	7
1980	24	251
1981	13	27
1982	6	7
1983	10	175
1984	6	5
1985	27	320
1986	4	249
1987	22	90
1988	8	99
1989	3	6
1990	10	19
1991	9	1
1992	8	1
1993	15	43
1994	13	11
1995	11	26
1996	11	119
1997	3	2
1998	3	17
	249	