PUERTO RICO NUCLEAR CENTER ‘THE RAINFOREST PROJECT A Renewal Proposal, Fiscal Year 1967 OF PUERTO RICO UNDER CONTRACT NO. AT (4®-1)-1899 FOR U.S. ATOMIC ENERGY COMMISSION ---Page Break--- PUERTO RICO NUCLEAR CENTER ‘UNIVERSITY OF PUERTO RICO ‘RIO PIEDRAS, PR, ‘THE RAINFOREST PROJECT ‘A Renewal Proposal for fiscal year 1967-1968, Submitted by Jerry R. Line March 1, 1967 ---Page Break--- TABLE OF CONTENTS Abstract ~~. Scientific Background Scientific Scope Biological Studies: Recovery, and Succession in Irradiated Area; General Biology, Weather Records = Chemistry of the Forest: Nitrogen Fixation North Carolina Participation HL Verde Field Station - Costing Source; A Preliminary Proposal - Scientific Personnel Other Personnel - Other Financial Assistance - Premises, Facilities, Equipment and Materials to be furnished by the Contractor Budget - Authentication ---Page Break--- ABSTRACT This is a renewal proposal for the rainforest project which covers two major areas of work. Part one concerns documentation of the recovery of vegetation in the area which was previously irradiated with 137Cs. In this part we will propose to continue mapping the new vegetation as it appears, to continue the biological productivity measurements, and to continue such indices of recovery as leaf area index measurements and optical density measurements. Other studies to be carried out include the continuation of photographic records in the area, the initiation of optical spectral measurements, the initiation of new species diversity measurements and the continuation of measurements on new shoots from old trees. Part two emphasizes continuation and amplification of the mineral cycling objectives of the project and includes proposals for further work on fallout radionuclide distribution, and biological residence time measurements which includes the use of tritiated water to study the flow of water from soils and plants. These as well as other studies are designed to provide a relatively complete picture of mineral cycling.

processes in the tropical ecosystem including rates and quantities of mineral flow in these cycles and the measurement of amounts and rates of input and escape from these cycles. Other phases of the proposal provide for the continuation of soil contamination experiments, for metabolism measurements and for continuation of the El Verde field station including the recording of certain selected weather variables.

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4) SoDRRPTPrC BACKGROUND ‘The Rainforest Project’ has been in effect since 1963. In the first three years of the project, a section of the lower mountain rainforest in the Tugutillo mountains of Eastern Puerto Rico was irradiated with 10,000 curies of 137Cs for a three-month period. The irradiation of the forest was preceded by about one year of general ecological survey studies of the plants and animals of the area and was followed up after the irradiation with similar studies where relevant in order to measure radiation effects. Many of these studies were carried out by visiting investigators from other institutions who came to Puerto Rico to contribute to the project within the area of their own specialties. This phase of the work is at present being organized into a volume entitled A Tropical Rainforest by H.I. Odum, former director of the project. The important results of this work are twofold. Firstly, the damaging effects of gamma radiation on a tropical ecosystem have been directly observed and will serve as a tropical basis for comparisons with other similar studies in temperate zones which have been carried out by ABD and should provide an objective basis for the prediction of effects of other types of radiation exposures which may occur in the tropics. Secondly, an extraordinarily extensive ecological survey of the environment of Eastern Puerto Rico involving 10 or more scientific specialties has been accomplished. This survey is similar in approach and scope to that demonstrated in the volume edited by Wilimovsky and Wolfe

and demonstrates again the efficacy of this method in

obtaining environmental data. * Wilimovely N.J. ed., Wolfe, J.N. assoc. ed, Environment of the Cape Thompson Region, Alaska. ‘UGABE Div. Tech, Int. (2ME-i81) 1965, 1050 pp. ---Page Break--- In the present project, the ecological surveys are no longer an important objective. It is intended rather to select certain restricted study areas which were shown to be potentially productive in the previous surveys for intensive work. Two areas of major importance which have been selected are the study and documentation of the recovery and succession in the revegetated area, and the study of mineral cycling in the tropical forest. These form the major basis for this proposal and are discussed more fully in the Scientific Scope section. ---Page Break--- 5) SCIENTIFIC SCOPE, WORK PHASES Introduction The ABC rain forest project is a study of irradiation effects and mineral cycling in a section of lower montane rain forest located at 1500 feet elevation on El Yunque mountain of Eastern Puerto Rico. The originally stated objectives of the project were: (1) to measure the effects of irradiation, direct and indirect, on the ecological system and its components. (2) to determine the quantitative nature of the biogeochemical cycles within the forest through tracer and fallout studies so that movements and fates of radionuclides may be predicted in rain forest. (3) To determine the general structure and processes of the rain forest system as part of the general quest for principles which will permit an understanding of radiation effects and isotopic movements in this and other ecological systems. These objectives continue to be the central motivation for the project. The experimental emphasis, however, shifted as demanded by circumstances. The present proposal, for example, is strongly oriented towards observations leading to the complete description of the recovery of the forest system with only minor effort directed to continued damaging effects. The specific objective of these studies is to determine whether the recovery is related to the source.

of damage. Thus many of the proposed studies include observations on ---Page Break--- other plots in the rainforest which have sustained damage from other sources than radiation. The recovery of the irradiated center will undoubtedly require many decades. It is anticipated, however, that the intensive recovery studies may be completed in a relatively short time. In a matter of only two or three years, we expect to be able to show the extent to which the recovery of the irradiated center resembles recovery elsewhere in the forest. Thereafter, the recovery studies will decline with regard to overall project effort, with perhaps only annual observational measurements of selected indices being required. Correspondingly, the staff will be increasingly available for other projects, some of which are presented for preliminary discussion in this proposal. The mineral cycling aspects of the Project are expected to increase. Extensive new laboratory space in the PREC building has been tentatively allocated to the Project contingent upon continuation of a new building wing. Thus, at about the same time that recovery studies begin to decline, the project will be in a position to propose a fully diversified and extensive program in mineral cycling. The present proposal is written in two major sections covering the recovery and succession studies and the mineral cycling studies. In addition, there are several proposals for relatively minor effort in other areas. These do not necessarily imply that the subject areas are of minor importance but only that with present staffing we are unable to make well-developed proposals. ---Page Break--- As an example, we propose only to maintain continuity in the accumulation of weather records while fully realizing that there is strong potential for highly relevant microclimatological research in the forest. The existence on site of a functional weather station and of a giant cylinder, and recent successful efforts in the use of tritiated water in the forest combine to make an unparalleled opportunity for

systematic research in gaseous diffusion for example. Other ideas are presented at various points

in the proposal to serve as a basis for future discussions of Project activities. The specific ‘fuming proposal for the next fiscal year is given in the following pages. ---Page Break--- ‘ECOLOGICAL STUDIES: RECOVERY AND SUCCESSION 1 THE IRRADIATED AREA; GENERAL BIOLOGY; WEATHER RECORDS Recovery and Succession Radiation center map. The radiation center has been mapped in 900 individual 1 meter square grids for the purpose of mapping the individual plants as they emerge in the radiation center. One survey was completed in 1966 and we will continue to make one such detailed map each year so that a record of the rate of change of populations in the irradiated center can be obtained. ‘The map to be made in September of 1967 will show all plants then existing in each grid by species. Comparisons with that made in the previous year will show changes which have taken place during the interval. Net productivity calculation. The survey of the radiation center grid will also include the taking of stem diameters, tree heights, and in the case of grassy plants areas of coverage. Since we have already shown that these data are reasonably well correlated with the individual biomasses of the plants, we will use them to calculate the total net biological production in the radiation center. Data for this calculation are already available for 1966 and another identical survey and calculation will be made in 1967. ‘The PRIC computer is not adequate for this task and the services section of the budget will reflect costs for programming and computer time to complete the calculations. Comparison of radiation recovery with that from other types of. Several areas on El Yunque mountain have sustained catastrophic damage from various ---Page Break--- sources. ‘These include the irradiated center, the cut center which was established as a control for the irradiation experiment, and several areas which were damaged by herbicides as part of

author project. Many of the herbicides areas are in the approximate same stage of recovery as the Radiation center. The Project will make two surveys of an herbicide damaged area and the cut center for the purpose of comparing the recovery land succession in these areas with that of the radiation damaged area. The surveys will consist of several optical density transects and several leaf area index transects of the damaged areas. Both measurement series will take place at six month intervals starting in September of 1967. Both types of transects are taken on a line running from unmanaged forest through the area of maximum damage and continue to the undamaged forest on the opposite side. The data obtained yield curves which are in index of the amount of vegetation in the areas. The change in the curves through time is related to the rate of regeneration of the damaged areas. Transects of the type described will also be run in the radiated center in an identical manner. The data obtained will enable us to determine whether the rate or character of the recovery in the irradiated area is in any way unique or different due to the fact that the original source of damage was radiation rather than chemicals or mechanical clearing. At the time that the data are collected in the areas of mechanical and chemical damage, a series of color photographs will also be taken of each area to provide a visual record of the recovery. These photos will be used along with the more extensive record taken in the radiation center to give a visual comparison series for recovery from various types of damage. ---Page Break--- Photographic Records. The project has accumulated a series of color slides of the radiation center which were taken monthly from the walk-up tower in the giant cylinder site. The series provides a useful record of the further changes which take place in the radiation center. We will expose at least 20 frames of 35 mm Ektachrome monthly from the walk-up tower to show the changes which continue to occur in the irradiated.

center. ‘The project now has a tower erected in the radiation center at the border line of radiation damage. This tower provides an excellent platform for viewing the succession of new plants in the area. A monthly series of both color and black and white photos will be taken from the tower to

show the rapid changes which are taking place in new growth. A monthly series of color and black and white photos will be taken of the radiation center from ground level to provide another perspective in the recovery. Another series of serial photographs of the radiation center will be taken during the summer of 1967. Latest age experiments, evidence from tracer experiments, from the recent injection of Chinese dobria, and from leaf scraping experiments indicate that tropical forest leaves are efficient collectors of radionuclides by surface interception from air or rain. Biological half-life measurements from the El Verde forest show long nuclide residence times. Data collected from leaf fall collection stations however imply that leaf ages in this forest might be relatively short. It is not possible to reconcile these two points of view. We therefore need a direct measure of leaf age in this forest in order to gain insight into the mechanisms of radionuclide retention. ---Page Break--- Several hundred leaves from tree species which can be reached from project walk up tower will be tagged with light aluminum tags around the petioles. The tags will be counted bimonthly until a reliable measure of age has been obtained. The radiation center may still be dying back due to radiation damage. It is no longer possible to observe this internally any longer because the canopy, if it exists, is extremely elevated. Since the new radiation tower has been placed at the current border of radiation damage we are able to make objective measures of canopy recession. These measurements involve tagging individual leaves from each of several species which can be reached from the tower and counting at bimonthly intervals for at least one year. Comparison of

Ste oft curves with those Obte’n ic Ses the WIE wp tover will give an objective measure of further employ & check. If the leaf age measurements are of importance not only to the Si Vente Forest but to others as well. It is of particular interest to estimate the quantity in the Eifin forest atop HL tongue because of the low abundance of fallout nationwide present in the vegetation there. As part of the general leaf age project we will tag in excess of 200 trees of each of 5 dominant tree species in this forest and will check these biodiversity with a multidimensional die-off curve that has been obtained. Stacies University 'dex. Species diversity is presently in a rapid period of change in the radiation center and the outer center. Initially, the area was invaded by only one species while presently both areas have several species of plants. It is of basic ecological interest and of specific interest to the radiation recovery program to note the pattern of diversity change through time. The rate of change data when obtained will be of value in determining the relationship between the achievement of full forest diversity and full forest maturity, and will provide a test of the hypothesis that diversity may be achieved considerably in advance of final maturity. These curves will also be of value in comparison with the current measures of net production since current energy budget theory would predict that energy spent in diversification would not be available for biomass production. The curves will also have considerable empirical value in comparing the recovery of the irradiated area with the cut area and should help in providing a basis for determining whether the character of recovery is in any way influenced by the original source of damage when such damage occurs as an essentially single catastrophic event. In the area between 10 and 15 meters from the old source position from the radiation center we will obtain a diversity index by counting the number of species encountered per 1000 individuals, in a circular.

manner rout the center, Tots will be done at 6 month intervals subject to modification according to rate of change observed until a reliable diversity increase function has been obtained, the procedure as described will also be carried out in an identical manner in the cut center. Sprouts. An important factor in the regeneration of the radiation center is sprouting from the base of old apparently dead trees. We have already verified that in a large percentage of cases the points of sprouting occur in positions which had line of sight protection from the radiation source, this

indicates ---Page Break--- that even though the main stems of trees were killed by the irradiation, local shielding of the predominantly surface roots in this forest may have been an important survival factor. Beating basal sprouts in the radiation center will be tagged and the center will be surveyed at 6 month intervals for the occurrence of new sprouts. These sprouts will be counted and tabulated according to whether they had line of sight protection from the radiation. Testing of the new sprouts as they are surveyed will give a method for determining the rate of emergence of new sprouts as a function of time, Spectral studies. Using the project spectroradiometer we will take spectral transects of the forest across the irradiated center and running at least 100 meters from the center. The purpose of these transects is to look for possible long distance radiation effects which have not been previously observed. Qualitative evidence from a series of aerial photographs recently obtained indicates that such long range effects might be present although this proposal represents the first attempt to objectively measure them. Arrangements of transects will be made in a transect series and at least two such series will be done during the year. Each transect will start at the radiation center and will proceed along one of the cardinal compass directions for at least 100 meters. A complete light spectrum in the visible region will be obtained.

along these transects at 10 to 15 meter intervals, at the forest floor. ---Page Break--- is General Ecology ‘Tree Growth. The 260 trees which were previously taped with vernier tapes will continue to be observed at monthly intervals as in the past. phenology of higher plants. The higher plant phenology records will be taken in order to provide a more reliable record of fruit and flowering in the forest. The measurements to be made monthly in a manner identical to the methods used in previous years will be done as follows: A) Count of fruit and flower fall on ground quadrate for 5 tree species, B) Weights of fruit and flower fall in the leaf fall baskets C) Counts of fruits and flower stalks on 50 selected plants and at 100 basket stations. Dr. Elizabeth McMahan (Univ. of North Carolina) will return to the project during the summer of 1967 to continue her detailed studies of termites in the El Verde area. The objectives of this visit are to carry out field studies on the survival of termite nests which were originally exposed to radiation during the forest irradiation project, and to carry out controlled radiation exposures of termites using the FRC Cobalt-60 Field. Laboratory studies to be carried out are listed as follows: 1) Identification and mapping of termite nests which have survived and those which have been abandoned during the year since they were last observed. 2) Measurements of the behavior and distribution of castes in surviving nests. 3) Measurement of population vigor in the field as indexed by tendency to repair controlled damage to nests. 4) Measurement of CO_2 metabolism in irradiated versus unirradiated nests. ---Page Break--- 5) Attempt to measure LD50 of various species of termites and conduct systematic exposures of known populations. Dr. McMahan will visit the project for a minimum of 60 days during the summer of 1967. Application has been made to carry out this project under an Oak Ridge Summer Research participant grant. If this is not obtained for any reason the project will provide

financial aid in the form of a per diem and travel expenses, with no salary or consultant fees included. Another insect diversity index should be measured in the radiation center to provide information on changing populations as the center fills in with vegetation. This will be carried out under the supervision of Dr. Mohanim who will select a graduate student to come to Puerto Rico for a short stay. The project will pay for travel and a small per diem. The student will sample the insect population in the radiation, control, and cut centers using appropriate methods until at least 1000 individuals have been gathered in each place. Collections will be done at least once during daylight hours and once during nighttime hours for each center. The insects will be separated by species, and the number of species per thousand individuals will be reported as the insect diversity index. Weather Records The weather station at HL Verde is a temporarily rigged, unconventionally

designed system which was built for the purpose of giving a short-term description of the major weather variables in the area. ---Page Break--- It fulfilled this purpose during the early years of the project but would now seem to have exhausted its usefulness in its present state. Principal objections to the station in its present condition are related to data recording on Rustack recorders which do not permit ready retrieval of large amounts of information, and lack of personnel specifically assigned to equipment maintenance and calibration. The operation of a functional reliable weather station is of benefit to our programs in recovery and succession, phenology, tree growth, trimming experiments, and metabolism. In addition, the station will provide a long-term meteorological record in the vicinity of Eastern Puerto Rico and could provide the basis for future proposals for research in microclimatology in the tropical forest. We therefore propose to create a meteorological data acquisition system by modifying the existing HL Verde system in the following

ways 1) Obtain the services of an electronic technician who is familiar with meteorological equipment and who can ensure the constant calibration and functioning of all apparatus. 2) Obtain at least the consulting services of a recognized scientist, microclimatologist, who can recommend and initiate investigations relevant to biology and to diffusion problems in the tropical forest. 3) Discard Rustrak data recording and convert to digital recording entirely. Overhaul digital data logging system including replacement of present nonfunctional and inadequate digital millivolt meter. Replace with a digital voltmeter and external amplifier designed for continuous service. 4) Process all data through modern commercially available computers with high-speed paper tape reading capability. 5) Replace certain field sensing equipment such as wind speed and direction indicators, and pyranometers and restring data and power cables to meet approved standards of industrial safety. ---Page Break--- After the above modifications have been completed we will record twenty channels of digital information as shown in the following table, VARIABLE CHANNEL VARIABLE CHANNELS Temperature 3 Solar Radiation 1 Rainfall 2 Optical Density 2 Wind Speed (hot wire) 2 Surface water runoff 1 Wind Speed (cup) 2 River Stage record 1 Wind direction 1 Trunk rundown 1 Relative Humidity 1 Lysimeter water conductivity 2 Voltage check 1 Lysimeter water volume 2 Data will be recorded at hourly intervals on a 24-hour per day schedule. Computer summaries including diurnal variations and averages, daily averages, weekly averages, and monthly averages will be for all data where appropriate, at six-month intervals. The data will be available to all project scientists and consultants and will be summarized in the annual report to ABC. Costs directly related to the outlined improvement of the station are itemized and not included in line items in the overall project budget. Cost Salaries, including overhead and fringe benefits for a technician, and fees for programming.

and consultation, 110,000 Services, estimated 20 hours per year of computer time at 60 dollars per hour. 1,600 Materials 500 Total Operation 22,200 Equipment (See appendix 3) 8,200 ---Page Break--- The chemistry of the forest The objectives of the forest chemistry program are: 1) Measure the amounts of fallout radionuclides, the amounts of corresponding stable chemical elements, and the amounts of possible neutron activation products now existing in several components of the forest system. 2) Identify for the same elements pathways of movements and measure rates of movements along these pathways. 3) Generate a testable predictive model for the retention and movement of these elements within a rainforest system. Work phases in this section represent a continued effort with our last year's proposal. We will continue the work started in trace element characterization of the rainforest with emphasis on thermal neutron activation products in forest materials and further exploratory work with shielded neutron activation, and D activation. We propose new effort in the trace element characterization of microscopical vegetation of the restoration center. The work concerned with distribution and retention of fallout radionuclides will

continue with new efforts directed to island wide geographical distribution as related to forest type and elevation. The interforest comparison work will be de-emphasized although we will continue to take samples in the Elfin Forest of El Yunque in order to more fully characterize biological half-lives of elements in this area. We will propose major new effort in our program to evaluate the dynamics of element movement in this forest. This program will be based as before on the use of radioactive tracers as well as stable element analytes. We have already installed more than 30 lysimeters of the type developed by Dr. Jonathan ---Page Break--- from the soils of RL Verde station. Fermentation has been secured to use tritium as well as isotopes of Cs, Sr and others in experiments. We are therefore in a

position to propose the management of both water and elemental movement in soils of the area, in addition to further studies on the behavior of microbes in plants, ‘Trace Element Composition of the Forest Neutron activation products. We have shown in samples of El Verde and other points in Puerto Rico as well as for soil from Fajardo that the primary ‘neutron activation products which can be measured instrumentally after the decay of interfering “Ti and Mn are 50 and 5Pe, while 12 is consistent with J.B. Kline's previous worldwide survey of soils. Tropical soils of Puerto Rico and Panama appear to be relatively depleted in La and Co. Further work is desirable in the instrumental neutron activation characterization of plant materials in the tropical forest. Instrumental neutron activation analysis will be carried out on at least 5 samples each of ashed tree leaves, epiphytes scraped from leaves. The resulting gamma ray spectra will be used to identify trace elements in these materials and epiphytic plants to include bromeliads, ferns, and moss which can be measured by this method and to make quantitative determinations where possible. Cosmochemical Activations. At present, it is not known whether plants and soils have characteristic gamma ray spectra when irradiated with neutrons of higher than thermal energies. Exploratory reactor irradiations of at least 5 soil samples from Puerto Rico and 5 ashed plant samples will be carried out with ---Page Break--- the samples enclosed in specially designed Cadmium cups. The resulting gamma ray spectra will be used to identify elements in these materials and to make quantitative determinations where possible. Further development in the technique of using LiD to produce cold neutrons is required. We have designed a Cadmium cup which allows access of thermal neutrons to a LiD source while at the same time protecting the sample within from these neutrons. Further work is needed to develop convenient handling and packaging techniques for LiD which is hazardous material when exposed to the

open air. Upon solution of this problem we will carry out irradiations of at least 5 sols and plants using 14D as a converter of thermal neutrons to fast neutrons. Game ray emitting radioisotopes which are produced in these irradiations will be identified and measured quantitatively where possible. Chemistry of Successional Vegetation. The vegetation now invading the radiation center is in a vigorous state of growth. This implies that the essential mineral nutrients required to support this growth are both present and chemically available. In order to characterize patterns of mineral nutrient uptake, 12 successional area samples of leaned grass will be collected from plants in the area at the time of the annual mapping and some survey for chemical analysis. The samples will be analyzed for K, Ca, Fe, and Cu by means of spectrophotometric or atomic absorption analysis. The results will be combined with the biomass calculations to give a standing state of these elements. Annual repetition of the survey and analysis will reveal patterns of nutrient uptake as compared with biomass production. At least 50 samples of plant materials will be analyzed during the first year of the project. ---Page Break--- Concurrently with the vegetation analysis, soils will be obtained from the area and subjected to analysis for the same elements. These elements will be determined primarily on aqueous extracts from the soils which are thought to be indicators of chemical

availability. Such extracts may consist of neutral ammonium acetate solutions or dilute mineral acid solutions. At least 5 soil samples will be thus analyzed the first year of the survey. Distribution and Retention of Fallout Radionuclides. Retention Time. Biological retention time for the nuclides 952r, 54n, and Moe have been estimated in the forest at HL Verde. It was found during a period of exceptionally low fallout that the forest plants bind these nuclides very tightly and that the major factor in the decline of radioactivity was the physical decay of the nuclides themselves. An estimate

For the environmental half-life of 137Cs was obtained, which indicated that this quantity was about nine years for this nuclide. The result was not statistically reliable because of the short time interval of measurement as compared with the apparent long environmental half-life. These measurements were complicated by the fact that the area received a fresh input of radionuclides within 20 days after the Chinese nuclear test of May 9, 1966. We now intend to continue the monthly sampling program at the El Verde station in order to characterize the behavior and immediate attribution of nuclides after a fresh injection. The nuclide which is most readily detectable from this injection is 90Zr-7. The Chinese injection of nuclides did not appear to alter the forest concentrations of 137Cs or Hm. Thus, the opportunity still exists to obtain a reliable environmental half-life for both nuclides. An apparently anomalous result was obtained for Hm in our previous measurements in that the environmental half-life was longer than the physical half-life. While this is a possible result, further measurements are needed to verify its reality. We will continue as before to collect monthly samples from 5 canopy and 5 understory trees along with samples of litter and soil for analysis by gamma ray spectrometry. The data will be used to provide more reliable estimates for nuclide residence times in the El Verde Forest. Residence times; El Verde Forest, water radiomelic levels in the El Verde forest on East Peak in the Aguatillo Mountains are now finally established in comparison to those at El Verde. The reason for the difference is not yet clear, the data from past measurements is not yet sufficiently reliable statistically to determine whether retention or accumulation are factors in this increased burden. We will continue to sample the leaves of two species of trees, mosses, ferns, and ground litter on a bimonthly basis for at least another year for gamma ray spectrum analysis. The data for 137Cs and Hm will continue to be.

used to estimate environmental half-lives for these nuclei. For Mo and 90Sr-95Zr will give some indication of the immediate behavior of fresh injections of radiomelides in this forest. ---Page Break--- Geographical Distribution of Nuclides. Preliminary evidence indicates that there may be a geographic gradient of radionuclides on the island running from high in the east to low in the west. This gradient, if it exists, could be caused by effective precipitation scavenging of the prevailing easterly trade winds as they strike the Inguillo Mountains of Eastern Puerto Rico. In order to confirm or reject the presence of these possible gradients, the vegetation will be sampled on the island in a series of adjacent transects which run from the north to the south coasts. Four such transects will be done. The first will be done on the eastern edge of the island in the mountainous areas. The second will be done parallel to the first but 30 miles further west. The third will be done 30 miles west of the second, and the fourth will be done near the west coast in the mountains near Maricao, Puerto Rico. Each transect will have 5 sampling locations. These locations will consist of the northerly level foothills, the northerly middle montane region, the peak region, the southerly middle montane region, and the southerly sea level foothills. At each station, 5 to 10 samples of vegetation will be taken. These will consist of leaves from prominent trees of the area, prominent epiphytes such as ferns, mosses, and bromeliads, leaf litter, and samples of surface soil. All samples will be dried and counted non-destructively by gamma scintillation spectrometry. The complex spectra will be resolved using our existing computer solution and the resulting data for 95Zr-95Nb, 137Cs, and others will be plotted over a map of Puerto Rico to illustrate any differences

found. ---Page Break--- 25 Strontium-90 Retention. A procedure for the determination of Sr has been successfully adapted to the analysis of tropical foliage, Samples

which were counted non-destructively for gun emitting nuclides have been retained. We are thus in a position to measure the environmental half-life of ^90Sr in the El Verde and Elfin forest regions. Approximately 100 plant samples from the collection will be ashed in a furnace and analyzed radiochemically for Sr. The samples will be selected from various dates over a period from 1964 to 196 from both the El Verde and Elfin forests. The results will be plotted on a semi-logarithmic scale as a function of time and will be subject to regression analysis in an effort to establish the environmental half-life for this nuclide. Pathways of Movement Within the Forest Tracer Experiment. Plant growth phases of the tracer experiment described in last year's proposal have been completed and the plants growing in the area have been harvested. The uptake of nuclides was slow and much of the original contamination remains where it was placed. The presently barren radioactive plots offer the opportunity to study uptake of ^134Cs and ^137Cs by successional vegetation. The plots will be cleared of surrounding trees to produce a small sunlit open area. This area will be allowed to reestablish plant growth naturally. When all plots have sufficient plant growth, samples will be taken for radioactive counting. The course of nuclide uptake will be followed by periodic sampling for at least one year or until a reliable description of uptake patterns has been obtained. ---Page Break--- The radioactive soil in this plot has been subject to natural weathering for more than one year. The radionuclides in the soil should now be in an equilibrium state. Small amounts of this soil will be removed from the plot for laboratory studies. These studies will consist of chemical extractions of soils from each of the four plots as follows: 1) Replicated extractions of field moist soils from plots with solutions of neutral normal ammonium acetate. The soils will be counted before and after the extraction to determine extractability of Cs and Sr. 2)

Replicate extractions of soils from 4 plots with solutions of dilute mineral acid. Determinations will again be made by the method of before and after counting. 3) Samples of the field moist soils will be subject to three wetting drying cycles and will then be extracted according to the method in (1) above to give an indication of the fixing power of the soils for Ce and incidentally Ma. ‘Tracer Experiment 2; Behaviour of Epiphytes. An area of the Zl Verde forest has been set aside exclusively for low level tracer experiments involving leaves and plants. This area has been fenced, warning signs have been erected, and Health Physics Division approval has been obtained. The area consists of approximately 500 square feet and was selected because of the high abundance of plants supporting epiphytic growth. Epiphytes have been previously implicated in the interception and retention of radionuclides and mineral elements from air and rain. ‘They have been shown to absorb nuclides rapidly from solutions in the laboratory. It remains unknown whether minerals captured by these surface plants can be transferred to the supporting leaf and thereby form a source of supply of essential nutrients to the higher plants which is outside of the normal routes involving root uptake and translocation. ---Page Break--- The following experiment will be done to aid in answering this question: 2) Many lowives of understory plants showing vigorous epiphytic growth will be contaminated on the surface, with neat neutral solutions containing subcurie levels of 60Co and 137Cs. 2) After a brief uptake period, the leaves will be rinsed in distilled water and cut into sections of approximately square centimeters each. 3) Thirty of these sections will be placed on the surface of thirty intact growing leaves in the field and held in place with a rubber band. Fifteen of the intact leaves will have vigorous epiphytic growth and fifteen will have no visible growth. ‘The overlays will remain in position for 2 hours, and will then be removed and

discarded. 4) The growing leaves will be harvested in groups of ten at the end of 3, 6, and 10 days after labeling. Five clean and five epiphytic leaves will be taken in each group. Each leaf will be sectioned into three parts which will consist of regions below the overlay, the overlay region, and the region above the overlay. 5) Each leaf section will be counted on the project single channel analyzer, first in the Sr energy region and then in the 134Cs energy region. The complex spectrum will be resolved using data from standards counted in the same way and the movement of radionuclides from epiphytes into leaves will be determined. Epiphytic leaves have been shown previously to be accumulators of fallout radionuclides. It has also been shown that environmental residence times for these radionuclides is long. It would seem then that those plants might be involved in the mechanisms which result in long retention times. We will study this point in the following experiment: 2) Both epiphyte-covered and clean leaves will be labeled with neutral solutions containing carrier-free 137Cs and using a micropipette to deliver exact volumes to each leaf surface. The solutions will be allowed to evaporate to dryness. Each leaf will be marked for later identification. 2) Leaf samples will be harvested immediately after the isotope solution has dried to serve as a set of counting standards. Other harvests will be made first 2 weeks after application, and then at longer intervals until at least 6 harvests covering at least one year after application will have been made. ---Page Break--- 3) The dead samples will be counted independently in the project single channel analyzer, first for 60Co and then for 137Cs. The resulting data will be plotted as a function of time for epiphytic and clean leaves. The results are expected to show whether surface retention is an important factor in observed long biological residence times for fallout, and whether epiphytes are involved in this retention as is now thought. Tracer Byronment 3: Water movement in soils

en plants. Using one of the lysimeter installations of Dr. Jordan, an attempt will be made to measure some aspects of the water balance in the forest. Several water balance plots have been constructed in connection with these installations. Such a plot consists of an enclosed section of soil surface of one to two square meters which lies directly above one or more of the lysimeters. The plot terminates at the edge of a pit on the downhill side and at this terminal as a trough. At each plot is a specially designed rain gauge for measuring under-canopy rainfall. Water falling on the plot through soil is intercepted by the lysimeter and that which runs off is caught in the terminal trough and directed to a container where it can be measured. One such installation has been fenced and equipped with warning signs for radioactive experiments. Health Physics Division approval has been obtained to use tritiated water in this area. Under Health Physics surveillance, we will apply a known amount of tritiated water to a known surface area above the buried lysimeters. Water flowing from the lysimeter and the runoff collector will be captured at periodic intervals and brought to the laboratory for liquid scintillation counting. The resulting data will be used to calculate the proportions of applied water which ran off the plots and the proportions which moved into soil. This experiment is exploratory and will undoubtedly form the basis for other future experiments which cannot be rigorously defined at present. ---Page Break--- Within the same security area, another tritiated water experiment will be carried out to measure the uptake and translocation of water by canopy trees. Approximately one curie of tritium will be diluted with two liters of water and the solution will be applied to the soil at the base of the tree. At two to three hour intervals thereafter, leaves will be harvested from the tree, placed in plastic bags, and frozen. The frozen leaves will be returned to our PRC laboratory where the unbound waters will be removed by passing a stream of

ary air over the leaves in a heated chamber and into a standard Liquid nitrogen cold trap. The volume of the condensed water will be measured and they will be transferred to a vessel for Liquid

scintillation counting. The specific activity of the waters extracted from leaves as compared to that of the waters originally applied will give an indication of the dilution with environmental water which has occurred and will enable a rough calculation of the total water saving into the tree per unit time. The time of tritium persistence in the tree will enable a rough calculation of the total water which has passed through the tree during the interval of measurement. While the experiment is in progress, approximately 2 flasks fitted with an aluminas pipe and containing liquid nitrogen will be exposed to the atmosphere at varying distances from the site of the experiment. The pipes will contain atmospheric water on their surfaces until the liquid nitrogen has completely evaporated, whereupon the pipes will warm and allow the condensed water to flow into the flasks. These were developed by the Health Physics Division to monitor safety aspects of the experiment. By placing them in a systematic grid around the experiment, they may yield some information on the diffusion patterns of water in the atmosphere of the forest. ---Page Break--- 30 Tracer Experiment by Radionuclide Movement in Soil. Water balance plots which include lysimeters at various depths in the soil and water runoff collectors have been prepared for radionuclide experiments. In one such plot, millicurie levels of both 134Cs and 85Sr will be applied to the soil surface in a carrier-free aqueous solution. At weekly intervals thereafter, the total volume of input water, the volume of lysimeter waters, and the volume of runoff water will be measured. Composite subsamples from lysimeters at the same depths will be taken for gamma ray counting. Samples for counting will be taken at first at weekly intervals until patterns of nuclide movement have been

established. After evaluation of these patterns we may find it feasible to count monthly composites of the water. This plot will be monitored for at least one year after the application of nuclides, at which time a decision will be made of whether or not it should be continued. It is expected that this plot will show the relative proportions of nuclides moving through soil, and the proportions of nuclides which have been immobilized by soil chemical reactions. Lysimeter Experiments; Ton and Water Movement in Soil. Approximately 36 lysimeters have been installed in various soils of the El Verde area. These sites include well-drained soils, poorly drained soils, soil on ridge tops and soils on hillsides. Most installations have been made at a depth of 5 inches, and each location has been replicated in quadruplicate. At each location a specially designed rain gauge which is two inches wide by 5 feet long is set up to give an integrated measure of rainfall penetrating the canopy. ---Page Break--- These installations will be used to obtain at least one year of water balance records under the indicated variations of soil drainage conditions. These records consist of weekly recording of the under-canopy rainfall at each site and weekly recording of volumes of lysimeter collected water. Using performance data from the tritium experiment an effective collection area for the lysimeters will be calculated, and this will enable the calculation of percolating water through the various soils. The difference between volumes per unit area of percolating waters and total input will be ascribed to runoff and evapotranspiration. At some later date when more experience has been gained in the construction and reliability of runoff plots we expect to be able to propose the measurement of evapotranspiration by difference when all of the mass flow variables are measured directly. ---Page Break--- 32 NITROGEN FLUXATION The 48 of key importance to the general understanding of mineral cycling in the tropical forest to have specific information on

the possibly unique nitrogen cycles. There are two reasons for that: 1) There is no significant geochemical source of biologically available nitrogen 2) Environmental conditions favor the rapid nitrification of biologically released nitrogen which may then be rapidly lost from the ecosystem due to its inherent chemical form and to the high rainfall of the area. Nitrogen which is lost in large quantities must be replaced in like quantities from any of several sources if the forest is to maintain its steady state. Possible sources of nitrogen include symbiotic fixation, non-symbiotic fixation,

epiphytes, and lightning strokes. Baisden (Univ. of Ga.) has previously examined root nodules of legumes plants of the area and found them to be apparently active and enriched in nitrogen content. We will initiate a preliminary study in cooperation with Dr. Baisden to determine the possible role of epiphytes in the nitrogen cycles and fixation mechanisms in the forest. Dr. Baisden will make at least three trips to the El Verde forest for the purpose of on-site study of epiphytes and for specimen collections. The specimens will be returned to Dr. Baisden's laboratory where attempts will be made to culture the leaf surface organisms in artificial media. Organisms which are successfully cultured will be examined for nitrogen-fixing capability. Nitrogen will be measured in epiphytes and leaves to determine any existing patterns of relative nitrogen enrichment. ---Page Break--- The project will provide costs of transportation and per diem for Dr. Baisden, but will not provide a consultant fee. Culturing and analysis of samples will be carried on primarily as graduate student projects under Dr. Baisden's supervision at no cost to the project. Data resulting from the study will be equally available to the University of Georgia and MC for use in annual reports and progress reports. Any resulting open literature publications will be under joint authorship from both institutions. BIOLOGICAL FUNCTIONS One of the stated

primary objectives of the Terrestrial Hoology Project 4s to study those aspects of biological function in the rainforest which could give theoretical interpretation and perspective to much of the empirical data already collected in the areas of mineral cycling and relation recovery. This remains an important one and in an area of research which could provide a unifying framework within which all other project activities are carried out. Because of staff obligations in the areas of mineral cycling and relation recovery, however, we are unable to make major research proposals in the area of energy cycling and biological function. The studies which we intend to carry out are restricted to those which require a minimum of manpower and expense and are listed as follows: 1) Respiration and photosynthesis will be measured on individual samples of plants utilizing the radiation sensor. This will be done on a few of the major species. An independent check on the proposed direct method to determine the reliability of this method. Elsewhere in this proposal, we indicate that H.7. Ofm will make a consultant visit to the project during the year. We expect to have his consultancy and participation in the metabolism work. 2) As indicated in the section of dust experiments, we will measure the metabolism of individual plants in the root covering experiment along with controls to determine whether covering the roots has any detectable metabolic effect. 3) The metabolism apparatus will be carried to the Elfin forest on El Yunque where metabolism will be measured on several plants including tree leaves, ferns, and mosses. These measurements will provide the first indices of the differences in energy utilization between this torrent and the one at El Verde. 4) As time and resources permit we will continue performance testing of the giant cylinder and attempt to obtain usable respiration and photosynthesis data. The performance tests of the cylinder will consist of the attempt to measure recovery of

controlled metered releases of pure CO2 in the middle of the cylinder, while the fan is running. These releases will be made from ground level and at 20-foot increments up the tower until the final release is made above the forest canopy. The data will indicate levels in which losses of metabolic gases are occurring out the top of the cylinder and should provide a correction factor that can be applied to all previous data taken from the cylinder and allow a rigorous calculation of the metabolic activity within. Concurrently with the performance tests, the cylinder will be run for at least one day and night without CO2 releases in an attempt to measure the natural metabolic processes. ---Page Break--- 35 EFFECT OF SURFACE DUST ON TROPICAL PLANTS Consistent with the previous year's project proposal, we have investigated in some small-scale experiments the effects of dust contamination in the tropical forest. The purely mechanical experiments show little of interest, at

least on the small-scale experimental level, and have been discontinued. In the biological effects experiments, however, preliminary results suggest that there may be definite detrimental results from relatively small inputs of soil. When the walls of bromeliads were closed by soil applications, preliminary data show that the rate of new leaf production may have been slowed. Plants with thinner treatment have thus far remained unaffected. Metabolism and photomorphogenesis of soil-covered leaves is variable. In some cases, we have seen apparent increases in metabolism by as much as ten percent. In others, a decrease of the same magnitude was found. The most interesting experiment involves covering the surface roots of plants in this forest with soil. In this plot, we have clearly produced accelerated leaf fall and death of some small trees by covering the roots with six inches of soil. The effects, however, are chronic rather than acute and the plot should be observed for a considerably longer time to establish the effects reliably. The exploratory

experiments do not justify an attempt at this time to carry out a major forest prism contamination experiment. While such an experiment may become desirable in the future, more data from the small-scale experiments is needed to demonstrate the need. ---Page Break--- » a) 3) 4) We will continue the small-scale experiments as follows: Bromeliads: The soil treated bromeliads will be observed monthly along with their matched control plants for the production of new leaves and for the death of old leaves. Palms: The soil treated palms will continue to be observed monthly for leaf production, stem growth, and leaf death. The same measurements will be made also on the matched control plants. Metabolism: Respiration and photosynthesis will continue to be measured for soil-covered leaves until a reliable effect has been demonstrated or until it has been shown that such treatment has no effect. Soil plots: The soil-covered plot will be observed monthly along with matched control plants, and the following variables will be measured on all plants: 1) stem growth, 2) leaf fall, 3) leaves on ground, 4) death of plants. The soil covering will also be checked periodically to determine whether there is any tendency for the plants to send their new roots back to the surface. If time and manpower permit, we will attempt to make metabolism measurements on the plants in the plot as compared with the control plants. ---Page Break--- aT [NORTH CAROLINA PARTICIPATION In addition to the consultant services of J. Odum of the University of North Carolina, the Project will continue to participate in the completion of a project being carried out by him in North Carolina. This is the publication of the book A Tropical Rainforest. The principal project support required for the book publication involves secretarial services for final manuscript preparation. The project will provide a secretary for this purpose to be employed at the University of North Carolina for 6 months, starting July 1, 1967. This is arranged as in the previous year by

purchase order to the University for the amount of actual salary with no overhead charges included. The services section of the budget includes an item for $2,800 for this purpose. ---Page Break--- Present the station continues to be fully utilized for project activity 38 ‘EL VERDE FIELD STATION. The physical facilities of the EL Verde field station have been described in some detail in previous proposals and annual reports. This utilization includes data recording in the Project instrument room, drying and grinding of field specimens for chemical and radiochemical analyses, final preparation and adjustment of field apparatus, preparation of low radioactivity specimens from tracer experiments for counting, counting of such specimens, housing for project herbarium, housing of project insect collections, and office space for project personnel. Experience from several years of operation of the Field site now shows that such operation corresponds to a various industrial situation. In order to continue operating the site it will be necessary to make investments leading to improved safety in the area. In particular, the site electrical system must be completely re-evaluated and rebuilt or else abandoned. There now exist 110 volts power cables lying haphazardly on the ground. These have been in place for more than three years and could deliver

a lethal electric shock to any person inadvertently touching them. Cables must be replaced where necessary, they must be encased in approved conduit, and the entire system must be provided with appropriate electrical safety devices to minimize shock hazard. Rebuilding of this system will take place under the closest supervision of FHMC Health Services Division. Existing trestle must be rebuilt with concrete steps and cable handrails installed at particularly steep portions; the ---Page Break--- 39 trail to the upper parking lot which is frequently used for official visitor access must be completely graveled with steps and bank retained installed in hazardous regions, the upper

River crossing must be rebuilt. Fences, gates, and signs must be installed to exclude unofficial project visitors and tourists from the research area. Guanis must be erected around the giant cylinder fan and engine. The cost of operating the NL Vorde Station, including installation of required safety provisions, is detailed as follows: Item Cost Limit year for maintenance, driving, and special safety provisions, including overhead and fringe benefits. 6,000 Services. Vehicular 500 Power 4,200 Materials: gravel, wire, fencing, cable, cement, for routine and special safety applications. 1,000 Total 11,700 ---Page Break--- ESTIM SOURCE; A PRELIMINARY PROPOSAL. Definite plans have not yet been formulated for future use of the source. Possibilities for its use are detailed in previous proposals. 1) Loan to Canada for Chali River spruce forest evaluation, 2) Reef irradiation, 3) Elfin forest irradiation. Alternative (1) is no longer being considered while (2) and (3) are still possibilities. A fourth and highly feasible possibility is now presented. As was suggested by Dr. Howard Andrews (Assistant Director for Health Physics RIC), the source could be placed in the center of the giant cylinder for an anticipated short-term irradiation with the objective of measuring the effects of irradiation on photosynthesis, respiration, and transpiration. Under this plan, it would not be necessary to irradiate until lethal effects became visible in the plants. Irradiation until definite patterns of alteration in these biological functions had been established would be sufficient. At least one year lead time would be required before this experiment could be carried out. This time is required to establish patterns of variation of these functions in the undisturbed forest, and to do further reliability and performance testing of the giant cylinder steel, with the hope of improving the performance or establishing correction factors for the known at cases that occur. Final decision to do the radiation experiment would be deferred.

untii project setentiste vere confident that the giant oylinter vas functioning properly. The experiment as outlined seens attractive for several reasons. 1) Tt would be the first attempt to measure the effects of radiation on ---Page Break--- a Biological functions at the ayaten level in the troptes. 2) Tt could be carried out on the existing project site vith many of the facilities and staff involved with the first radiation experiment still intact, 3) It could be done at less total cost than any of the other alternatives ao far Atecussea. The proposed experinent could be carried out unter Terrestrial Boology Administration, “Extensive ecological surveys carried out pric to the frst radiation expertsent vould not be required ond the proposed experiment could ‘be handled internally vith the addition of one professional level investigator and one or tvo field vorkers to the staff. Outside consultant's would be required only for special mossurenents euch as dosinetry. The experinent could be done vithout Joopariizing other project ‘progrens in ninerel cycling or radiation recovery since the source may be exposed only 2 to 3 weeks. Wile the exyertnent vould result in irradiation of the first radiation center the effects vould be slight since no effects ‘were found in the giant cylinder aite from the fret exposure and since the proposed exposure is for only 1/3 the duration of the firet. This te not a funding proposal for thie experiment. This outline 4s offered as a basis for future informal @igeussion only. In the event ‘these discussions lead to @ decision to do the experinent a formal propeal, AML be submitted, ---Page Break--- 6) SCLEMTIFIC PERSOMTEL 2) Jey R, Mine, M.D. Chief Scientist I and Director, Terrestrial 2) cart F. 3) George

Ecology Project. Experience in plant-soil relationships in agriculture crops; radiochonfcai an} instrumental investigations of thermal neutron irradiated scils end planta; investigations of fallout radionuclides in the enviroment utilizing gama-rey spectrometry and raiicchenical

separations, Formal training in Soil Chemistry and Analytical Chemistry. Full time. Jordan, Ph.D. Associate Scientist I, Terrestrial Ecology Project. Experience and formal training in Plant Ecology and Soil Science. Previous work and publication in the effects of fire on old field vegetation in New Jersey, Developer of simple lysimeter system for the measurement of water and soil flux through soil profiles. Full Time. S. Dremy, MS (Ph.D pending 1967). Associate Scientist I, Terrestrial Ecology Project. Experience and formal training in biology and ecology with special interest in animal behavior. Previous work and publications on the behavior of snakes and the vocal behavior of Puerto Rican Coqui, Self-taught electronics expert with circuit design capability. Full Time. ---Page Break--- 43 7) SOME PERSONNEL Henri Watson. Research Associate I. Project Field Botanist. Present status doubtful due to serious injury on Project. If recovery permits is employable despite possible physical handicap due to specialized botanical knowledge. Use full time. Teigon Yercado Buxgoa Ras. Assistant I. Hipiia Rivera Santiago. AieJo Atreda Pinto. eine Rule Reyes. Charles Robert Venator (Great). Fd ‘eel Rossy 00h. Guintero Cinteéa 258. faa Josefina Correa 1004. Hida Rosa Bocobales. oof Noieés Purrilla Sosarto 00%. Suan Martine: Yatgonet Field Worker in Terrestrial Biology I. oof Derotes Martines dares Field Worker in Terrestrial Biology T 2004 TA) Project Viattora "mo Project makes less use of technical consultants than in the past due to the fact that our interestingly detailed studies cannot be exploited effectively by these persons in short term trips. These are however certain areas where consultant relationships are advantageous. Consultant contracts will be entered into with the following persons to enable them to make site visits. ---Page Break--- Dr. Howard J. Cius. Professor of Biology. University of North Carolina, Chapel Hill, Site visits to permit organization of Rainforest book publication and to serve as consultant in metabolism and energy.

budget Dr. Elizabeth Newnan. Associate Professor. University of North Carolina, Chapel Hill. Summer field for detailed study of termite populations and behavior in radiation center and for experimental determination of radio-sensitivity of termites. Dr. Joe Bintsten. Associate Professor. University of Georgia. Initiation of preliminary studies on possible role of epiphytes in nitrogen fixation. 8) OTHER FUNCTIONAL ASSISTANCE The project is continually funded primarily from the single ABC grant. During the past fiscal year an appropriation of $10,000 was received through AB channels from Battelle Memorial Institute to permit fallout radiomclide studies in Panama and various on-site experiments in Puerto Rico. Project obligations resulting from this appropriation were fully accounted by the submission to Battelle of two progress reports covering the work performed. No winter arrangement has been negotiated for the forthcoming fiscal year. The project is subsidized to a certain extent by the participation of consulting scientists since it does not usually cover the full cost of research performed. In the usual arrangement, the project covers the costs of transportation and a nominal per diem for the participant while the home institution continues to pay the salary and costs of continued effort relating to the research outside of Puerto Rico. ---Page Break--- 45 9) PROGRESS, FACILITIES, EQUIPMENT, AND MATERIALS TO BE FURNISHED BY CONTRACTOR The main facility, the forest area and the El Verde field station, including a house for visiting personnel are furnished through a 5-year interagency agreement between the U.S. Department of Agriculture administering the Luquillo forest area and the Atonte Bureau Commission. Another residence house, Cionaga Alte house, 5 miles from the El Verde station and also on Rt. 186 is available by an interagency agreement between FRIC and U.S. Dept. of Agriculture. The Institute of Tropical Forestry furnishes 2 rooms in Rio Piedras and some

specialized equipment. Some utilities of

Foresizy Building is paid by FRIC. A laboratory building, 600 square feet, at FL Verde; an office and two laboratory rooms in the Biomedical Building at Rio Piedras; and considerable equipment previously bought for this project are furnished according to the provisions of the general operating contract between ABC and the University of Puerto Rico for the Puerto Rico Nuclear Center. ---Page Break--- 20) BncEr Salaries (Itemized in Appendix A) Revel Material and Supplies Services Overhead (65% of Salaries) Total Operating Cost Equipment (Itemized in Appendix B) Total Project Cost 98,000 5,000 10,000 21,000 0,000 184,000 112,000 196,000 100,600 6,000 312,900 28,000 60,000 193,000 30,000 203,000 ---Page Break--- Salary Budget 2) Salaries Jerzy R. Wine, Chief Scientist T $1,250/mo, full time Carl F. Jontan, Associate Scientist T $916.66/mo, full time George 2. Drewy, Associate Scientist T $791.66/mo, full time Henri W. Watson, Res. Associate I $566.66/mo, full time Yelson Merealo Burgos, Res. Assist. II $416.66/mo, full time Atomic Absorption Analyst, Full time Charles R. Venator, Res. Assist. T $275.00/mo, 50% time, graduate student Estrada Pinto, Res. Assist. T $302.50/mo, full time Eipidie River Santiago, Res. Assist. T $302.50/mo, full time Hilda Hoon Bocobaies, Res. Assist. I $230.00/mo, full time Sete Role Reyes, Res. Assist. I $250.00/mo, full time Gttberte Cinteén Valero, Res. Technician $2.75/hr. Approx. $1,040.00/yr, Grad. ‘eel Roary, Res. Technician $300.00/mo, full time ‘oa Josefina Correa Lépex, Adm. Secretary II $302.50/mo, full time T 35,000 31,000 94,500 6,800 5,000 5,300 2,200 3,630 3,630 2,760 3,000 2,680 3,600 3,630 ---Page Break--- Moisés Porrilia Rosario, Maint. Foreman $300.00/mo, full time Juan Martinez Maisonet, Field Worker $208.33/mo, full time Doroteo Martinez García, Field Worker $208.33/mo, full time Total Salaries Fringe Benefits (9.36%) Lump sum for rats Total ad oumer assistant 3,600 2,500 2,500 85,230 1,870 4,900 98,000 ---Page Break--- Appendix B euzent || tet watts 0 Pu

amiciee 00 | (3 Peer supplies 450 | mpiy Rrenontar tum i rho ww Laboratory Shaker Combustion Furnace Hollow Cathode Lamps (5) Conductivity Cells (5) ‘Twenty five liter Dewars for liquid W (2) 250 volt ter Ban MLLa 300 (citaey cutting ~~ 505~ Barnatend Still for distilled water 206 ‘Total 12,000 ---Page Break--- 22) AVIEEWTICATTON i ar Signature Title Signature Tele ae te ---Page Break---