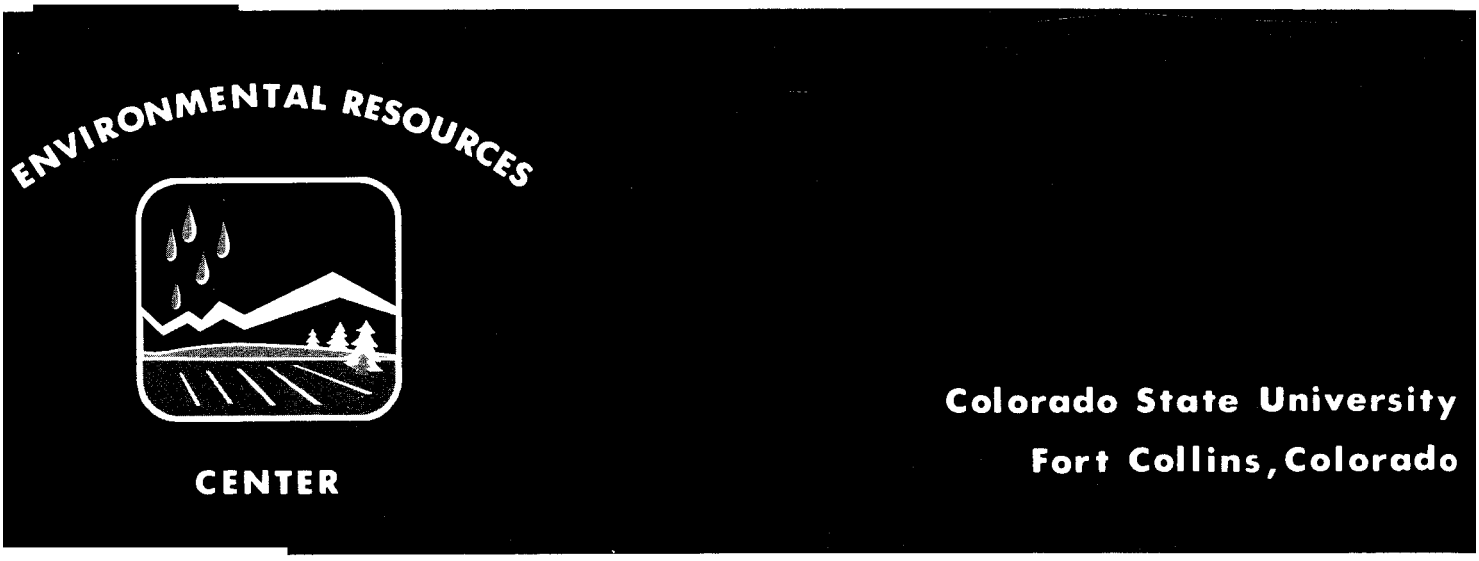
Inventory of Current

WATER RESOURCES RESEARCH at Colorado State University

July 1973



Information Series
No. 8

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PART I

CSU WATER RESOURCES RESEARCH

Section I

WATER CYCLE

THE DESIGN OF DESCRIPTIVE AND THEORETICAL HAILSTORM MODELS 1

Objectives

One of the final goals of the research is the synthesis and formulation of the field measurements into descriptive models of the various hailstorm stages of initiation, growth, and dissipation. The strong interaction between theoretical models and field measurement data will provide the formulation of more realistic mathematical models of the various hailstorm growth stages.

Approach

Computations on interacting cloud and environmental parameters will be made on the CSU CDC 6400 computer. The mathematical models will serve essentially two purposes: 1) provide a greater insight into the conditions which control severe storm initiation, growth, and dissipation; and 2) provide an independent means of deducing the modification effects of various hailstorm seeding techniques on a computer with the derived mathematical models. A study is in progress of the moisture distribution and flow patterns as they relate to the development of high plains hailstorms. An Airborne Atmospheric Data 3B System (AADS) provides wind component measurements. A F-101B and other aircraft are equipped with a MINUTEMAN-III inertial guidance system.

Principal Investigator: P. Sinclair

Department Involved: Atmospheric Science

Sponsor: NCAR

ANALYSIS OF COLORADO PRECIPITATION 2

Objectives

To conduct a systematic study of the distribution of precipitation across Colorado. The analysis will include study in both time and space dimensions to determine precipitation trends, variations that exist in precipitation records, and how the annual regime of precipitation is determined.

Approach

The study is based upon an analysis of existing precipitation records in Colorado. It involves the western Colorado oil shale region, western slope, and eastern slope and plains.

Principal Investigator: S. Cox

Department Involved: Atmospheric Science

Sponsor: OWRR (OWRR-A-018-COLO)

HYDROMETEOROLOGY 3

Objectives

Investigate the atmospheric water balance of the Colorado River Basin.

Approach

The relationship between winter season accumulation and the resulting runoff is being determined. Studies also are underway of the magnitude of the daily evaporation that occurs over the basin so that the effect of this parameter on the water resource can be estimated. The efficiency of orographic clouds and large storms were researched to evaluate the effect of cloud seeding on the physical system.

Principal Investigator: S. Cox

Department Involved: Atmospheric Science

Sponsor: CSU Experiment Station

SNOW-AIR INTERACTION AND MANAGEMENT OF MOUNTAIN WATERSHED SNOWPACK 4

Objectives

1. Design and carry out an experiment to evaluate the interface transport of water vapor between the snow surface and the atmosphere.
2. Carry out an experiment to test the effectiveness of procedures for increasing the water supplies derived from the alpine zones of mountain watersheds.

Approach

Research is conducted at two existing CSU facilities engaged in atmospheric research and snow hydrology: the College of Forestry and Natural Resources mountain site at Pingree Park, Colorado and the Department of Atmospheric Science observatory at Climax, Colorado.

The research includes a study of interface processes in which snowpack and overlying atmosphere are considered and the energy budget evaluated. Snow management procedures over alpine areas also are studied as a technique for increasing water supply.

Principal Investigator: J. Meiman, S. Cox

Departments Involved: Watershed Sciences, Atmospheric Science

Sponsor: OWRR (OWRR-B-073-COLO)

PREDICTION OF WATER YIELD FROM SMALL ROCKY MOUNTAIN WATERSHEDS 5

Objectives

1. Determine the hydrologic characteristics of the various physiographic, edaphic, and biotic components of typical small watersheds in the Rocky Mountain chain with respect to yield.
2. To determine the effect of the various combinations of site variables on the precipitation-runoff relationship and devise prediction equations for this relationship.
3. To identify specific areas within the watershed which have potential for treatment to increase water yield, and on the basis of present knowledge, estimate the maximum increase which could be anticipated.

Approach

A small typical mountain watershed has been selected and subdivided into logical response units based on soils, vegetation, topography, geology, and precipitation inputs. Storage, losses, and surpluses will be determined for each defined response unit, and excess water will be routed through the watershed and combined on the computer to estimate yield.

Principal Investigators: L. Miller, W. D. Striffler

Department Involved: Watershed Sciences

Sponsor: CSU Experiment Station

CONSTRUCTION OF A COMPUTER-BASED LANDSCAPE MODEL OF THE CACHE LA POUDRE WATERSHED 6

Objectives

1. Construct a high resolution computer model of the basic landscape features of the Little South Fork watershed of the Cache la Poudre River including

the characteristics of elevation, slope, aspect, geologic substructure, vegetation types, stand density, and stream net.
2. Utilize this model of the landscape as the input to a watershed simulation model and compare to conventional methods of outlining hydrologic units for such models.

Approach

Aircraft-level remote sensing techniques are employed to obtain up-to-date maps of characteristics of the basin, not already available in map form, which are needed as overlays in the landscape model. A ground test will be prepared with range comparable in scale, computer accessibility, and detail to the resolution of the ERTS (Earth Resources Technology Satellite--Model A) data to be available for this basin in a digital form.

Principal Investigator: L. D. Miller

Department Involved: Watershed Sciences

Sponsor: CSU Experiment Station

GRASSLAND HYDROLOGY 7

Objectives

1. To evaluate the water balance of native shortgrass prairie under four levels of long-term grazing (zero, light, moderate, and heavy).
2. To investigate in detail the processes of precipitation, infiltration, soil water redistribution (evaporation, transpiration, and percolation), and overland flow.

Approach

The approach involves measuring the components and processes of the hydrologic cycle on eight microwatersheds. Rainfall, soil water, and overland flow are measured with recording raingage, neutron probe, and H-flume/Fisher-Porter recorder respectively. Infiltration is measured using simulated rainfall on small plots. Soil water redistribution is studied using thermocouple psychrometers, resistance units, and neutron probe. These results are compared against the measurements of a 10 m diam, 150 cm deep undisturbed weighing lysimeter.

Principal Investigator: W. D. Striffler

Department Involved: Watershed Sciences

Sponsor: NSF -Natural Resources Ecology Laboratory

THE EFFECT OF ENVIRONMENTAL STRESSES ON THE DYNAMICS OF A SHORTGRASS ECOSYSTEM 8

Objective

To study the effects of nitrogen and water stress on phytosocial characteristics, above and below ground herbage dynamics, soil water dynamics, and other associated characteristics of a shortgrass ecosystem.

Approach

The application of environmental stresses to ecological systems is an efficient approach to studying interrelationships of structure and function of these systems. The two environmental stresses applied to the shortgrass prairies at the Pawnee Site (U.S. - IBP Grassland Biome) was the addition of water and nitrogen. These "stresses" represent environmental conditions other than those encountered in the development and normal function of the ecosystem.

Principal Investigator: P. L. Sims

Department Involved: Range Science

Sponsor: NSF - Natural Resources Ecology Laboratory

EXPERIMENTAL INVESTIGATION OF SMALL WATERSHED FLOODS 9

Objectives

Experimentally study the relationship between overland and subsurface flow hydrographs with a view to developing practical engineering methods for recognizing these two components in a runoff hydrograph.

Approach

The CSU rainfall-runoff facility will be covered with a layer of gravel to behave as a permeable acquifer. The surface will be ultimately covered by other soil or vegetated surface material to be able to study a larger range of potential infiltration capacities.

Principal Investigator: E. Schultz

Department Involved: Civil Engineering

Sponsor: CSU Experiment Station

HYDROLOGY OF SMALL WATERSHEDS 10

Objectives

To relate changes in the unit hydrograph to the physical alterations in the watershed caused by agricultural and urban developments.

Approach

The existing small watershed flood data file will be expanded to include from radically different watersheds data such as hydrographs from snow melt, urban areas, and watersheds having inordinately large subsurface flow.

Principal Investigator: E. Schultz

Department Involved: Civil Engineering

Sponsor: CSU Experiment Station

LARGE CONTINENTAL DROUGHTS 11

Objectives

To study the physical and probabilistic prediction of droughts as well as engineering, economic, and social impacts of large continental droughts.

Approach

Physical predictability of droughts has been investigated by relations of variables preceding each other in time. Probabilities of large droughts are studied by the application of stochastic processes. Simulation techniques are used to study probabilities of regional droughts. Uncertainties in droughts are specially analyzed by advanced methods. It is found that it is nearly impossible to predict droughts from known immediate physical phenomenon. The ocean temperature conditions used as predictors do not offer a prediction possibility of more than one month in advance. A technique has been developed for simulating large numbers of station series of precipitation in a region. It has been shown that historic droughts are often nonrepresentative of the samples in which they have been observed, and a technique is being developed for determining representative droughts.

Uncertainties in drought information on economic decisions are evaluated.

Principal Investigator: V. Yevjevich

Department Involved: Civil Engineering

Sponsor: NSF

STOCHASTIC PROCESSES IN WATER RESOURCES 12

Objectives

To provide a better understanding of patterns in time and space of river flow, precipitation, water uses, and other hydrologic and water resource processes, and river flow regulation problems and methods. Water requirements, water deliveries, water consumption, and water return are stochastic processes that need investigation as the realistic time distribution of outputs of various water systems.

Approach

By using large samples of data on runoff, precipitation, and water quality, deliveries, and consumption, and of other variables, attempts are being made to develop mathematical and/or mathematical-physical models which describe the dependence in sequence and in space of these variables. This project is a broad one involving 16 research areas.

Principal Investigator: V. Yevjevich

Department Involved: Civil Engineering

Sponsor: NSF

INVESTIGATION OF WATER RESOURCES IN KARST REGION 13

Objectives

1. Mathematical modeling of hydrologic processes in Karst and the determination of the responses of various Karst environments to inputs of water quantity and quality.
2. Application of a system approach to water resources engineering and planning under conditions necessitated by particular phenomena in Karst regions.
3. Use of field data for further scientific generalization about Karst water resources phenomena.

Approach

Computer technology will be used extensively.

Principal Investigator: V. Yevjevich

Department Involved: Civil Engineering

Sponsor: NSF

BOUNDARY LAYER FLOW OVER NONUNIFORM ROUGHNESS 14

Objectives

1. To develop a body of fundamental knowledge on the physical nature of shear flows with complex boundary conditions which lead to three-dimensional mean motion.
2. To firmly establish similarity criteria relating laboratory shear flows to corresponding flows (winds) in the lower layer of the atmosphere.
3. To develop maximum potential use of low-speed environmental wind tunnels for the purpose of predicting local winds at specific sites and for specific purposes.
4. To expand a unique capability for research on and solution of problems associated with environmental winds, including effects on water resources.

Approach

Studies will be made of shear flow over:
- plane surfaces with nonuniform roughness and temperature
- mountain-like irregularities
- a plane surface with momentum injection by jets

Studies also will be made of flow simularity and comparisons of atmospheric and laboratory shear flows.

Principal Investigator: J. Cermak

Department Involved: Civil Engineering

Sponsor: Office of Naval Research

SYSTEMATIC TREATMENT OF INFILTRATION WITH APPLICATIONS 15

Objectives

To develop a mathematical model of infiltration capable of responding to any spacial and temporal pattern of rainfall or its lack.

Approach

Controlled laboratory experiments are being conducted of infiltration in vertical soil columns of various depths with heterogeneities in the vertical or in the horizontal direction. Field infiltration tests also are being made. The BRUSTKERN model or the curve fitted version of it will be linked to a watershed model.

Principal Investigator: H. Morel-Seytoux

Department Involved: Civil Engineering

Sponsor: OWRR (OWRR-B-070-COLO)

MECHANICS OF FLOW AND SEDIMENT TRANSPORT 16

Objective

To obtain and analyze field measurements of hydraulic and sediment variables in a sand-bed channel. To study sediment transport, resistance to flow, bed configurations, and scour and fill in a sand-bed channel under equilibrium and nonequilibrium flow conditions.

Approach

Data were collected to describe the hydraulic and sediment transport variables for a range of flows and bed configurations. Data obtained included sounder profiles of the channel bed, vertical velocity profiles, sediment concentration profiles, samples of bed material, and water-surface slope.

Principal Investigator: J. Bennett

Department Involved: Civil Engineering

Sponsor: USGS

DETERMINATION OF URBAN WATERSHED RESPONSE TIME 17

Objectives

To systematically assemble, store, and analyze flood data from 30 Denver urban watersheds.

Approach

1. Assemble available basic data on gaged Denver urban watersheds in computer oriented form.
2. Derive unit hydrographs from the observed floods.
3. Compute watershed response time for the urban floods.
4. Compare the various methods of deriving the response time.

Principal Investigator: E. F. Schultz

Department Involved: Civil Engineering

Sponsor: U.S. Army Corps of Engineers

DEVELOPMENT OF MODELS FOR PREDICTING SEDIMENT YIELD FROM SMALL WATERSHEDS 18

Objectives

To develop prediction models for estimating sediment yield from a broad spectrum of source areas and watersheds.

Approach

The models, based on physical parameters, will provide estimates of sediment for summer and winter seasons and water years as well as for major runoff events. Validation of the models will be accomplished by testing the predictions against actual measurements. The study will be coordinated with other modeling studies of water yield and flood peaks, nutrient balance, and soil formation rates.

Principal Investigator: D. Simons

Department Involved: Civil Engineering

Sponsor: USFS - Rocky Mountain Forest and Range Experiment Station

THEORY AND EXPERIMENTS IN THE PREDICTION OF SMALL WATERSHED RESPONSE - PHASE II 19

Objectives

To compare the computed runoff hydrographs resulting from the application of analytical methods of predicting the flood response of the watershed.

Approach

Mathematical models of watershed response to flood-producing rainfall are to be verified in the CSU outdoor experimental rainfall-runoff facility. The sensitivity of the predicted runoff to various types of sampling errors will be studied. The predicted runoff hydrographs obtained using a kinematic wave theory and several forms of the unit hydrography theory will be compared with the hydrography measured in the experimental watershed.

Principal Investigators: E. F. Schulz, V. Yevjevich

Department Involved: Civil Engineering

Sponsor: OWRR (OWRR-B-064-COLO)

STOCHASTIC ANALYSIS OF SEDIMENT BED TRANSPORT AND SEDIMENT BED FORMS 20

Objectives

To investigate:
1. Sediment transport rate
2. Development of bed roughness due to sediment bed forms.
3. River morphology which includes river regimes, channel stability, etc.

Approach

Sediment transport rate and the development of bed forms are examined from a combination of fluid mechanics principles and stochastic approaches.

Principal Investigator: H. Shen

Department Involved: Civil Engineering

Sponsor: NSF

EXPERIMENTAL AND SIMULATION STUDY OF TURBULENT SHEAR FLOW 21

Objective

To experimentally test Phillips' hypothesis for eddy viscosity. Phillips proposed a mechanism for the manner in which turbulent components support Reynolds stress in turbulent shear flow. The model is a generalization of Miles' mechanism for wind generated water waves in that each turbulent component is assumed to interact with the mean flow to produce an increment of Reynold stress at the "matched layer" of that particular component. The derivation is rather involved but leads to a simple relation between measurable turbulence, statistical properties and eddy viscosity.

Approach

A fully developed pipe flow will be used to test Phillips' theoretical deductions. Hot wire anemometers will be used in water flow to measure the required lateral intensities and space-time correlations over an identical Reynolds member range.

Principal Investigator: L. Baldwin

Department Involved: Civil Engineering

Sponsor: NSF

ANALYTICAL AND EXPERIMENTAL MODELING OF AVALANCHE RELEASE PROCESSES 22

Objectives

To utilize modern techniques of stress analysis to determine distributions of stresses in actual avalanche-prone snowpacks. Also to develop testing techniques that will provide reliable methods of predicting the release of avalanches where there are safety as well as economic hazards.

Approach

Stress and strain analyses of the snowpack will be made. The strains (and displacements) predicted by the analyses will be compared with the measurements in the actual snowpack. Possible failure criteria may be applied, and the actual behavior of the snowpack with respect to failure can be compared with the computer model. Success will be defined as the prediction of the actual failure within a 24-hour period.

Principal Investigator: F. Smith

Department Involved: Mechanical Engineering

Sponsor: Rocky Mountain Forest and Range Experiment Station

DYNAMICS OF FLOW INTO DRAINAGE FACILITIES 23

Objective

To analyze and describe the subsurface movement of water and those factors which affect it in the flow region of drainage facilities.

Approach

Two-dimensional physical models will be used to determine sensitivity of drainage behavior to soil hydraulic parameters. Results from model studies will be used to evaluate mathematical simulation of two-dimensional unsteady drainage.

Principal Investigator: A. T. Corey

Department Involved: Agricultural Engineering

Sponsor: CSU Experiment Station

AN EXPERIMENTAL STUDY OF SOIL WATER FLOW SYSTEMS INVOLVING HYSTERESIS 24

Objectives

To experimentally test the predictions of the analyses of hysteretic flow. To make measurements and observations of the behavior of selected hysteretic flow systems.

Approach

One-dimensional vertical flow columns of the selected soils are programmed through sequences of infiltration and redistribution-evaporation-drainage. Measurements of water content and hydraulic and pressure head are made using the above-mentioned techniques. Depths of wetting during infiltration, the duration of redistribution process, and the intensity of evaporation are varied. The gas phase pressure is measured and the effects of gas phase flow are examined. The observed behavior of the flow system will be compared with the predicted behavior based on one or more of the schemes for solving the flow equation for hysteretic flow and an evaluation of the prediction scheme will be made.

Principal Investigator: A. Klute

Department Involved: Agronomy

Sponsor: OWRR (OWRR-A-014-COLO)

MEASUREMENT, PREDICTION, AND CONTROL OF WATER MOVEMENT IN ARID SOILS 25

Objectives

1. To apply soil water movement theories to real situations with emphasis on land area bases.
2. To develop practical and easily applied instruments and techniques for evaluating soil water content, potential, and flow.

Approach

Diffusion rates of water vapor through gravel and sand have been used to provide first estimates of effects of such layers on retarding evaporation. Such treatments are then evaluated under field conditions, including measurement of downward water movement in the profiles.

Well logs in the State Engineer's Office will be used to estimate texture and water-holding capacity of strata above the water table and time required for recharge to be effective. Effects of surface treatments on water use by plants will be evaluated to develop the best treatments for increasing water use efficiency. The centrifuge-analytical balance method for measuring hydraulic conductivity of unsaturated core samples will be developed and evaluated as a method for estimating groundwater movement.

Principal Investigator: W. Kemper

Department Involved: Agronomy

Sponsor: CSU Experiment Station

INTERNAL PLANT WATER POTENTIAL AND PHOTOSYNTHESIS 26

Objectives

Determine the relationships between evapotranspiration as it influences internal plant water potential and the rate of photosynthesis.

Approach

The rate of water loss by rose plants is determined and correlated with the internal plant water potential. Radioactive CO_2 applied to known areas of individual leaves provides the rate of $^{14}CO_2$ uptake as a measure of the photosynthetic rate. From knowledge of the effect of water potential on photosynthesis, the environmental conditions required for maximum food production should be predictable with much greater accuracy.

Principal Investigator: J. Hanan

Department Involved: Horticulture

Sponsor: Colorado Flower Growers' Assn.

MAN-INDUCED AND NATURAL EROSION AND DEPOSITION IN SEMIARID VALLEYS 27

Objectives

Locate within semiarid valleys those areas most susceptible to either erosion or deposition. Relate principles of channel erosion and deposition to gully and flood problems in Colorado.

Approach

Repeat surveys will be made in channels in which active erosion and/or deposition was studied about 14 years ago. Sites of natural erosion and aggradation will be studied in detail, and the sedimentary character of channels and recent deposits will be documented. An attempt will be made to relate erosional and depositional processes to the geomorphic characteristics of the drainage systems.

Principal Investigator: S. Schumm

Department Involved: Geology

Sponsor: CSU Experiment Station

DRAINAGE BASIN EVOLUTION 28

Objectives

To document the erosional development of a model drainage system and to relate changes in the hydrologic character of the system (runoff, sediment yield, flood peaks) to the morphology of the system.

Approach

A 30-by 50-foot container (Drainage Evolution Research Facility) has been constructed and filled with a mixture of sand, silt, and clay. Simulated precipitation will be applied at varying intensities. Precise mapping and photography will document the landform changes. Instruments have been installed to record precipitation, runoff, and hydrographs.

Principal Investigator: S. Schumm

Department Involved: Geology

Sponsor: U.S. Army Research Office

MODEL STUDY OF RIVER PATTERNS 29

Objectives

To generate a meandering channel in a flume by changing sediment load and discharge characteristics. This will enable investigators to determine the influence of sediment size and sorting on river patterns and channel morphology. They also will investigate the effect of changes in the ratio of suspended load to bed load on channel character.

Approach

Sediment and water will be introduced into the 24-by 100-foot long flume at the CSU Engineering Research Center. Changes in bed configuration and alignment will be measured and recorded photographically. Water sediment and discharges from each of four types of sediment will be measured.

Principal Investigator: S. Schumm

Department Involved: Geology

Sponsor: NSF

Section II

WATER SUPPLY AUGMENTATION, CONSERVATION, AND CONTROL

HYDRAULICS OF SURFACE IRRIGATION 1

Objectives

To provide fundamental surface-irrigation design understanding through investigation of the hydraulic characteristics of surface flow.

Approach

Extensive field data have been collected from irrigation furrows on many sites covering a wide range of soil conditions. Analysis will be published incorporating the regional project findings.

Principal Investigator: W. F. Hart

Department Involved: Agricultural Engineering

Sponsor: CSU Experiment Station

IMPROVEMENTS IN MOVING SPRINKLER IRRIGATION SYSTEMS FOR CONSERVATION OF WATER 2

Objectives

Infiltration rates of soils under sprinkler irrigation will be studied, particularly as they are affected by time-varying application rates of the type which are found under moving sprinkler systems.

Approach

Design and operational guidelines for the various moving systems will be established by mathematical simulation. The effectiveness of existing types of sprinkler systems will be compared with respect to application rates, uniformity of water application depths, and ability to match the intake characteristics of various types of soils.

An economic analysis will be made of existing sprinkler systems designs and modifications of existing equipment in terms of their irrigation efficiency and water conservation value.

Principal Investigator: D. L. Miles

Department Involved: Agricultural Engineering

Sponsor: OWRR (OWRR-B-039-COLO)

WATER MANAGEMENT RESEARCH IN ARID AND SUBHUMID LANDS 3

Objectives

To enhance the university's capacity to respond to specific problems of international development related to arid lands, and to advance its level of competence in the appropriate disciplines. The general objective is to increase food production in the arid and subhumid lands of less developed countries.

Approach

These objectives are pursued through the departments listed below. The studies are initiated at CSU and then transferred to West Pakistan.

Principal Investigators: M. L. Albertson, W. Schmehl, D. McWhorter, E. Richardson, R. Tinnermeier, G. Jones, D. Freeman

Departments Involved: Civil Engineering, Agronomy, Agricultural Engineering, Economics, Political Science, Sociology

Sponsor: AID

NUMERICAL SIMULATION OF OROGRAPHICALLY INDUCED PRECIPITATING CLOUDS 4

Objectives

The primary objective of this project is to develop a numerical model to simulate the life cycle of a cold orographically induced precipitating cloud.

Approach

The project is being carried out in two phases. In Phase I, a model is formulated which does not allow the condensation products to fall out of the air. In Phase II, the condensation products will have a finite fall velocity.

Principal Investigator: J. Peterka

Department Involved: Civil Engineering

Sponsor: NSF

AN EVALUATION OF THE EXTENDED AREA EFFECTS PROBLEM AS RELATED TO THE NATIONAL HAIL RESEARCH EXPERIMENT 5

Objectives

To develop and apply specific tests which can be used to determine if weather modification on a scale of social or economic significance occurs in areas outside of the NHRE seeded area.

Approach

1. Precipitation changes are evaluated using existing precipitation networks.
2. Cloud and heating change evaluations are made using satellite data.
3. Aerial extension of precipitation analyses are made using radar.

Principal Investigator: L. Grant

Department Involved: Atmospheric Science

Sponsor: NCAR

SIGNIFICANCE OF CUMULONIMBUS MOMENTUM TRANSPORT FOR ATMOSPHERIC PROCESSES 6

Objectives

To identify the vertical momentum transports by cumulus clouds. This should improve one- and two-day forecasting in the tropics where cumulus momentum takes place.

Approach

Large samples of upper air and rainfall information are taken on a daily and monthly basis. Heavy rainfall and thunderstorm activity is also studied in association with environmental cumulus potential buoyancy, vertical shears, and height deviation on the pressure surfaces.

Principal Investigator: W. Gray

Department Involved: Atmospheric Science

Sponsor: NSF

LABORATORY CLOUD SIMULATION TO SUPPORT WEATHER MODIFICATION AND FIELD RESEARCH 7

Objectives

1. Test cloud seeding devices.
2. Assist researchers desiring use of Simulation Laboratory facilities.
3. Describe the effect of composition on the nucleation of characteristics of silver iodide.
4. Refine and extend usefulness of cloud chambers and related equipment for research and testing purposes.

Principal Investigator: L. Grant

Department Involved: Atmospheric Science

Sponsor: NSF

ROCKY MOUNTAIN OROGRAPHIC CLOUD PRECIPITATION AND MODIFICATION 8

Objectives

To acquire an increasingly complete understanding of cold orographic clouds, their associated precipitation, and the changes in their characteristics and processes when artificial nuclei are introduced. This includes the determination of the precipitation potential from cloud modification and the development and evaluation of technology required for implementation of operational programs.

Approach

Continuing investigation of cloud processes and their modification.

Principal Investigator: L. Grant

Department Involved: Atmospheric Science

Sponsor: NSF

HYDROMETEOROLOGICAL RESEARCH 9

Objectives

To evaluate the water resources of West Africa as a function of the hydroclimatological regime and the large scale atmospheric circulation. To determine the demand, present and projected supply, control, and quality management of the water resources. To develop the concept of a water resource system and the most efficient approach to water development, aimed to meet the needs and to benefit the economy, society, and the environment.

Approach

Data collection, data analysis, and optimum design of water resources systems.

Principal Investigator: E. Reiter

Department Involved: Atmospheric Science

Sponsor: NSF

MANAGEMENT OF COLORADO MOUNTAIN LANDS FOR INCREASED WATER 10

Objectives

1. To test snowmelt acceleration materials and techniques on a large-scale (10-acre cirque glacier) treatment basis.
2. To complete field testing of continuous method of gaging streamflow previously developed.
3. To evaluate the water yield benefit expected from operational conversion of lodgepole pine forest to herbaceous vegetation.

Approach

1. Runoff from two segments of the cirque glacier will be compared for calibration purposes. One segment will be treated with snowmelt acceleration materials if sufficient calibration is obtained.
2. Hydrographs obtained by the continuous dye dilution methods are compared to hydrographs obtained from sharp-crested weirs on two Colorado mountain streams.
3. Three pairs of plots approximately three acres in size will be compared before and after the center one-acre portion on each of three plots is clearcut.

Principal Investigator: J. Meiman

Department Involved: Watershed Sciences

Sponsor: USBR

SOIL, WATER, AND PLANT INVESTIGATIONS AT HIGH ELEVATIONS 11

Objectives

To study the soil, water, and plant resources of the meadow as a means of obtaining greater efficiency in the production of forage.

Approach

The integrated effects of soil fertility, climate, and plant development are evaluated in terms of forage production at high elevations through laboratory, growth chamber, greenhouse, and field studies.

Principal Investigators: C. Rumberg, E. Siemer, C. Townsend, R. Whitney

Departments Involved: Agronomy, CSU Experiment Station, USDA-ARS

Sponsor: CSU Experiment Station

IRRIGATION WATER EFFICIENCY 12

Objectives

To evaluate the influence of amount and timing of irrigation on crop development, total consumptive use, crop yield, and irrigation efficiency in order to develop practices for maximum production from limited supplies of water.

Approach

Irrigation treatments will be used in field studies to establish various levels of soil water availability at specific periods of crop development. Plant growth processes and water use will be studied during the development periods and for the entire growing season. Instrumentation will be used to measure soil water changes, evapotranspiration, irrigation, and natural precipitation. Total seasonal water use and crop yields will be used to evaluate irrigation water efficiency as

influenced by irrigation application practices.

Principal Investigator: R. E. Danielson

Department Involved: Agronomy

Sponsor: CSU Experiment Station

PREDICTION OF NITROGEN FERTILIZER REQUIREMENTS OF SUGAR BEETS BY SOIL ANALYSIS 13

Objectives

To evaluate the effectiveness of NO_3N soil tests in predicting the fertilizer nitrogen requirements of sugar beets.

Approach

Randomized blocks utilizing four replications and four rates of N will be established at each site in the high plains area of northern Colorado. Yields of roots and tops, sucrose percentage of roots, and nitrogen contents of roots and tops will be determined on an individual basis.

Principal Investigators: J. Reuss, A. Ludwick

Department Involved: Agronomy

Sponsors: Great Western Sugar Co., Grower-Great Western Research Committee, Inc., CSU Experiment Station

QUANTIFICATION OF WATER-SOIL-PLANT RELATIONS FOR EFFICIENT WATER USE 14

Objectives

1. To determine relations of plant water stress to metabolic processes, growth, and composition.
2. To utilize quantitative water-soil-plant relations research to improve criteria for scheduling irrigations to achieve optimum water use efficiency.

Approach

Controlled environment will be used to evaluate methods for developing and maintaining water stress levels in plants. The relative influence of water stress per se and the mathematical methods used in developing stress will be evaluated in terms of plant response. Extrapolation of laboratory results to field conditions will be evaluated. Emphasis will be directed toward measuring the influence of time and degree of plant water stress on net photosynthesis and transpiration in order to evaluate water use efficiency by plants.

Principal Investigator: R. E. Danielson

Department Involved: Agronomy

Sponsor: CSU Experiment Station

COMMERCIAL FERTILIZERS, CROP RESIDUES, AND IRRIGATION PRACTICES ON THE GROWTH OF POTATOES 15

Objectives

1. Compare the effect of various commercial fertilizers as sources of plant nutrients on the growth and quality of potatoes.
2. Determine the effect of residue management on soil fertility, productivity, and pathogen population in a barley-potato rotation.
3. Determine the effect of irrigation practices and fertilizer application methods on potato growth and quality.
4. Correlate evaporation and soil-moisture tension data for irrigation scheduling.

Approach

Various fertilizer sources, crop residue managements, and irrigation methods studies are underway to determine their effect on growth and quality of potatoes, nutrient content, and feasible irrigation practices.

Principal Investigator: J. G. Walker

Department Involved: Agronomy

Sponsor: CSU Experiment Station

WATER CONSERVATION PRACTICES IN PROTECTED HORTICULTURE 16

Objectives

To investigate and assess feasibility of various cultural practices in greenhouse production that will reduce consumptive water use without concomitantly reducing yields.

Approach

Several hydrophyllic root substrate additives were tested for water retention in order to reduce irrigation frequency. Frequency of irrigations and length of individual irrigations were evaluated in order to reduce the water loss by drainage. Impermeable layers were utilized to eliminate evaporation from the soil surface. Other approaches are: reducing transpiration by chemical applications, increasing CO_2 levels, and complete recycling of the irrigation solution.

Principal Investigators: J. Hanan, W. D. Holley

Department Involved: Horticulture

Sponsor: Colorado Flower Growers' Assn.

TRICKLE IRRIGATION ORCHARD RESEARCH 17

Objectives

Reduce water consumption; even availability of water for the entire season; and avoid salinity buildup in the area surrounding each tree. Trickle irrigation also is expected to reduce waste of water by eliminating water runoff.

Approach

The orchard's water supply flows through a plastic pipe header with laterals and then into microtubes leading to each tree. The size of the microtubing is dependent upon the size of the individual tree and determines the amount of water delivered to the tree. This new system is being compared with present irrigation management systems.

Principal Investigator: M. Stacey

Department Involved: Horticulture

SYSTEMS OF MANAGEMENT FOR OPTIMUM WATER UTILIZATION 18

Objectives

1. Conduct research to determine the effects of crops, soils, topography, and water supply on water and fertilizer management, adaptability of irrigation systems and cultural systems, irrigation practices, environmental quality, and economic return on farms in southwestern Colorado.
2. Develop management systems for optimum production, water use, and soil and water conservation under non-irrigated condition in Colorado.

Approach

Gravity and sprinkler irrigation systems will be evaluated on a 300-acre farm. Water application, groundwater condition and quality, and quantity of return flow will be measured. Field studies will be used to evaluate soil, water, and crop management practices with an economic evaluation of various systems.

Principal Investigators: K. Brengle, H. Mann, H. Moore, R. Tinnermeier, W. Hart

Departments Involved: Agronomy, Economics, Agricultural Engineering

Sponsor: CSU Experiment Station

EVALUATION OF NATURAL AND ARTIFICIAL RECHARGE TO THE HIGH PLAINS GROUNDWATER AQUIFER 19

Objectives

To provide mechanisms for the conversion of water on the high plains or similar areas by: 1) developing techniques for evaluating the aerial and time distribution of natural recharge; 2) defining procedures for estimating the quantity of water available for artificial recharge on the high plains; and 3) evaluating the use of soil maps for selecting artificial recharge sites.

Approach

Selected techniques were applied and checked against observed recharge and runoff rates of one or more small areas in the high plains. Instrumentation has been installed to observe deep percolation rates and surface runoff on the selected sites. Recommendations will be made on the success of each technique evaluated.

Principal Investigators: R. A. Longenbaugh, D. B. McWhorter

Departments Involved: Civil Engineering, Agricultural Engineering

Sponsor: OWRR (OWRR-A-016-COLO)

Section III

WATER QUALITY MANAGEMENT AND PROTECTION

ECONOMIC AND INSTITUTIONAL ANALYSIS OF WATER QUALITY STANDARDS AND MANAGEMENT 1

Objectives

To provide state and federal water pollution control agencies with information relating to the costs and benefits associated with meeting specified water quality criteria in Colorado.

Approach

Specialists in environmental law will examine the legal and institutional basis for pollution control and appraise the adequacy of relevant state statutes. Several pollution situations will be studied in detail to establish economic optima with respect to abatement procedures and water quality standards.

Principal Investigator: R. Young

Department Involved: Economics

Sponsor: OWRR (OWRR-B-042-COLO)

ECONOMIC EFFECTS OF SALINITY IN THE COLORADO RIVER ON AGRICULTURAL WATER USES 2

Objectives

To find the most appropriate procedure for evaluating the economic effects of salinity in the flow of the Colorado River. This study is concerned only with the salinity effects upon users of water for crop irrigation.

Approach

1. Criteria will be established to aid in arriving at procedures to be used in the study.
2. Relevant physical, biological, and engineering literature will be reviewed and assessed.
3. Conceptual economic considerations in the selection of evaluation procedures will be reviewed and assessed. This includes formulation and assessment of alternative procedures for modeling irrigator response to changes in salinity of irrigation water.

Principal Investigators: R. Young, K. Nobe, W. Franklin, R. Whitney

Departments Involved: Economics, Agronomy

Sponsor: USBR

FEASIBILITY OF COMBINING WOOD PROCESSING RESIDUES WITH MUNICIPAL SEWAGE SLUDGE 3

Objectives

1. To determine the effects of various combinations of sewage sludge and three combinations of softwood residues (bark, wood, and a combination of bark and wood) upon nitrogen mineralization rate, nitrate leaching rate, and plant response.
2. To analyze the costs of producing, delivering, and applying combinations of sludge and wood/bark mixture to agricultural land.

Approach

Three kinds of studies will be made in the Department of Agronomy under Objective 1: greenhouse, laboratory, and column research in the laboratory. The cost/marketing studies are underway at the RMFR Experiment Station.

Principal Investigators: D. Markstrom, B. Sabey

Departments Involved: RMFRES - Forest Utilization and Marketing; CSU Agronomy

Sponsor: USFS - Rocky Mountain Forest and Range Experiment Station

RECLAMATION AND MANAGEMENT OF SALT-AFFECTED SOILS 4

Objectives

1. To develop more effective methods of reclaiming and managing salt-affected soils which have unfavorable physical characteristics.
2. To determine salt tolerance of various varieties and strains of economic crop plants adapted to specific climatic areas in the state.
3. To develop methods of diagnosis of salt-affected soils which are adapted to routine laboratory use.

Approach

The effects of deep tillage on reclamation and management of soils having hardpans or layered textural discontinuities will be determined. Factors causing cementation of soil particles, and the formation of hardpans in coarse textured saline-sodium soils, and root effects on aggregate stability in fine textured soils will be investigated.

The use of salty water having a favorable sodium adsorption ratio will be studied as a method of leaching salt-affected soils. Undisturbed cores will be used initially. Salt tolerance of selected varieties of crop plants will be determined and analytical methods adaptable to screening sodium soils on a routine basis will be sought.

Principal Investigators: W. T. Franklin, R. S. Whitney, C. W. Robinson

Department Involved: Agronomy

Sponsor: CSU Experiment Station

SOIL AS A WASTE TREATMENT SYSTEM 5

Objectives

1. To determine the effects of waste components on the chemical, physical, and biological properties of soils.
2. To characterize soils in relation to their waste treatment capabilities and determine soil parameters of most significance in the retention, fixation, and transformation of waste components consistent with meeting quality standards of water and air.
3. To devise guidelines for identifying and inventorizing recognized taxonomic soil units most effective for various types of waste management systems.

Approach

Effects of sewage sludge are studied on soil physical and chemical properties and plant growth in greenhouse and field. Laboratory and greenhouse studies are conducted to determine the influence of liquid sewage on seed germination and plant growth and also to measure the rate of sludge decomposition in the soil under varied soil moisture and temperature regimes.

Principal Investigator: B. R. Sabey

Department Involved: Agronomy

Sponsor: CSU Experiment Station

LAND APPLICATION OF METROPOLITAN DENVER SEWAGE SLUDGE 6

Objectives

1. To study recycling of sludge materials into the soil.
2. To determine maximum application rate without causing mineral, organic, and pathogenic pollution of soil or water.

Approach

Three cropping situations are used--fallow, grain sorghum, and millet in sandy soil. Five rates of sludge ranging from 0 to 8 acre-inches are applied to each crop in a single application prior to planting and final seed bed preparation. Soil depth samples are taken at the beginning of the experiment, at mid-season, and after harvest. Plant yields are measured from each plot and the data correlated with sludge application rates. Plots are sprinkler irrigated.

Principal Investigators: B. Sabey, W. Hart

Departments Involved: Agronomy, Agricultural Engineering

Sponsor: Metropolitan Denver Sewage Disposal District No. 1

TRANSPORT OF SALTS IN IRRIGATION RETURN FLOW 7

Objectives

To establish a method of predicting the transport in partially saturated soils of chemical species that interact significantly with the soil.

Approach

Interaction of sulphate ions with soil columns will be studied. The conditions influencing the movement of water will be varied so that chemical transport in both steady and cyclic flow of water can be observed. Data from the research and current knowledge of sulfate reactions in soils will be used to develop a model of the source-sink component. All soils, solutions, and conditions will be selected so that the reactions of sulfate can be best identified, characterized, and treated quantitatively.

Principal Investigators: D. McWhorter, D. Sunada, A. Klute, V. Cole

Departments Involved: Agricultural Engineering, Civil Engineering, Agronomy

Sponsor: OWRR (OWRR-A-017-COLO)

IRRIGATION PRACTICES, RETURN FLOW SALINITY, AND CROP YIELDS 8

Objectives

To evaluate the effects of various irrigation practices on the salinity of irrigation return flows as well as crop production, and to demonstrate that improved farm irrigation water management can reduce mineral water quality degradation simultaneously with increasing crop yields and farm profits.

Approach

One hundred plots will be provided with both individual drainage systems and solid-set sprinkler irrigation systems. The sprinkler systems will be designed to permit a variety of controlled irrigation treatment on the crops.

Principal Investigator: G. V. Skogerboe

Department Involved: Agricultural Engineering

Sponsor: CSU Experiment Station

INSTITUTIONAL REQUIREMENTS FOR OPTIMAL WATER QUALITY MANAGEMENT IN ARID URBAN AREAS 9

Objectives

1. To develop more effective programs for achieving water quality goals in areas which are rapidly changing from rural to urban in character, and which are faced with critical water shortage problems as well as serious water quality problems.
2. To determine the extent to which present institutios would prevent implementation of these programs.
3. To identify needed changes in water quality and water quantity management institutions, policies, and practices.
4. To develop a model program for management of water quality in water-short urban areas.

Approach

A simulation of the water supply and waste water disposal system is being developed from available water information. The model is designed to simulate the existing mode, alternative modes of the system and incorporates capability for projected changes in water demand treatment, waste water treatment, and waste water disposal for each of the system modes. Systems analysis is applied to the model in order to determine the least costly combination of actions required to attain any target stream quality criteria. The system will incorporate all of the physical, chemical, and biological parameters normally used to define stream quality, establish water quality requirements of various water uses, or to characterize various wastes.

Principal Investigators: G. V. Skogerboe, R. C. Ward, W. Walker

Department Involved: Agricultural Engineering

Sponsors: OWRR (OWRR-B-071-COLO), CSU Experiment Station

WATER QUALITY MANAGEMENT IN THE SOUTH PLATTE RIVER BASIN 10

Objectives

1. To develop more effective programs for achieving water quality goals.
2. To determine the extent to which present institutions would present implementation of these programs.
3. To identify needed changes in water quality and water quantity management institutions, policies, and practices.

Approach

The Denver Metropolitan area will be studied for conservation of water, recirculation or re-use, exchange of water and waste water, and collective treatment of waste water. The water institutions will be evaluated to determine if these alternatives can be implemented.

Principal Investigators: G. Skogerboe, R. Ward, W. Walker

Department Involved: Agricultural Engineering

Sponsor: CSU Experiment Station

MANAGEMENT OF SALT LOAD IN IRRIGATION AGRICULTURE 11

Objectives

To develop alternative methods of controlling salt load from irrigated agriculture by management of drainage water.

Approach

A digital computer model will be modified to incorporate water quality parameters. Field plots will be utilized to verify the models and study alternatives in drainage water management.

Principal Investigators: N. A. Evans, D. K. Sunada, D. McWhorter

Departments Involved: Agricultural Engineering, Civil Engineering

Sponsor: CSU Experiment Station

WASTE WATER DISPOSAL FOR ISOLATED MOUNTAIN SITES 12

Objectives

1. To investigate the possibility of evaporation of wastewaters from isolated mountain cabins.
2. To determine the costs involved.
3. To produce a detailed design of an evaporative facility that can be used by laymen.
4. To determine all disadvantages of this method of wastewater disposal.
5. Relate all of the objectives to elevation above mean sea level for Colorado latitudes.

Approach

From existing data, predict as closely as possible the expected evaporation rates as a function of elevation and time of the year for Colorado latitudes. Using this information, an evaporation facility will be designed and tested at various elevations and observed for possible disadvantage such as odor, etc. If necessary, the design will be modified to offset observed defects and to decrease unit costs.

Principal Investigator: J. D. Ward

Department Involved: Civil Engineering

Sponsor: OWRR (OWRR-A-020-COLO)

A SYSTEM FOR GEOLOGIC EVALUATION POLLUTION POTENTIAL AT MOUNTAIN DWELLING SITES 13

Objectives

To develop a hydrogeologic classification system for mountainous terrain. The classification system is to be designed for use in evaluating pollution potential at dwelling sites in the mountains.

Approach

Quantitative measures of topographic, geologic, and hydrologic variables were collected and divided into two groups containing information from 1) sites where contamination has been documented and a source of pollution identified; 2) sites where no contamination can be detected, but where a pollution source is present.

Principal Investigators: L. Burns, S. Morrison

Departments Involved: Geology, Microbiology

Sponsors: OWRR (OWRR-B-023-COLO), CSU Experiment Station

ARCTIC LAGOON MICROBIOLOGY 14

Objectives

This program was initiated during the summer of 1971 at Point Barrow, Alaska, to study the ecological interactions that take place in a coastal, salt-water lagoon and how they relate to sewage disposal by "lagooning" in high latitude regions.

Approach

Field studies consisted of semi-weekly sampling of water and bottom sediments to determine microbial interactions and changes in populations. Runoff water also was studied extensively during June. Post-field work is being done on certain public health aspects, and selected populations are being screened to determine their physiological potentiality for possible use as indices of fecal pollution.

Principal Investigator: W. Boyd

Department Involved: Microbiology

Sponsor: Office of Naval Research

LIME DISINFECTION OF SEWAGE BACTERIA AT LOW TEMPERATURES 15

Objectives

To make a laboratory study of the potential use of lime as a disinfectant agent for the bacteria in sewage at low temperatures. In sparsely populated areas in the far north, if lime is available, the successful flocculation of solids and destruction of potential bacterial pathogens could be a valuable sewage treatment process to abate pollution.

Approach

Basic studies in the laboratory will be made with comparison tests of raw sewage from a municipal plant. Specific data will be gathered on the interrelated mechanisms of flocculation and disinfection as influenced by temperature, contact time, and pH.

Principal Investigator: S. M. Morrison

Department Involved: Microbiology

Sponsor: EPA

DISPOSITION AND POSSIBLE ENVIRONMENTAL IMPACT OF SILVER IODIDE FROM CONVECTIVE CLOUD SEEDING FOR HAIL SUPPRESSION 16

Objectives

To study the disposition and environmental impact of silver iodide on vegetation, organic matter, soil, stream sediment, and water following cloud seeding in hail suppression operations.

Approach

The hail suppression target area is monitored before seeding commences each summer, after each seeding event, and at the end of the seeding season. Silver uptake by major forage and crop species is studied in the greenhouse. The environmental effects of varying silver

concentrations and sources are studied on both soil and aquatic microorganisms. Movement and possible concentrations of silver in the food chain will be investigated.

Principal Investigators: H. L. Teller, D. A. Klein

Departments Involved: Watershed Sciences, Microbiology

Sponsor: NCAR

DISPOSITION AND POSSIBLE ENVIRONMENTAL IMPACT OF SILVER IODIDE FROM OROGRAPHIC CLOUD SEEDING 17

Objectives

1. To monitor levels of silver on the San Juan target area of the Upper Colorado River Basin Project following cloud seeding operations.
2. To study the movement of silver through soil cores in the laboratory.
3. To carry out pilot studies on silver distribution and accumulation around generator sites.
4. To study the uptake of silver iodide by plants.
5. To determine the environmental impact of silver iodide on soil microorganisms, both in field samples and under controlled laboratory conditions.

Approach

Samples of soil, litter, and vegetation are collected twice a year at selected sites in spruce, aspen, and grass communities on the target area. Undisturbed soil cores are leached with silver solutions of varying concentrations and subsequently analyzed for silver through the profile. Generator sites are sampled for silver accumulation. Soil respiration and other tests are carried out with varying concentrations and sources of silver on field samples from the target area, samples from treated plots, and on laboratory cultures.

Principal Investigators: H. L. Teller, D. A. Klein

Departments Involved: Watershed Sciences, Microbiology

Sponsor: USBR

WATER QUALITY EFFECTS OF WOOD CHIP DECOMPOSITION ON CLEARED FOREST SLOPES 18

Objective

To study possible effects of decomposing wood chips and the substances leaching from them on the quality of water flowing from the area.

Approach

Develop procedures and identify: 1) the major classes of leached chemicals derived from decomposing chipped wood and bark of lodgepole pine; 2) estimate the total quantity of each identifiable major class of leachate that may be expected from a unit volume of chips/bark and determine the probable leaching rate; 3) investigate the potential toxicity of the total leachate and the major individual classes.

Principal Investigator: H. L. Teller

Department Involved: Watershed Sciences

Sponsor: USFS - Rocky Mountain Forest and Range Experiment Station

PLUTONIUM IN THE ROCKY FLATS ENVIRONS 19

Objectives

To identify and quantify any biological pathways for movement of plutonium in the three major water courses of Rocky Flats.

Approach

Samples of water, sediment, aquatic plants and animals were collected and assayed for plutonium content. The species and seasonal abundances of the plant and animal life were inventorized concurrently.

Principal Investigators: J. E. Johnson, R. L. Watters

Department Involved: Radiology and Radiation Biology

Sponsor: Dow Chemical Co.

STREAM AND LAKE POLLUTION IN THE ROCKY MOUNTAIN NATIONAL PARK 20

Objectives

To establish a baseline description of the plant and animal communities of selected lakes and streams subject to contrasting degrees of polluting use in the park and to develop indicies of eutrophication for future reference. Three lakes and three streams will be investigated for existing pollution-caused changes.

Approach

The planktonic and benthic communities of three lakes will be sampled intensively during and after the period of heavy visitor use of pollution evidence. Measurements of water chemistry also will be made. The three streams will be evaluated up and downstream of known pollution entries.

Principal Investigator: W. J. McConnell

Department Involved: Colorado Cooperative Fisheries Unit

Sponsor: National Park Service

POLLUTION STUDY ON THE YELLOWSTONE RIVER 21

Objectives

To determine the degree to which quantity and quality of aquatic life in the Yellowstone River is changed by existing sewage inflows and to use this information to estimate levels of eutrophication which will begin to cause noticeable and undesirable changes in the river biota.

Approach

A comparison will be made of bottom-dwelling biota in relation to zones of increasing pollution exposure. Data will be examined for quantitative response by biota to differences in ambient sewage concentrations which serve as a basis for predicting the results of increased or decreased sewage loading.

Principal Investigator: W. J. McConnell

Department Involved: Colorado Cooperative Fisheries Unit

Sponsor: National Park Service

LIMNOLOGY OF EVERGREEN LAKE 22

Objectives

Evergreen Lake is a reservoir created by impounding Bear Creek. Sediments carried by the creek have filled the basin to the extent that its capacity has been reduced by one-third. Results of the study will influence the decision whether or not to rejuvenate and deepen the lake or allow it to fill in.

Approach

Studies were made which determined that there is a lack of temperature mixing in the lake resulting in low oxygen content and in some areas, high orthophosphate concentrations. There also is abundant plankton in the lake necessitating the use of copper sulphate to keep algae from interfering with the processing of drinking water. The study is continuing on a monthly basis.

Principal Investigator: E. B. Reed

Department Involved: Zoology

Sponsor: City of Evergreen, Colorado

ENVIRONMENTAL IMPACT STUDY OF THE ST. VRAIN NUCLEAR POWER PLANT SITE 23

Objectives

To make a baseline ecological study of the South Platte River and the land area in the vicinity of the plant site. The results of this study will be compared with those which will be made following the activation of the plant.

Approach

Regular data-gathering field studies will be made by the investigators.

Principal Investigators: C. Carlson, W. Fronk, W. McConnell, P. Kugrens

Departments Involved: Zoology and Entomology, Fisheries and Wildlife Biology, Botany and Plant Pathology

Sponsor: Thorne Ecological Institute

Section IV

Water Resources Planning

DEVELOPMENT OF TECHNIQUES FOR ESTIMATING THE POTENTIAL OF WATER RESOURCES DEVELOPMENT IN THE WESTERN REGION OF THE UNITED STATES FOR ACHIEVING NATIONAL AND REGIONAL SOCIAL GOALS 1

Objectives

To develop methods and techniques in which the social effects of water resource management decisions, particularly investment streams, may be more specifically identified and measured in the arid and subhumid regions of the western United States. Of particular concern are the possible contributions of alternative water resources development policies to selected national and regional goals.

Approach

A panel of specialists formed a technical committee for guiding the project. Variables will be identified which define national and regional goals, specify the connectives between these goals and water-related activities in the 11 western states, and quantify these connectives. Important resource constraints will be analyzed to achieve consistency in the model framework, and estimate the degree of substitution between alternative goals given the physical, institutional, and political fabric of western water resources.

Principal Investigator: H. Caulfield

Department Involved: Political Science

Sponsor: Utah State University (Subcontract), OWRR

INSTITUTIONS FOR METROPOLITAN WATER RESOURCES MANAGEMENT 2

Objectives

To study the development of institutions to deal with water resource planning, management, and development within and without a metropolitan community.

Approach

1. Survey literature and experience dealing with institutions for metropolitan water resource planning, development, and management.
2. Study other institutions and their accomplishments in the control and direction of human behavior and relate that to water in the metropolitan context.

Principal Investigator: N. Wengert

Department Involved: Political Science

Sponsor: OWRR (OWRR-W-122-COLO)

FINANCE IN PUBLIC WATER RESOURCE USE AND DEVELOPMENT 3

Objectives

1. To conceptualize the domain of "finance" in relation to water use and development.
2. To identify research completed or underway relating to finance.
3. To appraise the depth and significance of its main concern and the coverage of the domain by all identified research.
4. To undertake an appraisal of the application in Colorado since 1965 of the cost-sharing provisions of the Federal Water Projects Recreation Act of 1964, and an appraisal of alternative methods of financing federal irrigation works in the light of experience of federal reclamation projects in Colorado.

Approach

The Federal Water Projects Recreation Act of 1964 will form a basis for part of this study. An analysis of its legislative history will identify the policy intentions of its cost-sharing provisions. Certain Colorado projects will be selected for detailed study to determine relationships between implementation practices and policy intent. Federal reclamation projects in Colorado will be used as case studies with regard to financing methods, alternatives that could be used, problems of financing under law, etc.

Principal Investigators: H. P. Caulfield, R. Young

Departments Involved: Political Science, Economics

Sponsor: OWRR (OWRR-A-015-COLO)

SYSTEMATIC DESIGN OF LEGAL REGULATIONS FOR OPTIMAL SURFACE-GROUNDWATER USAGE 4

Objectives

To develop a model which will provide guidance for the design of rules for the conjunctive use of surface and groundwater which satisfy the law and which maximize the beneficial use of water. One objective is a realistic analysis of the simultaneous behavior of river flow and groundwater movement under prevailing conditions of water use in the South Platte River Basin. The physical model must be compatible with the regional economic model which will be developed simultaneously.

Approach

Small scale prototype physical and economic models will be developed. The models will be generally representative of the complex relationship occurring under conjunctive use. Legal reviews and analysis of statutes, case law, and other literature will be carried out in order to define the legal constraints applicable to the quantitative model and within which the design of optimal rules must proceed.

Principal Investigators: R. A. Young, G. Radosevich, H. P. Caulfield, J. Morel-Seytoux

Departments Involved: Economics, Political Science, Civil Engineering

Sponsor: OWRR (OWRR-B-076-COLO)

AN ECONOMIC ANALYSIS OF WATER USE IN COLORADO'S ECONOMY 5

Objectives

1. To determine the economic interrelationship between the major sectors of Colorado's economy.
2. To estimate future output of specific sectors and determine the impact of these output changes on all sectors of Colorado's economy.
3. To delineate the economic importance of water resources on major sectors of Colorado's economy.
4. To estimate the economic impact of assumed water resource changes on Colorado's economy within both a positive and normative framework.

Approach

Input-output analysis will be used to accomplish objectives 1, 2, and 3. Objective 4 will combine elements of normative analysis with the positive analysis of the input-output model.

Principal Investigator: S. L. Gray

Department Involved: Economics

Sponsors: OWRR (OWRR-B-059-COLO), CSU Experiment Station, Colorado Water Conservation Board

CONSOLIDATION OF IRRIGATION SYSTEMS: PHASE II--ENGINEERING, ECONOMIC, LEGAL AND SOCIOLOGICAL REQUIREMENTS FOR ACHIEVING CONSOLIDATION 6

Objectives

The research program covers two phases. In the first phase, observation, analysis, and interpretation was made of the engineering, legal, and sociological factors affecting the consolidation of irrigation systems. The second phase involves the social and economic aspects of attaining consolidation along with legal and engineering requirements.

Approach

1. Determine and evaluate the engineering characteristics of the system, magnitude and time-variation of the water supply, physical characteristics of the system, operational methods, and alternative physical and operational systems.
2. Identify and analyze from a legal perspective whether or not present laws operate as impediment to consolidation, institutional arrangements which control the use of water, legal rights of individual users, and to impose legal constraints in consolidation proposals. The sociological dimension of this research focuses attention on the organizational arrangement of irrigation companies, perceptions of satisfaction and dissatisfaction by persons associated or affected by irrigation companies, and exploration and delineation of organizational alternatives for consolidation proposals.

Principal Investigators: E. Vlachos, G. V. Skogerboe, G. E. Radosevich, P. C. Huszar

Departments Involved: Sociology and Anthropology, Agricultural Engineering, Economics

Sponsors: OWRR (OWRR-B-083-COLO), CSU Experiment Station

OPTIMUM UTILIZATION OF WATER RESOURCES WITH EMPHASIS ON WATER DELIVERY AND REMOVAL SYSTEMS 7

Objectives

1. To accelerate food production through improved irrigation water management, crop adaptation, cultural practices, soil fertility, pest control, drainage and salinity control measures within the economic and sociological framework of water deficient areas of South Asia.
2. To improve the understanding of the mechanics of erosion and sedimentation in rivers and canals to insure the future successful operation and maintenance of complex and expensive water distribution systems.
3. To evaluate the application of these technological advances in water resource and water management in the light of economic and social consequences to the region.

Approach

The combined experiences and knowledge in soil and water management (of the Council of U.S. Universities for Soil and Water Research in Arid and Subhumid Regions) on food increases requirements is being brought to bear in water deficient areas in South Asia.

Principal Investigators: M. L. Albertson, E. Richardson, W. Schmehl, H. Bigg, G. Jones, H. Caulfield, E. Vlachos, G. Skogerboe, W. Hart

Departments Involved: Civil Engineering, Agronomy, Economics, Political Science, Agricultural Engineering, Sociology

Sponsor: AID

OPTIMIZATION OF WATER DELIVERY SYSTEMS 8

Objectives

To research methods of optimizing the delivery and utilization of the water resources of Colorado. This includes:
1. Developing methods and procedures to optimize the delivery of water to agricultural, domestic, and industrial users.
2. Studying methods of reducing seepage from canals, small reservoirs, and storage ponds.

Approach

The delivery system for a river basin with numerous canal companies, cities and industrial users will be modeled on a digital computer. The model will include river flows, storage reservoirs and the water rights of the various users. The model will be developed as a management tool for the operation of the basin and as a research tool to study the economic effect of various management decisions on allocation and delivery of water. Physical measurements of seepage and methods of control also will be studied.

Principal Investigator: E. V. Richardson

Department Involved: Civil Engineering

Sponsor: CSU Experiment Station

ESTABLISHMENT OF A PROGRAM FOR MULTIPURPOSE ENVIRONMENTAL MANAGEMENT OF WATER AND RELATED LAND RESOURCES 9

Objectives

To develop the most efficient plans for multipurpose uses of water and related land resources that will protect the interests of public health, wildlife, recreation, and agriculture.

Approach

A section has been added to the Institute of Rural Environmental Health for multipurpose environmental management of water and related land resources following a recommendation by the President's Water Resources Council. The section will utilize interdisciplinary teams working side-by-side at the field level to develop and evaluate ecological management techniques. Through these vector prevention and control could be integrated with the other multipurpose interests involved in water and related land resources.

Principal Investigator: J. R. Bagby

Discipline Involved: Epidemiology

Sponsor: Colorado State University

ENVIRONMENTAL, ECONOMIC, AND SOCIAL EFFECTS OF URBANIZATION OF MOUNTAIN WATERSHEDS 10

Objectives

To determine and assess the changes in natural resource use on public land; the impacts on certain environmental values; and the changes in the type, quantity and quality of goods and services produced when private lands in a mountain watershed change from ranch use to residential development. To identify emerging problems associated with such changes in land use and the management of public lands, and to suggest measures which may be taken to alleviate such problems.

Approach

The landscape of the watershed will be analyzed and evaluated in terms of scenic and recreation values. These data with other resource data will be digitized for computer retrieval. Land ownerships and patterns of land use will be determined and the approximate year when current land use was established will be determined. A model will be constructed to depict the ecological changes that can be expected in the watershed, given various changes in land use. A survey instrument also will be designed to determine the values and attitudes of private land owners, public land managers, and other user groups in terms of present conditions and probable future conditions.

Principal Investigator: R. Burnell Held

Department Involved: Recreation Resources

Sponsor: USFS - Rocky Mountain Forest and Range Experiment Station

TREE BIOMASS CHANGES FOLLOWING CLOUD SEEDING OPERATIONS 11

Objectives

To monitor changes in tree biomass over time and to determine if the changes in biomass are related to changes in snow accumulation due to weather modification through cloud seeding.

Approach

1. Determine coefficients of linear allometric model for tree bole biomass by destructive sampling.
2. Establish total tree biomass on an area basis by application of allometric equations to plot data.
3. Remeasure plots over time and to relate changes in biomass to levels of snowfall that occur over time.

Principal Investigator: E. Mogren

Department Involved: Forest and Wood Sciences

Sponsor: USBR

MOISTURE STRESS (SAN JUAN ECOLOGY SUBPROJECT) 12

Objectives

To determine effects of increased winter snowpack on moisture stress of Englemann spruce and quaking aspen in the San Juan mountains.

Approach

1. Collect weekly measures of tree moisture stress at six forest sites during the growing season.
2. Monitor soil moisture and temperature at same sites.
3. Relate data from 1 and 2 to snowpack, air temperatures, precipitation.

Principal Investigator: C. P. Reid

Department Involved: Forest and Wood Sciences

Sponsor: USBR

EFFECT OF INCREASED SNOW ON ELK 13

Objectives

To determine the effect of increased snow on elk in the San Juan Mountains. Specifically, to determine: a) how the winter distribution of elk is affected by snow; b) how elk calving areas are related to snow; and c) what effect snowfall has on oak biomass production and the community structure of Gambel's oak in the target area.

Approach

Aerial locations of wintering elk related to elevation, aspect, habitat, and snow depth were taken at monthly intervals and were paired with on-site reconnaissance of snow conditions. Fixed wing and helicopter flights were flown during the spring for location of calving elk as to elevation, aspect, habitat, and relation to snow cover and were paired with on-site reconnaissance of calving areas. Plots were located in stands of oak to define the present community structure of the stands, determine their biomass production, and to determine the timing of major phenological events.

Principal Investigator: H. Steinhoff

Department Involved: Fishery and Wildlife Biology

Sponsor: USBR

SMALL MAMMALS STUDY IN CLOUD SEEDING TARGET AREA 14

Objectives

Determination of mortality, population size, age structure of populations, movements of populations, and food habits of cricetid rodents, ground squirrels, and shrews in representative stands within the USBR cloud seeding target area, and relate this to snowpack condition and vegetative type.

Approach

Studies of home range and litter survival were conducted on a 15.7-hectare grid of 196 nest boxes and 196 live trapping sites.

Principal Investigator: H. Steinhoff

Department Involved: Fishery and Wildlife Biology

Sponsor: USBR

WATER LAW IN ITS RELATION TO ENVIRONMENTAL QUALITY 15

Objectives

To define the activities of man, and the cultural and institutional influences which have adversely affected the natural fresh water aquatic environment in the United States, and thus to determine the importance of water law as one of the influences.

Approach

The study involves an analysis of water laws as they affect environmental quality with specific emphasis upon recreational and aesthetic values, and fishery and wildlife resources. Federal laws and the water laws of 17 western and two eastern states will be studied in detail. A model law and administrative institutions for implementation will be developed. The aspects given most intensive attention include the relationship of water law to minimum stream flow, to minimum or permanent water levels in lakes and reservoirs, and the legal restrictions, if any, upon disturbances of natural streams, lakes, and wetlands by highway construction, residential or industrial developments, and other such intrusions upon natural bodies of water.

Principal Investigators: G. Swanson, G. Radosevich

Departments Involved: Fishery and Wildlife Biology, Economics

Sponsor: OWRR (OWRR-C-3107-COLO)

PUBLIC RESPONSE TO A PROPOSED ALTERNATIVE TO FLOOD PROBLEMS OF BOULDER CREEK 16

Objectives

To define social impacts and consequences of available management alternatives for implementation on the Boulder Creek flood plain.

Approach

Study both public and leadership response to eight alternatives for management of the Boulder Creek flood plain. Also determine some of the probable causes to the responses.

Principle Investigator: D. W. Hill

Department Involved: Political Science

Sponsor: U.S. Army Corps of Engineers

Section V

RESOURCE DATA

METROPOLITAN WATER INTELLIGENCE SYSTEMS PHASE III 1

Objectives

1. Investigate and describe modern automation and control systems for the operation of urban water facilities with emphasis on combined sewer systems.
2. Develop criteria for managers, planners, and designers to use in the consideration and development of centralized automation and control system for the operation of combined sewer systems.
3. Establish the feasibility constraints, both technical and social, of automation and control systems for urban water facilities with emphasis on combined sewer systems for a wide range of size and type of urban areas.

Approach

The project has been divided into eight tasks, each contributing to the total objective. Each task will be summarized in a technical report and the total effort will be summarized in a final completion report.

Principal Investigators: M. L. Albertson, G. Smith

Department Involved: Civil Engineering

Sponsor: OWRR (OWRR-C-4172-COLO)

WATER DATA BANK ESTABLISHMENT 2

Objectives

To collect information on surface and ground water in Colorado in order to provide a Water Data Bank for the processing, storage, retrieval, and study of water records for the Colorado Division of Water Resources.

Principal Investigator: R. Longenbaugh

Department Involved: Civil Engineering

Sponsor: State of Colorado, Department of Natural Resources

WATER RIGHTS TABULATION UPDATE 3

Objectives

To prepare tabulations and revisions, in order of seniority, of all decreed water rights in all of the State of Colorado water divisions.

Principal Investigator: R. Longenbaugh

Department Involved: Civil Engineering

Sponsor: State of Colorado Division of Water Resources

FEASIBILITY OF REMOTE EVAPORATION AND PRECIPITATION ESTIMATES 4

Objectives

An experimental feasibility demonstration is sought which illustrates how space observations of drainage basins might be used for evaporation and precipitation estimates.

Approach

The demonstration used MSFC's three channel scanner to:

1. Calibrate and check out MSFC's scanner and classification algorithms for repetitive estimates of water vapor burden from controlled water spray injections with known temperature and humidity control.
2. Demonstrate the feasibility of evaporation loss and precipitation input estimates for simulated and real small drainage basins.

Principal Investigator: W. Z. Sadeh

Department Involved: Civil Engineering

Sponsor: NASA

RAPID MEASUREMENTS OF SOIL MOISTURE AND WATER TABLE DEPTH BY A SHORT PULSE RADAR 5

Objectives

To determine the effectiveness of a short pulse radar system to measure depth to water table from the earth's surface and to measure content from stationary to moving platforms.

Approach

The optimum frequency range for acceptable system performance will be determined. Pulse generators and antennas for a mobile system will be designed and built. Following testing and modification of a system from a stationary platform, design recommendations will be made for an air-borne system.

Principal Investigator: R. Vickers

Department Involved: Electrical Engineering

Sponsor: USBR

DETERMINATION OF SNOW DEPTH AND WATER EQUIVALENT BY REMOTE SENSING 6

Objectives

1. To determine how precisely snow depth and water equivalent can be estimated from snowmelt patterns as detected by air photography in a mountain watershed.
2. To develop an operating system for the routine determination of snow depths and incremental accumulations photogrammetrically.
3. To determine the accuracy and precision of the system for different field conditions.
4. To evaluate the economics of these procedures compared with current practice in terms of time, cost, and accuracy.

Approach

The study is divided into three complementary phases:

1. Air photographs were made of the study area. Patterns of snow melt within each stratum of eco-system, aspect and elevation were measured from the air photos and related to ground measurements of snow depth and water equivalent.
2. This phase is based on aerial photography of the Wolf Creek Pass area. A comparison of the photo-observed versus the ground-observed areas will provide a test of the photogrammetric system.
3. This phase is centered on the Missionary Ridge area east of Durango, Colorado. Analysis of photography also is made. Accurate records are kept of the cost of this new system in terms of time, money, and accuracy. This will be compared with the cost of conventional methods of measuring snow depths.

Principal Investigators: H. Steinhoff, H. L. Teller, A. Barnes, M. Skinner, J. Ruff

Departments Involved: Fishery and Wildlife Biology, Watershed Sciences, Civil Engineering

Sponsor: OWRR (OWRR-A-019-COLO)

MEASUREMENTS OF SNOWFALL RATES USING LONG PATH RADIATION ATTENUATION 7

Objectives

To design, test, and calibrate a long path sensor system for remote determination of snowfall rates and amounts.

Approach

The basic theory was tested that detection of snowflakes in the view-volume of an infrared radiometer looking at a constant temperature target is possible. Design of a lens system to present the radiometer with a cylindrical view-volume is in progress by researchers. Tests involving an infrared radiometer viewing a blackbody target in an insulated, constant temperature box determined that such a system as that proposed is feasible for remote determination of snowfall rates and amounts.

Principle Investigator: W. M. Marlatt

Department Involved: Watershed Sciences

Sponsor: USFS - Rocky Mountain Forest and Range Experiment Station

Section VI

ENGINEERING WORKS

WATER RESOURCES HYDRAULICS 1

Objectives

1. To improve erosion and sedimentation theories including transport, degradation, and aggradation phenomena.
2. To study in greater detail the mechanics of flow in both alluvial and rigid boundary channels to increase efficiency of water distribution, delivery, and application.

Approach

Flumes will be used to study the processes of degradation and aggradation resulting from construction of dams and diversions works. Also, the geometry of alternate bars in crossings, their response to changing flow conditions, and the variables affecting them will be studied. The measurement of turbulence in open channels will be further developed and related to sediment transport using a hot film device. Work will be initiated to show the absolute necessity of developing river basins in an integrated and coordinated manner. This will initially involve the utilization of basic theories and field data from eroding river systems.

Principal Investigators: D. B. Simons, J. Gessler, M. M. Skinner, S. Karaki

Department Involved: Civil Engineering

Sponsor: CSU Experiment Station

DILUTE POLYMER PIPE FLOWS 2

Objectives

To provide engineering information to enable more accurate predictions of viscous drag reduction (VDR) and a better understanding of mechanisms causing drag reduction.

Approach

A 12-inch diameter pipe, 40 feet long will be used for this study. The size of the pipe and the flow rates available at the laboratory will allow the present drag reduction prediction techniques to be evaluated for developing flows with boundary layer thickness and shear stresses more representative of prototype flows, such as external flows around naval vessels. Measurements will include flow rate, mean velocity profiles, mean concentration profiles, pressure drop along the pipe, turbulence structure in the boundary layer, and characterization of the water and polymer solutions.

Principal Investigator: J. P. Tullis

Department Involved: Civil Engineering

Sponsor: U.S. Office of Naval Research

ENVIRONMENTAL IMPACT OF MISSISSIPPI RIVER CHANNEL DEVELOPMENT 3

Objectives

To conduct sand-bed model studies of the ecological impact of dike systems on several typical reaches of side channels of the Mississippi River between St. Louis, Missouri and Cairo, Illinois.

Approach

The study involves an analysis and evaluation of the impact of dikes and their extension on the morphology and geometry of the main channel system and side channel areas. Time lapse photography will document the results of the model studies and will provide a permanent record for comparison with the prototype.

Principal Investigator: D. Simons

Department Involved: Civil Engineering

Sponsor: U.S. Army Corps of Engineers

PERFORMANCE OF PIPE LINES 4

Objectives

To research the transient pressure and flow conditions that occur in pipelines during filling operations in order to provide a method of better examining and designing pipe line installations.

Approach

The pressure rise and transient conditions in plastic peak section will be measured when air is released with the system pressurized to 18, 40, and possibly 60 psi. The wave celerity will be measured. Also to be recorded are: conditions at representative filling velocities with air release valves on one and two inch risers; testing of three percent plastic peak; and tests to determine the effect of peak angle on pressure rise for various filling velocities and static pressures.

Principal Investigators: M. Albertson, J. Ball

Department Involved: Civil Engineering

Sponsor: Johns-Manville

MODEL STUDY--NEW YORK CITY BOARD OF WATER SUPPLY 5

Objective

To test and report on riser valves and recovery pipe sections for New York City Tunnel No. 3.

Approach

An initial model will be made and tested of a three-dimensional model of a 48-inch riser valve and its recovery pipe sections. Cavitation, vibration, pressure profiles, head loss coefficient, values of drag on the fully open needle versus rate of flow, and hydraulic conditions acting on the prototype valve will be studied.

Principal Investigator: J. P. Tullis

Department Involved: Civil Engineering

Sponsor: City of New York

Section VII

SCIENTIFIC AND TECHNICAL INFORMATION

IRRIGATION RETURN FLOW QUALITY LITERATURE ABSTRACTING 1

Objectives

1. To pull together published results from related research efforts and make these available to others in the field.
2. To maintain a current summary of literature within the irrigation return flow category in the files of the Water Resources Scientific Information Center EDP facility.
3. To identify gaps in the collective effort and simulate research to fill these gaps.
4. To assist in the application of research results to the solution of water pollution problems.

Approach

To meet these objectives, a selected list of 100 publications are being reviewed, and articles pertaining to irrigation return flow quality will be abstracted. Abstracts and copies of the articles abstracted will be provided to the Water Resources Scientific Information Center (WRSIC) and to the FPA laboratory at Ada, Oklahoma. A survey of these publications indicated that approximately 1000 articles will be abstracted annually from the selected list of publications.

Principal Investigator: G. V. Skogerboe

Department Involved: Agricultural Engineering

Sponsor: EPA

PART 2

INDEX TO PROJECTS BY COLLEGES AND DEPARTMENTS

Asterisks indicate interdisciplinary projects

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COLLEGE OF NATURAL SCIENCES

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Department of Zoology

COLLEGE OF VETERINARY MEDICINE AND BIOMEDICAL SCIENCES

Department of Microbiology

Epidemiology

Department of Radiology and Radiation Biology

PART 3

WATER RESEARCH BY FEDERAL AND STATE AGENCY UNITS LOCATED IN FORT COLLINS

COLORADO DIVISION OF WILDLIFE

Fisheries Research

RELATION OF Daphnia galeata mendotae POPULATION STATISTICS TO ENVIRONMENTAL VARIABLES IN HORSETOOTH RESERVOIR, COLORADO 1

Objective

To derive estimates of *Daphnia* population statistics and relate these to environmental variables in Horsetooth Reservoir.

Approach

Population numbers, rate of exchange numbers, birth rate, and death rate of *D.g. mendotae* were related to temperature, isolation, extinction coefficient, dissolved oxygen, primary productivity, plankton volume and numbers of some other zooplankton species by multiple regression methods.

Principal Investigator: W. C. Nelson

COMPARATIVE LIMNOLOGY OF COLORADO-BIG THOMPSON PROJECT RESERVOIRS AND LAKES 2

Objective

To survey the limnology of the Colorado-Big Thompson Project lakes and reservoirs.

Approach

A study was made of the water exchange times for storage and regulation reservoirs. Surface water temperature, thermal stratification, pH, and dominant genera of phytoplankton also were investigated.

Principal Investigator: W. C. Nelson

AERATION STUDIES 3

Objective

To investigate the winterkill problem in Road Canyon Reservoir in an effort to find a solution.

Approach

Many attempts have been made to modify conditions in the reservoir so that fish populations could over-winter. Recent efforts include electrically powered Fresh-flo aerators installed about 1 km. apart and operated from November until March. This was unsuccessful. A Hinde Air Aqua system was installed in 1970 but required constant attention. Also under study is a Helixor and a compressor that will operate from a standard windmill.

Principal Investigator: W. H. Babcock

FRYINGPAN-ARKANSAS STUDIES 4

Objective

To determine the effects of the Fryingpan-Arkansas Project on fish and wildlife of the affected area.

Approach

Surveys are underway to determine physical, chemical, and biological properties of lakes, reservoirs, and streams in the project area.

Principal Investigator: L. M. Finnell

ACTIVATION AND ADAPTATION OF A NITRIFYING FILTER FOR A HATCHERY REUSE SYSTEM 5

Objective

To test water recirculating systems for trout hatcheries in order to determine which provides the best nitrification.

Approach

Two identical water reuse systems are to be built over converted raceways at the Bellvue Research Hatchery. The nitrifying filter for each system will be filled with a different bacterial substrate. Water samples from each filter will be analyzed daily for ammonia, nitrites, nitrates, pH, and oxygen to determine which of the two substrates provides the best nitrification.

After a favorable substrate has been chosen, different methods of activation will be analyzed. One filter will be activated biologically and the other chemically. Tests should determine the fastest, easiest, and most efficient methods in obtaining a stabilized, nitrifying, bacterial colony on the provided substrate.

Principal Investigator: L. E. Harris

WATER POLLUTION STUDIES 6

Objectives

To determine the effects of zinc, lead, and copper on rainbow trout through a series of chronic and acute bioassays. In the long-term chronic bioassay, a maximum acceptable toxicant concentration (MATC) which will not interfere with any stage of a fish's life cycle is being sought.

Approach

Atomic absorption analysis with the metals are conducted. Weekly water quality analyses are performed on all chronic experiments. Pulse polarography, as well as atomic absorption, is used to measure lead. Static bioassays also are conducted on aquatic insects.

Principal Investigators: J. P. Goettl, Jr., J. R. Sinley, P. H. Davies

DISEASE INVESTIGATION 7

Objective

To control fish diseases within Colorado fishery units.

Approach

All fishery facilities are monitored with regard to disease; history of disease outbreaks and treatments are recorded; wild fish populations used as brood stocks are surveyed and indiscriminate movement of fish from unit to unit, halted. A diagnostic laboratory was established, equipped to perform all procedures necessary to diagnose viral, bacterial, and parasitic diseases of fish.

Principal Investigator: L. J. Griess

USDA AGRICULTURAL RESEARCH SERVICE

Colorado - Wyoming Area

FLOW IN POROUS MEDIA IN RELATION TO DRAINAGE DESIGN AND DISPOSAL OF POLLUTANTS 8

Objectives

Investigate the hydraulic properties of porous media as related to design of drainage systems and the disposal of agricultural pollutants based upon suitable mathematical description of relationships among pertinent variables.

Approach

Drainage design criteria are studied in laboratory flumes and models on the functional relationships between permeability and soil water content or fluid pressure. Field investigations on movement of agricultural pollutants in water, under both unsaturated and saturated conditions, also will be conducted.

Principal Investigator: H. R. Duke

EFFECTS OF LAND USE AND SLOPE ON RUNOFF FROM PLOTS IN THE CENTRAL GREAT PLAINS 9

Objectives

Evaluate differences in rates and amounts of surface runoff due to changes in cover from grassland to a wheat-fallow rotation.

Approach

Six, one-half acre plots have been instrumented on slopes of 2% and 6%. One plot in each slope class is in continuous grass; the other two are in a wheat-fallow rotation. Precipitation, runoff, soil moisture, crop yields, residue, and intake rates are measured.

Principal Investigator: R. Mickelson

CONSERVATION OF RUNOFF IN THE CENTRAL PLAINS 10

Objective

Develop practical methods of increasing, storing, and utilizing runoff water in the Central Plains.

Approach

Land forming methods will be developed which will most efficiently handle runoff from various types of watersheds. Methods of increasing runoff for diversion to control areas also will be investigated. Crop and management methods will be tested for adaption to the system.

Principal Investigator: R. H. Mickelson

STUBBLE MULCH FOR MAXIMUM PRODUCTION AND CONSERVATION OF SOIL AND WATER IN THE CENTRAL GREAT PLAINS 11

Objectives

Determine the physical and chemical properties of the soil as related to stubble mulch management and to develop residue management practices for maximum erosion control and crop production in wheat-fallow systems.

Approach

Various rates of wheat straw will be applied in alternate crop-fallow sequence. The influence of residue rates on plant growth, yields, soil moisture storage, soil nitrate production, and soil temperature will be determined on terraced and non-terraced fields.

Principal Investigator: B. W. Greb

SOIL-WATER CONSERVATION UNDER DRYLAND IN THE CENTRAL PLAINS 12

Objectives

To develop methods and systems for the efficient use by plants of the limited precipitation on dryland.

Approach

Land-forming systems will be developed for using runoff for increasing crop productions. Row spacing, snow-drift control procedures, tillage, weed control, and mulching methods will be studied to maximize water-use efficiency.

Principal Investigator: R. Mickelson

CHLORINATED PESTICIDES IN THE SOIL-WATER-PLANT SYSTEM AND THEIR MANAGEMENT TO AVOID POLLUTION 13

Objectives

Determine the effects of soil type, temperature, organic matter, pH, aeration, and water content on the persistence, absorption, and movement of chlorinated pesticides in the soil-water system and on plant growth for the development of better systems of soil and water management and decontamination for the Northern Plains.

Approach

Mechanisms and rates of volatilization of chlorinated pesticides added to soils and their effects on soil metabolism are measured. Soil and water samples from experimentally treated plots, watersheds, and fields are analyzed for accumulation and rates of loss of pesticides.

Principal Investigator: F. G. Viets

SIMULATION OF HYDROLOGIC SYSTEMS 14

Objectives

1. Develop stochastic and deterministic mathematical models of hydrologic systems.
2. Develop simulation as a design technique in watershed engineering.

Approach

Initial work will be concentrated in three areas: numerical solutions and investigations describing free overland flow, the interaction between free-surface flow models and vertical infiltration models, and development of a stochastic model of thunderstorm rainfall.

Principal Investigator: D. A. Woolhiser

SOIL-PLANT-WATER-METEOROLOGICAL RELATIONS IN THE CENTRAL GREAT PLAINS 15

Objectives

To evaluate soil-plant-water-meterological relations and to develop methods and systems for maximizing solar

energy conversion and water use.

Approach

Study water flux from the soil through the plant into the atmosphere as related to plant growth. Different cropping systems will be evaluated as to water use and dry matter production.

Principal Investigator: H. R. Gardner

WATER CONSERVATION BY MANIPULATION OF SOIL PROPERTIES 16

Objectives

Develop methods and systems to increase water conservation by manipulation of soil properties.

Approach

Evaporation of water from various sized soil columns will be studied on three of the predominant soils in the Central Great Plains. In the field various landforming and cropping systems will be utilized to determine the maximum storage and use of rainfall in the Plains.

Principal Investigator: H. R. Gardner

DESIGN AND OPERATION OF IRRIGATION SYSTEMS TO MAXIMIZE EFFICIENCIES OF WATER USE 17

Objectives

1. Develop and field test devices to automate pipeline and open channel irrigation systems.
2. Develop methods to predict ET and schedule irrigations based upon climatic parameters and to measure effective precipitation.
3. Develop mathematical models to design efficient irrigation systems.

Approach

Research is underway to develop and adapt various types of closures to existing control structures in pipes and open channels for remote operation. Evapotranspiration of various crops is measured and correlated with climatic parameters to predict ET and to schedule irrigations on a project basis utilizing computer techniques.

Principal Investigator: H. Haise

PLANT GROWTH AND WATER USE IN THE NORTHERN PLAINS 18

Objectives

Develop systems and methods for maximizing plant growth on limited water on drylands.

Approach

Net radiation, soil heat flow, soil temperature, windspeed, and evapotranspiration measurements will be made on irrigated and dryland site under various moisture and cropping conditions. Net radiation, water vapor, carbon dioxide, windspeed, air temperature, water potential of leaves, transpiration resistance of leaves, and soil heat flow will be obtained at hourly intervals on selected days.

Principal Investigator: D. F. Heerman

SEDIMENT DETACHMENT, TRANSPORT AND DEPOSITION PROCESSES 19

Objectives

Study the probability density function of instantaneous boundary sheer stress and turbulent velocities near a channel bed. Develop a stochastic model describing sediment entrainment, transport, and deposition in open channel flow.

Approach

Measurements of turbulence and instantaneous boundary shear stress will be made in the laboratory utilizing constant temperature anemonetry. A stochastic model describing spatial and temporal variations in boundary shear stress will be postulated and the parameters will be estimated from the laboratory data.

Principal Investigator: D. A. Woolhiser

DESIGN, PERFORMANCE, AND AUTOMATION OF SURFACE IRRIGATION SYSTEMS, UPPER COLORADO BASIN 20

Objectives

Develop and evaluate for efficient water use and crop production facilities, methods, design criteria, and automation for surface irrigation systems. This includes hydraulics of flow in border strips in relation to stream size, slope, crop retardance, soil roughness, and intake rate.

Approach

Field investigations are conducted to develop relationships of the factors that affect flow of water in furrows and border strips. Data obtained form the basis for developing equations to predict flow characteristics for design purposes using computer techniques. Automation of various irrigation methods using semi-automatic devices are studied and performance evaluated under a wide variety of soil, crop, and climatic conditions.

Principal Investigator: J. C. Lorimor

INTEGRATION OF FERTILIZER, WATER AND SOIL MANAGEMENT SYSTEM FOR HIGH ALTITUDE RANCHES 21

Objectives

Determine principles and practices for the conjunctive use of fertilizers, irrigation water, soil and crop management practices for the most efficient production and use by cattle of grasses and legumes in high altitude wet meadows.

Approach

Field and laboratory studies will be conducted using variables of fertilizer rates, water management regimes, renovation practices, and cutting schedules on various species of grasses and legumes alone and in combination for the production of hay and pasture. Laboratory studies and analyses will be made to assess changes in soil fertility status, the reactions of fertilizers with soil and sod mats, and for assessing the effects of treatments on mineral composition and uptake of the various species.

Principal Investigator: C. B. Rumburg

ASSESSMENT AND PREVENTION OF EXCESSIVE NUTRIENT ENRICHMENT OF SURFACE AND GROUNDWATER BY FERTILIZERS 22

Objectives

Assess the extent of excessive nutrient enrichment of surface water by runoff and erosion and accumulation of nitrate in groundwaters by deep percolation as it is affected by kind and amount of fertilizer currently applied for crop and range forage production. Determine if fertilizer recommendations for most efficient crop and range forage production are compatible with pollution control.

Approach

Laboratory, lysimeter, and field studies involving nitrogen and phosphate will be made to determine: the extent of movement in solution and on sediment in runoff water and leachate as affected by fertilizer application related to crop needs; the availability to aquatic plants contained in sediment; the extent of denitrification in the deep profile, and absorption of nitrate by deep rooted alfalfa. Effects of burning of crop residues and leaching of nutrients from vegetation onto frozen soils also will be studied.

Principal Investigator: F. G. Viets

MANAGEMENT OF ANIMAL WASTES AND FEEDLOTS TO AVOID SOIL AND WATER POLLUTION 23

Objectives

Discover chemical, microbiological, physical principles, and engineering systems for the effective disposal of animal wastes and management of cattle feedlots so that the combination of manure, urine, and precipitation will not pollute or eutrophy surface groundwater and air.

Approach

Laboratory and field studies are conducted to determine: the relation of runoff, deep percolation, and evaporation to precipitation and water in excreta on different slopes, soil site conditions, and densities of animals; the kinds and rates of chemical transformations occuring between the surface and water table; the role of microorganisms in these transformations and the persistence of the common microbial pollution indicators under different management systems.

Principal Investigator: F. G. Viets

RUNOFF CONTROL BY MANIPULATION OF SOIL PROPERTIES 24

Objectives

Develop methods of manipulating soil properties so that runoff can be increased or decreased.

Approach

Basic studies of soil particle bonding will be made. Amendments that influence soil properties will be tested.

Principal Investigator: A. Klute

USDA FOREST SERVICE

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

Water Yield Improvement Unit, Central Rockies

Alpine Snow and Avalanche Project

PHOTOGRAMMETRIC ANALYSIS OF SNOW COVER DEPLETION ON WATERSHED INDEX AREAS 25

Objective

To use changes in snow extent on a small indicator area to estimate volume of snow water on a watershed. The applications are for updated runoff forecasts from aerial and/or satellite photography.

Approach

Comparisons are made of changes in snow cover, shown on small index area aerial photos, with those of an entire watershed.

Principal Investigator: C. Leaf

AREAL EXTENT OF SNOW COVER IN RELATION TO STREAMFLOW AT FRASER EXPERIMENTAL FOREST 26

Objectives

1. To improve streamflow forecasting by using the proportion of a watershed with snow cover to update runoff estimates.
2. To be able to estimate the amount of runoff yet to be produced at definite dates during the snowmelt period.

Approach

Aerial photographs used to show changes in snow cover are correlated with streamgaging and rainfall data.

Principal Investigator: C. Leaf

AERODYNAMICS OF FOREST CLEARINGS 27

Objective

To learn how openings in the forest canopy affect windflow. Small openings in the forest are efficient collectors of snow. This study will eventually give information about the most effective size and arrangement of openings for trapping snow.

Approach

Theoretical models are developed and tested against measured airflow in forest canopy space and in actual experimental clearings.

Principal Investigator: J. Bergen

SNOWMELT LYSIMETERS FOR ESTIMATING SNOWMELT 28

Objective

To test a device for measuring snowmelt from the natural snowpack so that melt rates can be measured for specific areas.

Approach

Lysimeter measurements are compared with values from snow survey and theoretical values derived from radiation estimates.

Principal Investigator: R. Schultz

ESTIMATING THE QUANTITY AND DISTRIBUTION OF NEEDLES AND BRANCHES WITHIN THE CROWNS OF LODGEPOLE PINE 29

Objectives

1. To measure the aspects of tree crowns that influence windflow at different heights above the ground.
2. To devise fairly simple methods for characterizing tree crowns for trees of different sizes and spacings.

Approach

Allometric models are developed from actual sampling of needle and branch weights.

Principal Investigator: H. Gary

HYDROLOGY OF THE PARK RANGE, COLORADO 30

Objectives

To measure the precipitation and streamflow for three watersheds on the west side of the Park Range.

Approach

Stream gaging and snow survey techniques are used to develop basic data for use in a subalpine watershed model.

Principal Investigator: C. Leaf

EFFECT OF TIMBER HARVEST ON STREAMFLOW AND SEDIMENT 31

Objectives

To learn how timber harvest systems can influence water and sediment yields from mountain forest lands.

Approach

A calibrated watershed method is used to determine results of applied treatments.

Principal Investigator: M. Hoover

CHEMICAL QUALITIES OF WATER FROM SUBALPINE WATERSHEDS 32

Objectives

1. To devise efficient sampling methods to measure chemical properties of mountain streamflow.
2. To measure chemical properties of selected natural and logged watersheds to learn effects of management.

Approach

Water samples are collected at varying intervals to determine durinal and seasonal variations. Efficient sampling schemes will be established from these statistics to obtain treatment effects.

Principal Investigator: E. Frank

A MATHEMATICAL MODEL OF THE EVAPORATION FROM WIND BLOWN SNOW 33

Objective

To develop a mathematical model to estimate the mass of snow that sublimates as the air-snow mixture moves downwind.

Approach

A theoretical approach is being used. Assumptions and limitations are made by drawing on numerous laboratory and field studies of physical processes in order to develop a model of snow sublimation and evaporation under field conditions.

Principal Investigator: R. A. Schmidt

PROTOELECTRIC SYSTEM FOR AUTOMATICALLY RECORDING SNOW DEPTH 34

Objective

To develop an instrument that will measure and telemeter depth of snow from remote locations.

Approach

Design the necessary circuitry and field test a photoelectric device for monitoring snow depths. A vertical array of pulsed light sources and photodiodes will be used.

Principal Investigator: R. A. Schmidt

WIND SPECTRA AND SNOW DEPOSITION IN IRREGULAR TERRAIN 35

Objective

To test the hypothesis that gusty winds carry more snow than steady winds of the same average velocity over irregular terrain.

Approach

Field measurements of the mass flux of snow and wind spectra will be made in alpine areas to verify or refute the hypothesis.

Principal Investigator: R. A. Schmidt

MEASUREMENT OF SNOW FLUX BY SNOW PARTICLE COUNTERS 36

Objective

To calibrate snow particle counters to give the mass of snow being carried by the wind.

Approach

Sand particles of a known size were used to develop a relationship between particle size and the amplitude of the electronic signal coming from the counter. Once the particle size is known, mass can be computed from the density and shape of the particle. After the technique has been worked out using sand particles, the same procedure will be conducted in a cold room using snow particles.

Principal Investigator: R. A. Schmidt

DEVELOPMENT OF AN INSTRUMENT TO MONITOR DRIFTING SNOW 37

Objective

To modify the snow particle counter so that its output can be integrated over time and displayed on a normal strip chart recorder.

Principal Investigator: R. A. Schmidt

USDA ECONOMIC RESEARCH SERVICE

Natural Resources Economics Division

USDI GEOLOGICAL SURVEY

Water Resources Division

THE IMPACT OF URBANIZATION ON THE FRONT RANGE IRRIGATED AREA 38

Objectives

1. To document and measure the extent and effects of urbanization in an eight-county area of the Front Range and to project urbanization rates which might be expected under several alternative policies of subdivision, water supply, and air pollution controls.
2. Measures will be suggested to bring about orderly development or channel development to areas of less conflict, such as less intensively cultivated lands. Guides would include the use of soil survey data to help locate subdivisions, recognition of potential air quality problems, water supply, and sanitation costs.

Approach

Identify, measure, and analyze land conversions from irrigation to other uses, land value changes, sources and prices of water, and impacts of these changes on irrigation companies.

Principal Investigator: R. L. Anderson

TRADE-OFFS BETWEEN TRADITIONAL AND ENVIRONMENTAL QUALITY OBJECTIVES IN SMALL WATERSHED DEVELOPMENT 39

Objectives

To formulate a methodology and determine the nature of the trade-offs between the traditional objectives of small watershed projects and obtaining preferred environmental values.

Approach

Environmental attributes that may be affected by small watershed developments will be identified. Techniques will be developed for identification of the nature and measurement of the trade-offs between selected environmental attributes and traditional objectives.

Principal Investigator: J. Kasal

TRANSPORT PROCESSES IN ALLUVIAL CHANNELS 40

Objectives

To develop deterministic and stochastic models of sediment transport processes for use in modeling, predicting, and designing flow in alluvial channels.

Approach

Controlled laboratory experiments in flumes ranging in width from eight inches to eight feet with controlled discharges up to about 100 cfs form the basis of the project activities. Subjects receiving particular attention are:

1. Statistical analysis of the dune bed configuration.
2. Alluvial channel bed forms and the resultant channel roughness and resistance to flow.
3. Sediment transport and resistance to flow.
4. Responses of alluvial channels to changes of equilibrium conditions.
5. The lateral and longitudinal dispersion characteristics of particles of varying size and specific gravity.

Principal Investigator: C. F. Nordin

PART 4

DESCRIPTOR INDEX

The Roman and Arabic numerals following each descriptor indicate the section and number under which a project may be found in PART 1.

Federal and State projects are identified with the Prefix P3 and may be found in PART 3.

DESCRIPTOR INDEX