Dear Richard, Rick and David:

The Panel recognizes the many advantages of the Kimballton site as the location for DUSEL. As such, Kimballton provides a unique and visionary opportunity for NSF to create a world-class laboratory that will attract leading international basic and applied research in many disciplines. The host rocks at Kimballton are similar to those that cover 3/4 of the earth’s surface, produce 90% of the earth’s groundwater, 99+% of the earth’s hydrocarbon resources, and host 85% of the underground mines in the U.S. Kimballton will attract the broadest range of researchers outside of physics, including researchers in geosciences, mining engineering, rock mechanics, hydrology, geobiology, petroleum geology and production, carbon management, waste isolation and other related disciplines. Kimballton is the only site that will attract researchers and funding from the petroleum industry and from the DOE.

The Panel recognizes that one of Kimballton’s strengths is its highly qualified and experienced science and management team. A large proportion of our team members are non-local when compared to other sites; these scientists are attracted by the unique characteristics and research opportunities offered by Kimballton, as well as their professional judgment that DUSEL can be successfully developed at Kimballton. Kimballton DUSEL poses no threats to the natural environment or to workers and visitors to the facility, and enjoys unparalleled support from the local community, unlike some of the competing sites.

Kimballton offers the advantages of a greenfield site (including the ability to optimize the design for research) while at the same time profiting from the knowledge and benefits provided by an existing mine (such as knowledge of the subsurface geology and long-term stability of caverns at depth, land access, existing infrastructure, and permitting). The current limestone mine provides a synergistic arrangement that permits immediate implementation of science experiments to a depth of 2300 feet, while drive-in horizontal access to a mid-level laboratory at 4000 feet is easily accommodated within an acceptable timeframe.

Below we provide additional details on three issues identified as concerns in the Panel summary: distance from accelerators, site characterization, and cost. We urge the Panel and the NSF to consider these clarifications in their final assessment.

DISTANCE FROM ACCELERATORS:

Based on their interpretation of the S-1 report, the Panel implied that Kimballton would not meet the requirements for minimum distance from accelerators. The S-1 report carefully couched this ‘requirement’. The entry under “main requirements” in Table 1 states: “As deep as economically feasible: \( \geq 1500 \text{ m.w.e.} \) [and] \( \geq 1000 \text{ km from accelerator (see text)} \).” The text then reads: “In the scenarios that have been most studied so far (neutrino beam of approximately 3 GeV energy, produced by the proton drivers at BNL or Fermilab), there is a broad optimum around 2500km and distances between 1000km and 5000km are adequate. Shorter baselines will require lower energy beams; however, not enough progress has yet been made in such designs to allow a complete comparison. An extreme approach presently favored in Europe for the short baseline between CERN and Modane (130km) is to use very low-energy (300 MeV) electron neutrino beams from radioactive nuclei (‘beta beams’). Establishing a minimum baseline requirement at this point is premature. The motivation for a long baseline experiment is driven by the desire to observe multiple oscillations and to take advantage of the matter effect. The very long baseline, multiple oscillation cycle scenario is based primarily on work by Diwan et al., Phys. Rev. D68, 012002 (2003). However, that study did not quantitatively consider the possibility that a shorter baseline, lower-energy experiment could measure the parameters to the same (or better) sensitivity, which is the subject of current investigations. While matter effects in the Earth’s crust would seem to favor a very long baseline, they also introduce additional ambiguities. For example, the paper by Koike, Ota and Sato (Phys. Rev. D65, 053015, 2002) points out that “the sensitivity of the CP-violation search is greatly spoiled when the baseline length is longer than \( \sim 1000 \) km, which turns out to be due to the ambiguity of the matter effect”.

A thousand kilometer plus baseline necessitates a powerful neutrino source (proton driver) and a very large detector (>500 kton), together costing several times the presumed cost of DUSEL. Such a large expense must be evaluated within the context of the well-advanced Japanese facilities of JPARC and HyperK (1 megaton), as well as the potential linear-collider. Anchoring DUSEL to this single combination (and only one physics goal of a large detector) in preference to other more realizable possibilities at shorter baselines is unwarranted. In fact, ultra-long baseline experiments, once a superbeam becomes a reality, could involve detectors at the surface, such as NOVA, and thus be completely decoupled from an underground site.

An example of a lower energy study is a 100kt scintillation detector coupled with the proposed BNL...
SITE CHARACTERIZATION ISSUES:

The Kimballton geoscience team has over a century of experience working in the Appalachians. Kimballton is located in well-characterized Appalachian foreland Fold and Thrust belt stratigraphy that is regionally consistent and predictable. The geologic structure on the scale of the facility is well-defined. The rock units that will host the underground facility are known with a high level of confidence. Extensive geotechnical testing indicates that these carbonate rocks have high strength [UCS 80 -170 MPa] and have rock mass quality comparable to values reported for other competing sites.

Data from outcrops on the flanks of Butt Mountain can be interpolated into the subsurface because the mountain represents a regional-scale syncline. Fold wavelengths in the carbonate units that dominate the stratigraphy are on the scale of kilometers and the fold geometry is well known from surface exposures, hydrocarbon extraction wells, and decades of seismic exploration. The area is characterized by the regionally extensive Narrows thrust fault and the more local, widely-spaced, high-angle fracture sets that likely have limited extent into the subsurface. The seismic reflection survey completed last summer confirmed the structure and stratigraphy under Butt Mountain. The geology at the scale of the facility is known as well as, or better, than that of most of the other competing sites.

The planned deep borehole from the top of Butt Mountain will be completed with full geophysical logging. Additional holes drilled from the proposed portal site and several inclined holes now being drilled from the deepest levels (2300 feet) of the current mine workings will supplement data from the deep hole. The deep hole will confirm and refine the overall stratigraphic and structural model that is being used to develop the conceptual design. The convergence of results from field studies, published USGS maps, recent and earlier seismic studies, and underground observations have instilled a high level of confidence in the geologic model.

Groundwater hydrology at Kimballton is predominantly controlled by fractures. Major fractures are subvertical, organized into parallel sets, with spacing on the order of several hundred meters to a few kilometers. If these syntectonic fractures persist to depth, they are expected to be closed due to post-tectonic burial to depths up to 10 km. Only a single location of water inflow sufficient to require pumping has been encountered in over 40 years of mining and over 80 kilometers of underground drifts in the Kimballton limestone mine. Based on these observations, water encountered during tunnel construction and operation of DUSEL is expected to be manageable. According to the South Dakota Science and Technology Authority Review Committee’s Report on the Homestake Underground Laboratory Conversion Plan (2004), “groundwater flow and recharge [at Homestake] is [sic] relatively unknown”.

The rocks that will host underground caverns at Kimballton are dense Paleozoic limestones and dolostones with strengths on the order of 80 - 170 MPa, corresponding to the Very Strong range given by Hoek (2000), Table 11.2, after Brown (1981). These strengths are comparable to those reported for Henderson, Cascades and San Jacinto in their S-2 proposals (Homestake and Soudan did not report rock strengths). Similarly, the Kimballton Q and RMR are in the same ranges as values reported by Henderson and Cascades. The general competence of the rocks at Kimballton is also evidenced by decades-old, unsupported chambers up to 10 x 30 x 150 meters, and the high seismic velocity (6 km/sec) of the limestones. In contrast, “the geotechnical properties of the nearby Yates member, a target host rock for large caverns [at Homestake], are relatively unexplored", as reported in the South Dakota Science and Technology Authority Review Committee’s Report on the Homestake Underground Laboratory Conversion Plan (Dec. 2004).

As part of the S-2 process, we will consider a range of options to manage and reduce uncertainties related to construction conditions. The conditions revealed in the vertical boring will provide information on constructability of a vertical shaft. We are also considering an additional inclined continuous core boring from the deepest mine levels that will approximately follow the tunnel alignment into the DUSEL facility. The advantage of such a hole is that it will provide detailed information on geotechnical and construction conditions along the same path as a sub-horizontal access tunnel.

COST OF KIMBALLTON DUSEL:

The Panel expressed concern that Kimballton is essentially a greenfield site and would be developed completely on NSF funds at relatively large expense. The cost to build Kimballton DUSEL will depend on the design of the facility, including factors such as means of access and the amount of new infrastructure that must be developed. For example, we have not finalized the access method. An 8% grade, drive-in access to the full depth would indeed be very expensive owing to the length of tunnel required. For this reason, an 18% grade (using cogwheel vehicles)
is one of several access options being considered, making the complete round-trip approximately 10 miles (shorter than Gran Sasso). The potential to include some combination of vertical shafts and horizontal tunnels remains, and we plan to solicit input from the community to weigh the relative advantages and disadvantages of these options.

As the purpose of S-2 is to devise a conceptual plan for developing, operating and maintaining the infrastructure, it is premature for any site to present realistic cost estimates at this time. It is also important to emphasize that the cost of DUSEL must include operating costs over the 40-year lifetime of the facility.

DUSEL construction will be funded through the NSF MREFC process, which represents a separate line item in the President’s budget to Congress. It will not be funded from NSF base funding (Research and Related Activities Account). Furthermore, the construction costs can be amortized using the $150M bonding authority already approved by the Commonwealth of Virginia. After the laboratory is constructed, operating costs for the facility will come from the NSF R&RA budget, and thus must be considered when estimating the total costs to build (and operate) DUSEL. Some advantages that Kimballton DUSEL offers over competing sites in terms of these operating costs are summarized below.

In consultation with Charles Nelson and Associates (CNA), we have estimated cooling requirements of about 157 tons/yr at Kimballton, compared to 400 tons/yr at Homestake. At $1,000/ton the annual difference in AC and ventilation is $243,000 or nearly $10 million over the duration of the laboratory. These calculations assume equal costs for electricity at the two locations. However, the cost of electric service in southwest Virginia is the lowest in Virginia and the fifth lowest in the United States, suggesting the cost difference will be even larger.

At Kimballton, water pumped from the mine meets all EPA and State standards and is released directly into Big Stony Creek. Thus, water from Kimballton DUSEL will not have to be treated before release. Moreover, Giles County (in which Kimballton is located) is in discussions with the Chemical Lime Company to use water from the mine for municipal use. Conversely, arsenic concentrations in the mine water at Homestake average 61 micrograms/liter. The maximum allowable drinking water limit is 10 micrograms/liter - this represents a new standard that goes into effect January 2006, and will have to be met in order to develop DUSEL at Homestake. Homestake water is 600% above the new limit for arsenic, indicating that pumped water must be treated before it is released to the environment. Fallon, NV, recently constructed a water treatment plant to achieve the new standard at a cost of $10-15M. The sulfate concentrations at Homestake average 2390 mg/l or 1000% over the allowable limit (250 mg/l). Estimates for treating the expected 700 gpm range from $2-6 million per year depending on the method used, resulting in $80-$240 million dollars over the life of the laboratory, and does not include the cost of treating water currently accumulating in the deep levels of the mine. These costs will not be incurred at Kimballton.

As reported in publicly available DUSEL proposals, many sites require a substantial investment in surface campus facilities. Kimballton DUSEL is located 15 miles from Virginia Tech (28,000 students) and many of the facilities required for DUSEL are already present on campus and in the associated Corporate Research Center, resulting in major savings (and enhanced educational and research opportunities). Kimballton DUSEL is closer to a major research university than any of the competing sites. Additionally, Kimballton is located adjacent to major highway and rail lines, significantly reducing the cost of transporting equipment to DUSEL.

The assumption that NSF must bear the entire cost of building and operating Kimballton DUSEL is incorrect. Giles County has already indicated that, through their Industrial Development Authority, they will provide all surface infrastructure such as road improvements, sewers, water and utilities at a potential savings of many millions of dollars to NSF. Similarly, it has been suggested that a private corporation that operates theme parks in Virginia and elsewhere may be interested in building and operating the DUSEL Visitor and Education Center, again at a cost savings to NSF of several tens of millions of dollars. The cost to dispose of waste rock from lab construction will be minimal – it will either be stockpiled underground or sold as chemical grade lime or aggregate. Other alternative sources of funding are being considered to reduce NSF’s burden to develop Kimballton DUSEL. It should also be noted that Virginia Tech has invested significant resources and has committed additional funds to assure the success of this project.

**SUMMARY:**

The S2 process allows development of a credible option for DUSEL at Kimballton that can be presented to the NSF and US science community. This can be accomplished in a timely manner and at an acceptable cost to the NSF, as has been noted by the Panel. The added and enhanced science potential of Kimballton will result in a world-class facility, and we encourage the NSF to capitalize on the committed effort of the 150+ members of the Kimballton team.