

FOLIO
TA7
C6
CER-58-16
Cp 2

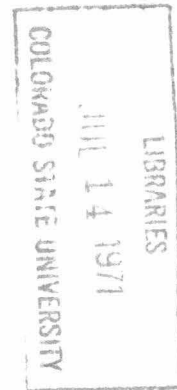
LIBRARY OF THE
FEDERAL BUREAU OF INVESTIGATION

CIVIL ENGINEERING SECTION

COLORADO AGRICULTURAL EXPERIMENT STATION

ANNUAL REPORT

April 23, 1958



CIVIL ENGINEERING SECTION

COLORADO AGRICULTURAL EXPERIMENT STATION

ANNUAL REPORT

April 23, 1958

CER58ARC16

CIVIL ENGINEERING SECTION
COLORADO AGRICULTURAL EXPERIMENT STATION

ANNUAL REPORT

April 23, 1958

I. ACCOMPLISHMENTS BY PROJECTS

Regular Experiment Station

103 - Laboratory and Field Study of the Vortex Tube Sand

Trap: - Study of the sand trap progressed utilizing a large flume and a recirculating sediment system. Tubes at 45 degrees to the direction of flow were operated under different flow conditions. The efficiency of trapping and percentage of water removed have been determined for a large range of tube designs, sediment concentrations, velocities and depths of flow.

The amount of flow removed by a tube seemed to be a function of the depth of flow over the tube and the area of the discharging end of the tube. The width of tube slot, elevation or design of the downstream lip have no effect on the amount of flow taken out by the tube.

The efficiency of trapping bed load sand varied with velocity and depth of flow across the tube, the size of sand or gravel, the percentage of water removed and the L/B ratio (length of tube times the width of opening divided by the cross-sectional area). In general, the tubes seemed to have their highest efficiency of trapping at a Froude number near a value of one. (Critical depth across the tube).

The highest efficiencies were noted for the largest sand materials tested. Efficiencies increased with the percentage of flow removed by the tubes up to about 15 percent. The highest efficiencies were noted for a L/B ratio of 28.7 and the lowest at 11.7.

104 - Meteorological Observations: - The routine weather observations were taken and summarized as they have been twice daily since 1887. These summarized weather data have been published monthly by the U. S. Weather Bureau. In addition to the usual meteorological observations, data were taken on the evaporation from a free water surface, temperatures at various depths in the soil and incident radiation. All these data were made available to newspapers, radio stations, farm groups, student groups, and other interested parties.

105 - Groundwater Fluctuations and Their Relation to Pumping: - The regular fall and spring measurements to the water table in selected wells in the South Platte and Arkansas drainage were made as usual. The only deviation from the usual program indicated above was that of omitting the spring 1956 observation; in its stead a round of measurements was made in the late fall of 1957. The program is now in its thirtieth year. The data have been of immense value to groups and agencies in the State of Colorado in connection with groundwater legislation. The latest set of readings indicate that the groundwater level has, in many cases, recovered several feet as a result of the last year and a half of near normal precipitation following the previous several years of drought.

106 - Development and Improvement of Water Measuring Devices: -

Calibrations are under way on small trapezoidal measuring flumes at the present time. Free flow relationships as well as flow under submerged conditions are being studied. The effect of velocity of approach on the head-discharge relationships is being determined.

The preliminary tests indicate that for some conditions these flumes may be superior in operation to the Parshall flumes. Indications are for the smaller sizes tested that they will operate under much higher degrees of submergence than the Parshall without deviation from the free flow relationship. This would mean that no correction was necessary except for very high degrees of submergence.

107 - Hydraulic Laboratory: - Various items of maintenance and repair in the Hydraulic Laboratory were accomplished.

A research project on the fall velocity of particles at extremely low Reynolds numbers was started. The result of this work will be extremely significant in alluvial channel research and in the design of such channels. Furthermore, the research will add to the fundamental knowledge of flow in low Reynolds numbers.

A four-foot wide by eighty-foot long tilting flume was constructed in cooperation with the Agricultural Research Service. This flume is being utilized for research sponsored primarily by the Agricultural Research Service on the hydraulics of flow in bridges and corrugations. However, it is also being used for Project 106 discussed above.

108 - Sealing of Irrigation Canals by Sedimenting with

Colloidal Clays: - This project, which is supported by the ARS, Colorado Experiment Station, and the Bureau of Reclamation, is now concentrating its efforts on the installation and evaluation of sediment sealing of canals at five sites. These sites are Twin Lakes near Aspen, Colorado, the Coors Farm near Center, Colorado, the Coachella Canal near Imperial, California, Lateral 1 near Torrington, Wyoming, and Lateral 19.3 near Bertrand, Nebraska. These five sites are representative of the range of materials which might commonly be found in canals throughout the West -- fractured rock to loessial soil. The before-lining installation evaluations have been completed on two sites. The sediment sealing has been completed on two sites and partially completed on one other site. The after-sealing evaluations are partially complete.

A detailed laboratory program has been designed and carried out for the Lateral 1 site. This laboratory program has had as its objectives (1) an investigation of the mechanics of the sealing action of the bentonite lining, and (2) the hydraulics of seepage from canals under non-saturated flow conditions.

109 - Snow Course Measurements and Forecast Analyses: - Stream flow forecasts were prepared for 45 gaging stations in Colorado based on snow surveys on March 1, April 1 and May 1, 1957. Because of the heavy late season snow in the spring of 1957, runoff was very substantial compared to the several previous drought years and was above the long term normal. Technical advice was provided to State and Federal agencies interested in flood prevention. The snow course data up to March 1958

indicate that normal or above normal runoff can be expected in the spring of 1958.

Standard interpretation methods were developed for data from the 22 soil moisture units. These standard methods will be used until further experience indicates the method is unsatisfactory. In addition to developing these methods, about ten improved forecast relationships were developed during the year.

110 - Calibration of Current Meters in Rating Flume: - A number of current meters were rated for the Geological Survey, Colorado municipalities and several consultant engineers. The speed range capabilities of the facility were increased from 1.0 to 6.5 feet per second up to 0.1 to 11.0 feet per second. This increased capability of the facility was carried out in order to fulfill the needs indicated by the field staff now working in municipal and irrigation water supply.

111 - Determination of Proper Irrigation Well Construction Materials and Maintenance Practices for Obtaining Maximum Economical Life and Performance: - This project, which will play a very important role in the development of the underground water resource in Colorado, was administratively authorized to begin 1 July 1958 subject to availability of financing.

124 - Study of Gravel Filter Design for Irrigation Wells: - A model representing a section of an irrigation well was constructed to test the stability of various combinations of aquifer and gravel pack materials. A range of flows representative of those from a well were passed through the model. The hydraulic head losses were measured throughout the sections and the amount of aquifer material which moved into the filter was noted for each combination.

Four combinations of materials have been tested to date. All of these were stable in the model and should, therefore, be suitable for wells in the field. It has been noted that more sand moved into the gravel packs composed of uniform sized particles than into those with a wide range of particle sizes. The head loss in the packs increased slightly as the uniformity coefficient of the gravel increased.

125 - Development of Drainage Design Criteria for Irrigated Lands: - This project was continued for the second season essentially as during the previous and expanded to include studies on other drain systems in the area. The purpose is to collect sufficient data on existing farm drains under the most usual conditions in Northeastern Colorado, so that a more comprehensive approach can be made for future drain designs. Measurements have been made of physical and soil features, drain discharges, water table positions and hydraulic conductivity.

The average flows for the drains reflect, to a great extent, the available water supply. During 1957, with an ample supply of water, the average flows ranged from two to three times those during 1956 when the water supply was limited. Peak flows also reflected this trend. The elevations of water tables were higher in 1957 than in 1956.

It had been thought that in a particular area where soils, topography, design of drain, and method of irrigation are similar, that a simple relationship between average hydraulic conductivity and drain flow per unit length h could be determined. However, there seems to be no such relationship existing due to the other factors not considered.

A relationship was noted between the hydraulic conductivity and the permeability, which considers the hydraulic gradient. This

means that a resultant hydraulic gradient as well as the average conductivity must be determined in order to predict the quantity of flow which will result from the installation of an interceptor drain.

227 - Evaporation from Soils: - During the year an effort was made to determine the physical principles relating to the movement of water from a water table to the surface of the soil. A phenomenon was discovered in this connection which has not previously been reported either in published literature or in progress reports of this project. It was found that the maximum evaporation from a soil occurs under environmental conditions which produce less than maximum evaporation from a free-water surface. When the ambient evaporating conditions are increased beyond a critical value (as by additional input of radiant energy) the rate of water loss from the soil may decrease although a dry layer will be produced at the surface. This is significant because it points out the futility of using evaporating pans to estimate evaporation from soils.

A theory based on the concept of hysteresis in soils was developed to explain the observations described above. This theory may be useful in that it suggests possible ways of reducing evaporation from soils. Work is now in progress to develop such methods. Most of the methods under investigation are designed to maintain a thin layer of dry soil at the surface -- one possibility is the use of surfactants to reduce the capillarity of the surface layer.

Institutions on Groundwater Use in the Lower Bijou Basin, Morgan County,

Colorado: - Measurements were made to the water table in 108 wells in the Bijou Valley. Calculations on the specific yield of the unwatered sediments proved unsatisfactory. Water table measurements to be made this spring will provide more adequate data. A report will be prepared on the project by July 1958 interpreting these data in the light of the objectives of the project as indicated by its title.

The Bijou study indicated above involved groundwater as a single source of supply. A revision of the project involving a different site has been approved by administrative personnel in charge of this regional project. This continuation of the project will deal with both surface and groundwater supplies when these two supplies are inter-related. The new site was chosen near Brighton, Colorado mostly because of the considerable amount of data which is available on it. Furthermore, the Brighton site was decided upon because the State Engineer's Office and the State Water Conservation Board are able to actively support our research effort at this site. It is planned that data will be gathered over a period of three years at this site.

Colorado State University Research Foundation Projects

707 - Diffusion of Heat and Gases into an Atmosphere with Various Degrees of Stability: - This project is technically closed as was reported last year. However, administrative details still remain. It is anticipated that at least another year will be required to close

this project at the rate the Air Force moves. At the present time the sponsors are still withholding one percent of the contract.

708 - Behavior of Seaplane Hulls in a Simple Sea: - The final report has been accepted by the Navy. This project is, therefore, technically complete and only administrative closure must still be done. The results of the project indicate that a high length-beam ratio for seaplanes is favorable in improving seaworthiness. High speed performance of seaplanes can best be carried out either parallel to the crests of waves or in the direction of wave travel.

713 - Behavior of a Ship in an Oblique Sea: - The final technical report has been accepted by the sponsors in fulfillment of that aspect of the contract. Administrative closure must still be completed. The results of the research indicate that the greatest heaving and pitching of a ship occur in the 135° and 180° headings with respect to the direction of wave travel. The ship motions tended to be a maximum when the wave length of the sea in which the ship was running was approximately twice the hull length.

715 - Field Study of the Regime Theory of Self-Formed Sediment Bearing Channels: - This project was technically completed and administratively closed during the year. The U. S. Bureau of Reclamation printed the final report on this project. The project reconciled the practices of American and Indian engineers with respect to alluvial channel design. There is every indication that the work reported under this project will become a classic in open channel hydraulic design; particularly, in the design of canals for the conveyance of irrigation water. The report was also used as a Ph. D. dissertation of D. E. Simons.

719 - Resistance to Flow in Open Channels: - Investigation of roughness in open channels of rigid boundaries was continued. The roughness used in the tests this year consisted of rectangular battens nailed to the walls of a triangular flume 400 feet long. The final report has been prepared on this phase of the project. Since all funds from the National Science Foundation have been expended, Colorado State University, which has only been administering the project for the Rocky Mountain Hydraulics Laboratory at Allenspark, will drop out at this point. The Rocky Mountain Hydraulics Laboratory has requested additional funds from the National Science Foundation to continue the research.

723 - Interaction of Ships and Waves: - A series of experiments were conducted on three widely different model ships in shallow water waves. The findings and reports are classified by the Department of the Navy because they contain vital defense information.

724 - Investigations of Contracted Openings in an Open Channel: - During the previous three years, approximately 1500 tests were made on the hydraulics of flow through contracted openings, with rigid boundaries in both the channel and the contraction. The 400 page report on this phase of the research is now in press.

The next phase of the research is an investigation of scour around bridge abutments. Preliminary experiments have been done in the Hydraulics Laboratory. As a result, a formula for estimating the maximum depth of scour around abutments has been derived. These experimental results and the formula have been verified by experimental data obtained from other institutions and field measurements.

With the aid of reliable methods of estimating the maximum backwater and the maximum depth of scour which result from building abutments for highway bridges, the design of these bridges can be more economical. It is estimated that millions of dollars can be saved in the construction costs of the multi-billion dollar interstate highway system now under way.

726 - Flow Patterns on Landing Impact of a Seaplane Hull: -

The final report which was used as a thesis by Mr. d'Utruy is being revised for submission to the Navy Department. The purpose of the project was to determine flow patterns underneath two-dimensional craft such as seaplanes during landing. The second purpose of the project was to find a way to make the flow patterns which result from the impact of wedges or hulls visible to an observer. The only scheme which proved satisfactory was one using zero buoyancy bubbles immersed in water. The resultant visible flow pattern was correlated to the force-time history of impact for wedges of various included angles. The project will be technically completed during the coming year.

735 - Scour at Base of Cantilever Outlets: - Experimental data have been obtained to permit preliminary design of armored (graded gravel riprap) stilling basins for two and three dimensional jets. The two-dimensional jet is associated with drop structures used in irrigation canals and drainage systems. The three-dimensional jet is associated with pipe culverts under road beds. The armored stilling basin is designed to dissipate kinetic energy of flowing water in the vertical direction and to control the rate of scour by armor plate. This stilling basin can be constructed at much less cost than the conventional concrete basin with baffle piers and end sills.

736 - Methods of Creating a Complex Seaway for Model Studies: -

The ultimate goal of wave-basin operators is to reproduce a replica of an observed storm sea in a model basin so that models of ships may be tested under the authentic hydrodynamical conditions which they may be expected to meet at sea. An investigation was made of the possibility of accomplishing this and the requirements to be met if this goal is to be attained. The investigation was based upon mathematical studies.

Work was begun on the development of a new type of wave maker which would be suited to the purposes indicated above. None of the available types of wave making devices would be suitable because they are unable to compensate for the disturbances caused by waves which arrive at their locations from other wave makers.

A study was made of the bending moments which can be expected in a ship's structure due to "slams." A slam is a violent blow delivered to a ship under certain conditions met at sea. The case investigated is that where a ship is moving through waves in a direction normal to their crests and in which the waves are sufficiently high to cause the forefoot to emerge as the ship comes through the crest.

738 - Research Directed Toward the Study of Low Level

Turbulence: - Work has continued on the design and construction of a new wind tunnel facility. Construction has proceeded to the state where the electrical drive installation is all that remains to be done before testing of the tunnel can begin. Designs for a heated floor for the tunnel have been completed.

Data have been collected which describe the turbulent boundary layer formed over a rough, plane, heated boundary. Considerable modification of the hot-wire anemometer equipment has been made to permit collection of reliable turbulence data in a heated turbulent boundary layer.

The new wind tunnel and experimental data have considerable potential practical value in the fields of air pollution, soil and water conservation, and chemical warfare. Field diffusion studies which now cost approximately \$150,000 for a few hours sampling period can possibly be accomplished by model techniques in the wind tunnel for about one-tenth the cost.

740 - Roughness and Sediment Transport in Alluvial Channels: -

The complete range of alluvial channel roughness regimes extending from beginning of motion up to and including antidunes has been investigated, using one sand size and gradation, in the adjustable slope flume. This flume is 8 feet wide, 2 feet deep and 150 feet long. Hydrographs have been routed through the foregoing flume using the same sand as above. The fact that roughness varies as much as 300 to 400 during a flood provided the proper conditions exist was verified.

Testing is under way to determine wash load effect on sediment transport and channel roughness. Bentonite (clay) is being introduced as the wash load. A project to investigate the effect of wash load on sediment transport using a turbulence tank has been approved. This work will be initiated about May of 1958. The soma-scope (a sonar type piece of equipment to measure depth and bed roughness in flumes) has been developed to the practical state. It is currently being used.

740-B - Effect of Turbulence and Proximity of Boundaries

on the Performance of Current Meters: - The standard Price and Pygmy current meters and several experimental vane type meters were tested to determine effect of turbulence and proximity of the boundary on their ability to measure the true mean velocity of flowing water at a point. The data indicates that: (1) Turbulence with a scale the same size as the meters has little effect on the performance of the meters, (2) That proximity of the meter to a rigid boundary has little effect on the performance of the meter, and (3) That proximity to the free surface has considerable influence on the performance. The influence of the free surface is related to the velocity of the flow. At lower velocities the meters tend to under-register and at higher velocities to over-register the velocity of the flow.

The data and experience gained from this testing will be used to develop a new type current meter. With the importance of water to the nation and particularly to the West, a continued effort must be made to improve the basic records of the quantity of water available. This is just one of the many projects sponsored by the U.S.G.S., A.R.S., and C.S.U. to improve the knowledge and measurement of the water resources of the nation.

747 - Water and Sediment Measuring Equipment for Ephemeral

Streams: - This research project has been practically inactive during the last year. However, the Forest Service constructed 12 structures based upon the research reported for the fiscal year 1957. With the data which have been obtained on these structures during the past year, the project will be reactivated in fiscal year 1959.

The observations which have been taken in the field on the 12 flow measuring structures have indicated that the device is basically sound and that only minor modifications will be required.

749 - Analytical Study of Alluvial Channel Roughness: -

Excellent experimental results have been obtained and an empirical equation on the beginning of ripples on a sand bed has been established. Analysis of numerous data on alluvial channel flow has shown a promise of finding a new formula for estimating the mean velocity of flow in an alluvial channel.

If the mean velocity in a channel can be accurately estimated by knowing the depth of flow, channel slope, and bed material, the design of irrigation canals and the control of natural waterways can be improved.

752 - Hydraulic Behavior of the Prototype Dam on a Scale

Model: - The investigations of the performance of the 1:49 scale hydraulic model of the multi-million dollar Bocono Dam in Venezuela are nearly complete. The studies included determination of the size of the stilling basin, calibration curves for the spillway gates, pressure distribution in the river outlets and effect of stilling basin operation on pressures in the turbine draft tubes.

The latter study covered an unusual feature in that the power plant operations can be influenced by the stilling basin operation in a non-uniform manner. So far as is known this is the only dam in the world of the design used. The model tests provided data from which criteria could be developed for operating the power plant while the stilling basin was functioning, or for suspended operations at high flow.

These model tests will save the Venezuelan Government many tens of thousands of dollars.

757 - Equilibrium Conditions in Open Channels: - The research effort under this project has been directed along two lines. The first of these reanalyzed data by Simons and Bander in order to determine the extent and nature of the secondary circulation in straight reaches of irrigation canals. The result of this research has revealed several important facts regarding secondary circulation, which are now being written up in a report that will be completed during the coming year.

The second line of attack has been to approach the problem of secondary circulation from a theoretical point of view. Unfortunately, this theoretical approach seems to be possible only in a qualitative way. Therefore, it is difficult to relate the theoretical results to the experimental data mentioned above. It is felt, however, that this theory has laid important groundwork upon which we can build in the future.

759 - Interaction of Waves and Hydrofoils: - A series of experiments were conducted with a hydrofoil deeply submerged in

shallow water waves. The primary findings are classified by the Navy Department because they contain data which is vital to the national defense. Incidental to the research, a new capacitance influence probe for measuring wave profiles was developed. This probe records the wave profile without touching or disturbing the water surface. It is felt that this probe will play an important role in the future research program, which will be making use of stochastic seas.

760 - Construction of a Tilting Flume: - The National Science Foundation granted the University \$10,000 with which to construct a tilting flume. Design of the flume has been completed. However, construction will be delayed for sometime because no space is currently available in which to build the facility. It is hoped that adequate space will become available during the coming year either by the removal of old equipment or by the acquisition of sorely needed additional laboratory space.

761 - Calibration of Turbinometers for the Martin Company: - The turbinometers which are being calibrated under this project are being used in the development of the Titan Intercontinental Ballistic Missile. The meters which are being tested are used for the measurement of the flow rate of liquid oxygen, liquid nitrogen, JP-4 Rocket Fuel, water and organic liquids.

Under this project the University has acquired the use of approximately \$50,000 worth of capital equipment, such as electronic instruments, large capacity pumps, etc.

762 - Hydraulics of Meanders and Spur Dikes: - A theoretical investigation of the mechanics of meander formation has been completed.

A paper is now being prepared for publication on this work. Even though a vast amount of experimental data is available, this is the first time that any reasonable progress has been made toward developing a fundamental theory which will make it possible to interpret this vast volume of experimental data.

As another aspect of this project, construction of a 16-foot wide flume of variable slope has been started. This will be a unique facility in the United States for experimental laboratory research on meanders.

763 - The Consequences of Model Restraint on Results of Seaworthiness Tests:- This project is in its initial phase. Design of experimental apparatus is proceeding satisfactorily. Experimental work will be carried out during the summer of 1958.

768 - U. S. Bureau of Public Roads - Educational Film: -
An outline of the script for this film has been completed. A number of field shots which will go into the film have been taken during the flooding of a number of bridges along the Eastern Seaboard. Exploratory filming in the Hydraulics Laboratory has been completed. It is anticipated that all camera work and script writing will be completed during the coming year. If possible, the sound track will also be dubbed in and the film printed and distributed.

769 - Model Studies of the Cumbaya Project Tunnel By-Pass: -
This project is an investigation of the performance of a hydraulic model of a tunnel by-pass. This by-pass is part of an underground hydro-electric plant in Ecuador located 225 feet below the surface. The model studies have demonstrated that the manifold stilling basin

which was invented at Colorado State University will be several times more economical as an energy dissipator device for this tunnel by-pass than the conventional stilling basin commonly used. The research will be completed during the coming year.

770 - Evaluation of Flowmeters for the Martin Company: -

The Gentile tube, the Galton Ultrasonic flowmeter, the Potter floating rotor turbidimeter and the Waugh turbidimeter have all been evaluated under this project. The meters were evaluated as to dynamic response, accuracy, flow range, effect of the viscosity of the liquids being conveyed and linearity of calibration curve. This evaluation has utilized organic fluids and water. The results of the tests have been transferred analytically to simulate the flow of liquid oxygen, liquid nitrogen and liquid helium.

These evaluation tests have amply demonstrated that a tremendous amount of research is needed in the flow measurement field.

771 - A Study of Shear Stress at a Fluid Solid Interface

by Measurement of the Electrokinetic Potential: - This project is less than three months old. However, the laboratory equipment has been designed and most of the items have been either purchased or constructed in our laboratory shops.

773 - Distribution of a Wetting and Non-Wetting Fluid Phase

in a Porous Solid: - The National Science Foundation granted the University \$3,000 to investigate some aspects of multi-phase flow in a porous solid. This research will be important in gaining a better understanding of the multi-phase flow that exists in petroleum reservoirs and near the soil surface of agricultural lands.

775 - The Forces and Moments on a Pitching and Heaving Sur-

face Ship: - Design of the experimental apparatus is nearly complete. The project will involve the towing of two special model ships while they are being mechanically oscillated. These model ships have each been cut into seven segments. Each segment is attached to a mechanical oscillator by means of a special forced balance so that the magnitude and direction of the vertical force and moments along the length of the model can be continually measured.

778 - Atmospheric Surface Layer Phenomena: - This study has just begun and will cover a period of two years. The research, which will be carried out in the University wind tunnels, will involve the measurement of turbulent boundary characteristics of air flow over plane, smooth, and rough heated and unheated boundaries.

781 - Scour Below Outlets: - The Association of American Railroads has awarded the University a \$3,000 grant to begin investigations on the diffusion of a three-dimensional jet impinging upon a flat plate. This research will play an important part in our research on development of scour control measures for cantilevered culverts and other drop structures.

782 - Makio Dam Model Study: - The hydraulic behavior of a 1:60 model of the Makio Dam in Japan will be investigated. The model of the 225 foot high spillway has been built and preliminary tests started. It is already evident that detailed investigation on the model will save the contractors several thousands in excavation costs.

New - Investigation of Spur Dikes for Highway Bridges: -

The hydraulic performance of spur dikes placed near bridges which are used to cross wide flood plains will be investigated. At the present time without spur dikes the flow which converges toward the main channel of a river from a flood plain along the highway embankment during high spring water exceeds the highway abutments and frequently causes bridge failure. There is considerable possibility that installation of spur dikes will alleviate this erosion problem to a large extent.

II. PUBLICATIONS AND REPORTS

- Bittinger, Morton W. Evaluation of the Effect of Approach Tubing Size upon the Calibration of 3/4-inch Turbine Flowmeters, prepared under Contract DEN 57-10195 for the Martin Company, November 1957.
- Chamberlain, A. R. and Kassi Devar. Interim Report on Model Studies for Bocoño Dam, prepared for Tipton and Kainbach, Inc., October 1957.
- Chamberlain, A. R. Hydraulic Research - Summary of Research Projects, prepared for Hydraulic Research in the United States, National Bureau of Standards, December 1957.
- Chamberlain, A. R. and Fred Vidson. Evaluation of the Effect of Viscosity on the Calibrations of Several Flowmeters, prepared for the Martin Company under Contract DEN 57-10195, February 1958.
- Corey, A. T. Study of Evaporation from Soil Surfaces in Terms of Soil and Micrometeorological Factors of the Western Regional Research Project W-32, Progress Report No. 3, prepared for the Technical Committee Meeting held in Tucson, Arizona, December 1957.
- Dimmeyer, R. D., Jr. Use of Colloidal Clay Sediments in Sealing Irrigation Canals, International Commission on Irrigation and Drainage, Third Congress, San Francisco, May 1957.
- Dimmeyer, R. D., Jr. Means of Making Watertight the Beds and Dikes of Navigable Canals and Rivers, IIR International Navigation Congress, London, July 1957.

- Dimoyer, R. P., Jr. Progress Report - Research and Development Project on Sedimenting Methods of Sealing Irrigation Canals, prepared for the 7th Annual Meeting of Four States Irrigation Council, January 10, 1958.
- d'Ursay, Bernard. Decalcification during Impact of Scapular Bullets on a Water Surface. Master's Thesis. August 1957. Project 726.
- Fiala, Gene R. Laboratory Study of a Manifold Stilling Basin. Master's Thesis. May 1957. Project 107.
- Glover, R. E. Estimates of Bending Moments and Pressures due to Slamming, prepared for DWSB under Contract Nour 1610(02), Technical Report No. 5, August 1957.
- Glover, R. E. Requirements for Production of a Replica Sea in a Model Basin, prepared for DWSB under Contract Nour 1610(02), Technical Report No. 6, October 1957.
- Glover, R. E. Arch Dams - Review of Experience, Proceedings Paper 1217, ASCE, April 1957.
- Glover, R. E. A New Type of Wave Generator, prepared for DWSB under Contract Nour 1610(02), Technical Report No. 7, March 1958.
- Lin, H. K., J. H. Bradley, and E. J. Plate. Backwater Effects of Bridge Piers and Abutments, prepared for the U. S. Bureau of Public Roads, Contract CBR 11-5103, October 1957.
- Lin, H. K. Discussion of the Present Status of Research on Sediment Transport by Ming Chien, Proceedings Paper 505, April 1955.
- Lin, H. K. Discussion on Proceedings Paper 1331, Systematic Changes in the Beds of Alluvial Rivers by W. C. Casey and M. Dean Keller, March 1958.
- Lin, H. K. Mechanics of Sediment Ripple Formation, ASCE Proceedings Paper 1107, April 1957.
- Nelson, Duane F. The Effect of Shape of a Pinna, Smooth Saturated Surface on Evaporation Rate. Master's Thesis, August 1957. Project 707.
- Nowman, H. C. Report on Laboratory Testing of the Sediment-Sealing Method. Part I. Sealing Effects of Dispersed and Flocculated Bentonite Suspensions in a Dune Sand. August 1957.
- Plate, E. J. Laboratory Studies on the Beginning of Sediment Ripple Formation in an Alluvial Channel. Master's Thesis, June 1957. Project 749.
- Robinson, A. F. and Carl Rubinow. Measurement of Canal Seepage, Paper No. 2035, Transactions, Vol. 122, 1957, p. 347.

- Robinson, A. R. and Jack Keller. Model Study of Tile Interoceptor Drains. October 1957, prepared for ASCE, Portland, Oregon in June 1958.
- Robinson, A. R., R. W. Nelson, R. H. Brooks and E. G. Kruse. Annual Report 1957 - ARS Western Soil and Water Management Research Branch, Irrigation and Drainage Facilities Section (confidential), February 1958.
- Robinson, A. R. Well Screens and Gravel Packs for Water Wells, USDA Farmers Leaflet (in press).
- Robinson, A. R. Drainage Research in Colorado. American Society of Agricultural Engineers, winter meeting, December 1957.
- Robinson, A. R. and H. A. Evans. Drainage Research in Colorado, presented at ASAE meeting in Chicago, Illinois, December 1957.
- Schulz, E. P. Description of Facilities for Seaworthiness Testing of Model Hulls at Colorado State University, May 1957; revised August 1957.
- Schulz, E. P. and J. E. Phillips. Use of a Capacitance Influence Probe for Measuring Wave Profiles, prepared for the DMB, Navy Department, Contract Nant 1610(C2). January 1958.
- Schulz, E. P. Interaction of Ship and Wave Pressure Effects. Part I. Experimental Procedure for Model Studies prepared for DMB, December 1957. (classified)
- Shen, R. T. Report on Laboratory Testing of the Sediment-Sealing Method. Part II. Sealing Effects of Dispersed Bentonite Suspensions and Dispersant Solution in Greeley Fine Sandy Loam and Loveland Lake Sand. August 1957.
- Shen, R. T. and C. P. Cass. Discussion of paper, "Drainage in the Mississippi River Valley" by Louis W. Hummel, ASCE Proceedings Paper 1363, Vol. 83, No. ER3, September 1957.
- Simons, D. B. Theory and Design of Stable Channels in Alluvial Materials, May 1957, prepared for U. S. Bureau of Reclamation, Contract 63652.
- Simons, D. B., E. V. Richardson and H. L. Albertson. A Laboratory Study of Roughness in Alluvial Channels, prepared for the U. S. Department of Interior, Geological Survey, January 1958.
- Simons, D. B., E. V. Richardson and H. L. Albertson. Discussion of Sediment-Ripple Formation by H. K. Liu, ASCE Proceedings 1958.
- Smith, G. L. and Buckstein, L. K. Design of an Anomalous Stilling Basin, prepared for the Bureau of Public Roads, February 1958.

Smith, G. L. On the Design of an Amorphated Stilling Basin for a
Artificially Created Outlet on the Turkey Creek Watershed, Colorado prepared for
the Bureau of Public Roads, November 1957.

Smith, G. L. Scour and Energy Dissipation Below Culvert Outlets, April
1957.

Smith, G. L. An analysis of Scour Below Culvert Outlets, June 1957.
Master's Thesis. Project 735.

Staley, R. W. Effect of Wind Velocity and Depth of Water Table on
Evaporation from Fine Sand, October 1957. Master's Thesis.
Project 237.

Stackwell, Homer. Snow Report Bulletins, published on the tenth of each
month following the regular snow report dates of February 1, and

Symposium on Arch Dams, reprinted from Journal Power Division, Proc.
ASCE, September 1957.

III. PUBLIC SERVICES

G. L. Smith spent considerable time advising the Colorado State
Highway Department on erosion problems below culvert outlets.

R. E. Glover taught two courses in Special Studies of Transient
Groundwater Phenomena. This can be considered as a public service since
no remuneration was given.

The Section as a whole devoted considerable time to explaining
the various research projects that are going on in the laboratories to all
types of outside groups, such as university administrators, grade school
children, editors of Colorado newspapers, etc.

A. R. Erickson, among others, has devoted considerable time to
answering written inquiries concerning problems involving water measure-
ment and conveyance, seepage measurements and drainage. He is also acting
as a consultant to the Irrigation Institute of CSU and vice president of
the Fort Collins Engineers Club.

W. H. Strickland rendered consultation and advice to the Ideal
Cement Co. regarding technical problems of air pollution control.

A. T. Cosby is serving in the capacity of chairman of the Regional Project W-32 Technical Committee. This committee is made up of members from the eleven western states and Hawaii.

A. R. Chamberlain served on the Steering Committee and as moderator for the National Science Foundation Science Conference held in Boulder, Colorado, February 1958. He has also discussed Colorado State University's engineering research program before several civic groups during the year.

Maxwell Parrshall has prepared local weather data and given it to the Fort Collins radio station twice daily. He also transmitted weather data and forecasts of future weather to the local newspaper daily. Precipitation and temperature data, details on unusual weather and climatological data have been given to many private citizens and grade school children.

IV. OTHER RESEARCH ACTIVITIES

Under this section are summarized those research activities which cannot be related to a specific research project.

The research staff as a group have acted as major professors on a number of Master Degree theses above and beyond any responsibilities that some of these people might have had on resident instruction.

H. K. Lin worked as a member of the American Society of Civil Engineers, Hydraulics Division, Task Force on Local Scour Problems. In this capacity he cooperated with top sediment engineers in various parts of the United States on problems of scour around bridge piers and similar structures.

D. V. Simons served as advisor for two graduate students working on their Master's Degree in Civil Engineering at the University

Richard Dismeyer was employed as a consultant to the Wyoming Natural Resources Board with respect to the lining of irrigation canals in several irrigation districts in Wyoming. He acted in a similar consultant capacity to several irrigation districts in both Colorado and Wyoming.

R. E. Glover has been employed by the U. S. Geological Survey in various investigations on the saline water problem. Furthermore, he has been employed by the U. S. Bureau of Reclamation as a consultant to assist in the final design of the abutments on the Glen Canyon Dam.

A. R. Chamberlain carried out two investigations for Tipton and Kalkbush, Inc. The first of these was a theoretical investigation on an underground surge tank for a hydro-electric development in Ecuador. The second was the design of a manifold stilling basin for an underground hydro-electric plant.

Several staff members in the Civil Engineering Section attended technical conferences at various times throughout the year. These conferences were attended in order to present a technical paper or promote research of the sponsored type for CSU.

J. E. Cetmek served on the Fluid Dynamics Committee of the Engineering Mechanics Division, American Society of Civil Engineers. He was also on the Fluid Mechanics Committee of the Hydraulics Division of the American Society of Mechanical Engineers. He acted in the capacity of Research and Development Coordinator, Office of the Chief of Ordnance as a part of his responsibility as an active reserve officer.

A. R. Robinson, in addition to his responsibilities to the Experiment Station, was administratively responsible for three professional and three sub-professional Agricultural Research Service employees of the Western Waters Management Research Branch. In this capacity he was in charge of ARS research in the drainage field.

V. RECOMMENDATIONS

The principal recommendation as far as Civil Engineering is concerned is that every effort should be made to induce the State Legislature, private industry, and individuals to make available to the University more nearly adequate funds for expenses and capital investment in equipment and buildings. At the present time, with Experiment Station expense accounts essentially being held constant and no Station monies available for capital investment, it is impossible to conduct Station research in a satisfactory manner in the face of continually rising expense costs and the continuous aging of presently available equipment. As an absolute minimum, even if additional building space cannot be made available, funds should be found to offset the rising costs of expenses incurred in research and to replace worn out equipment. In addition to the needs for capital investment, funds are needed to employ additional semi-professional assistants. At the present time the output of our professional employees is considerably less than it could be if they had adequate semi-professional help.

Continuing efforts should be made to improve the salary rates of our eleven-month employees. These employees at the present time are, in general, paid less than their nine-month counterparts, paid less than their equivalent in the Government service who are stationed with us and paid far less than private industry is offering them.

Reiterating a recommendation made earlier on which no action has been taken, social security benefits or its equivalent should be arranged for our hourly employees. At the present time

they are not eligible for the Public Employees Retirement Association benefits or social security. The University cannot expect hourly employees to (1) work at less than union wages; (2) have practically no sick leave or vacation privileges; (3) not have any foreseeable income when they reach retirement age, and (4) be happy about the situation.

A year ago the recommendation was made that American graduate students be employed in research programs at rates of pay of two-thirds to three-fourths of what they would earn as a full-time employee. This was recommended because of the fact that it was absolutely impossible to interest American students in going on for graduate work. On an experimental basis, four graduate students have been employed on such a basis. The results of this trial indicate that it is possible to interest top quality American students to go on for graduate work if they are given an existence wage with which to support themselves and their families. Therefore, it is recommended that we not only pursue the program indicated above but enlarge it if possible.

Capital investment in equipment and facilities during the last year were as follows:

Experiment Station	<u>None</u>	<u>None</u>
USRF		
a) Electronic Equipment	\$ 7,200	
b) Office Space	3,600	
c) Sediment Analysis Lab	1,100	
d) Pumps, Motors and Starter	9,000	
e) Constant Head Tank	12,500	
f) Wind Tunnel	26,000	
g) Flow Calibration Stands	<u>11,000</u>	<u>\$73,400</u>
Total		\$73,400

(Handwritten signature)
 DEPARTMENT OF CIVIL ENGINEERING
 UNIVERSITY OF CALIFORNIA
 BERKELEY, CALIFORNIA