

**The Influence of Glen Canyon Dam Discharge on  
Riparian Climate Throughout Grand Canyon**

**Quarterly Report  
3RD Quarter, 1994**

Grand Canyon National Park  
Special Use Permit WRO-GRCA-6000-4010

Glen Canyon National Recreation Area  
Special Use Permit RMR-GLCA-25A0-006

Co=PI's:  
Melvin G. Marcus  
Anthony J. Brazel  
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Date of Report: October 1, 1994  
Project Start Date: March 12, 1994  
Project Funded By: National Geographic Society  
Project Supported By: National Park Service, Bureau of Reclamation, Arizona State  
University

## THE INFLUENCE OF GLEN CANYON DAM OUTFLOW PATTERNS ON CLIMATE IN GRAND CANYON

Climate studies were conducted in both Glen and Grand Canyons during selected field periods during July through September, 1994. This represents the second quarter of work on the three-year research described in a proposal presented through our funding organization, National Geographic Society, and appropriate agencies concerned with the Glen Canyon Environmental Studies, especially the National Park Service and Bureau of Reclamation. The research was in accordance with NPS permits.

### Progress To Date

Previous research completed by June 30, 1994 included: (1) establishment and operation of an energy balance cross-section in the boundary layer zone at RM -14.5, USGS cableway (mid-March and mid-June); (2) diurnal measurement of energy balance parameters over variable vegetation zone transects at RM -14.5, 43.1, 55 and 194 (mid-April [spring], late June [pre-monsoon]); placement of datalogger-recorded thermistors and pyranometers at RM -14.5, 43.1, and 55 (late June); and initiation of riparian habitat related studies to assess seasonal microclimatic interrelationships with plant productivity and changing surface cover (mid-April, late June).

During the July-September period, the following was accomplished: (1) continuation of the diurnal measurement of energy balance parameters over vegetation at RM -14.5, 43.1, 55 and 194 (completion of the late June - early July [pre-monsoon work] and an early August [monsoon] trip); (2) completion of the placement of datalogger-recorded thermistor, relative humidity sensor, and pyranometer profiles at the above mileage locations and on both sides of the river (nineteen new sensors and five dataloggers); (3) establishment of a six-sensor profile across Tapeats Creek and upstream from its gorge; (4) continuation of remapping of microclimatic vegetation zones; (5) the first comprehensive measurement of plant productivity, especially at RM 55; (6) field surveying of all research and transect sites, with subsequent data reduction and placement of the climate net into the GCES survey base; (7) operation for the third time of the energy balance cross-section at RM -14.5 (late September); and (8) classification and reduction of data collected to date and initial analyses.

### Future Plans

The currently-active research team -- which consists of two faculty, one Ph.D. student, two M.A. students, and two undergraduates -- will devote the October-December quarter primarily to data analysis, climatic mapping, and writing.

The next cableway effort and downriver transect series are currently anticipated for the first weeks of January, 1995 (to fill out the measurement series with a winter season), but it is probable that the RM -14.5 cableway work will be initiated in late December.

Lastly, efforts will be made to download the ten dataloggers along the river at least twice during this quarter.

## Problems Encountered

Problems encountered during this quarter include:

(1) Loss of two ASU 21X dataloggers by water damage at RM -14.5 when 1300 h releases from Glen Canyon Dam ramped upward at an unexpected rate (3 August 1994). One datalogger was a total loss; the other is being repaired at a cost of \$600.

(2) Between-trips damage to thermistor wires at RM 43 and 194 by animals. This reinforces our need for protective conduit which is not covered by the current budget. We had only sufficient conduit to place at RM 55R.

(3) The performance of OARS boat crews on the Lees Ferry - RM 225 trips in July and August were not up to standards we have experienced with the cableway OARS crews and on the April trip. This was duly reported in the most recent post-river evaluation forms.

**The Influence of Glen Canyon Dam Discharge on  
Riparian Climate Throughout Grand Canyon**

**Quarterly Report  
4th Quarter, 1994**

**Grand Canyon National Park  
Special Use Permit WRO-GRCA-6000-4010**

**Glen Canyon National Recreation Area  
Special Use Permit RMR-GLCA-25A0-006**

**Co=PI's:  
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Anthony J. Brazel  
Diane Stanitski-Martin**

**Date of Report: January 1, 1995  
Project Start Date: March 12, 1994  
Project Funded By: National Geographic Society  
Project Supported By: National Park Service, Bureau of Reclamation, Arizona State  
University**

## THE INFLUENCE OF GLEN CANYON DAM OUTFLOW PATTERNS ON CLIMATE IN GRAND CANYON

Climate studies were conducted in both Glen and Grand Canyons during selected field periods during October through December, 1994. This represents the third quarter of work on the three-year research described in a proposal presented through our funding organization, National Geographic Society, and appropriate agencies concerned with the Glen Canyon Environmental Studies, especially the National Park Service and Bureau of Reclamation. The research was in accordance with NPS permits.

### Progress To Date

Previous research completed by September 30, 1994 included: (1) establishment and operation of an energy balance cross-section in the boundary layer zone at RM -14.5, USGS cableway (mid-March, mid-June, and late September); (2) diurnal measurement of energy balance parameters over variable vegetation zone transects at RM -14.5, 43.1, 55 and 194 (mid-April [spring], late June [pre-monsoon], and mid-August [monsoon]); (3) placement of datalogger-recorded thermistors and pyranometers at RM -14.5, 43.1, and 55 (late June, and in August, completion of the placement of datalogger-recorded thermistor, relative humidity sensor, and pyranometer profiles at the above mileage locations and on both sides of the river (nineteen new sensors and five dataloggers); (4) establishment of a six-sensor profile across Tapeats Creek and upstream from its gorge; (5) initiation of riparian habitat related studies to assess seasonal microclimatic interrelationships with plant productivity and changing surface cover (mid-April, late June, and mid-August); (6) the first comprehensive measurement of plant productivity, especially at RM 55; (7) field surveying of all research and transect sites, with subsequent data reduction and partial placement of the climate net into the GCES survey base; and (8) classification and reduction of data collected to date and initial analyses.

During this quarter, data storage modules were collected from nine permanent sites and downloaded; a tenth datalogger (at Tapeats Creek) had been vandalized. These and earlier collected data were reduced and used in preliminary analysis during November and December. Early results show strong confirmation of hypotheses relating vegetation zones to distance and height from river; the role of canyon walls is particularly apparent as a control on, not only radiation receipt, but temperature regimes. Local variability of climatic elements was in many cases much greater than expected and may prove an influential forcing factor on vegetation.

### Future Plans

The currently-active research team -- which consists of two faculty, one Ph.D. student, one M.A. student, and two undergraduates -- will continue analysis, climatic mapping, and begin to write during the January-March fourth quarter.

The next cableway effort and downriver transect series will take place in the last few days of December, 1994, through 16 January, 1995, which will provide the first winter

season data at the same time, the ten dataloggers along the river will be downloaded. An additional downloading will be planned for early March.

Two papers are being presented at the Annual Meetings of the Association of American Geographers in March: Diane Stanitski-Martin, *Glen Canyon Dam Impacts on Downstream Riparian Climate*; and Anthony J. Brazel, Melvin G. Marcus, and Richard J. Schiller, *Seasonal Albedo Variations: Riparian Habitat, Grand Canyon*.

At least three papers will be prepared and submitted for the Ecological Society of America Annual Meetings, July 31 - August 2, 1995. We will begin plans for an April (Spring) repeat of the field measurements insofar as the April, 1994, effort was a pilot study as full instrumentation was not in place until the later trips.

There will be increased analysis and writing in the coming quarter. Also, a special seminar on Grand Canyon Bioclimatology will address many pertinent issues during the Spring term at Arizona State University.

### Problems Encountered

Problems encountered during this quarter include:

- (1) Shorting of the thermistor and datalogger system at RM -14.5R, which led to loss of temperature data for the August through September period. This was corrected for the subsequent third quarter observation period.
- (2) Vandalization and loss of datalogger at the tributary upstream Tapeats Creek site, RL.

The Influence of Glen Canyon Dam Discharge on  
Riparian Climate Throughout Grand Canyon

Quarterly Report  
2nd Quarter, 1995

Grand Canyon National Park  
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Special Use Permit RMR-GLCA-25A0-006

Co=PI's:

Melvin G. Marcus  
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Date of Report: July 1, 1995  
Project Start Date: March 12, 1994  
Project Funded By: National Geographic Society  
Project Supported By: National Park Service, Bureau of  
Reclamation, Arizona State University

**THE INFLUENCE OF GLEN CANYON DAM OUTFLOW PATTERNS ON  
CLIMATE IN GRAND CANYON**

Climate studies were conducted in both Glen and Grand  
Canyons during selected field periods during April through June,  
1995. This represents the fifth quarter of work on the three-  
year research described in a proposal presented through our  
funding organization, National Geographic Society, and

appropriate agencies concerned with the Glen Canyon Environmental Studies, especially the National Park Service and Bureau of Reclamation. The research was in accordance with NPS permits. Fourth quarter activities were included in the Annual Report submitted at the end of March.

### Progress To Date

Previous research completed by April 30, 1995 included: (1) establishment and operation of an energy balance cross-section in the boundary layer zone at RM -14.5, USGS cableway (mid-March, mid-June, late September, late December, 1994, and mid-March, 1995); (2) diurnal measurement of energy balance parameters over variable vegetation zone transects at RM -14.5, 43.1, 55 and 194 (mid-April [spring], late June [pre-monsoon], and mid-August [monsoon], January [winter]); (3) placement of datalogger-recorded thermistors and pyranometers at RM -14.5, 43.1, and 55 (late June, and in August, completion of the placement of datalogger-recorded thermistor, relative humidity sensor, and pyranometer profiles at the above mileage locations and on both sides of the river (nineteen new sensors and five dataloggers); (4) establishment of a six-sensor profile across Tapeats Creek and upstream from its gorge; (5) initiation of riparian habitat related studies to assess seasonal microclimatic interrelationships with plant productivity and changing surface cover (mid-April, late June, and mid-August); (6) the first comprehensive measurement of plant productivity, especially at RM 55; (7) field surveying of all research and transect sites, with subsequent data reduction and partial placement of the climate net into the GCES survey base; and (8) classification and reduction of data collected to date and initial analyses.

During this quarter, data storage modules were collected from nine permanent sites and downloaded. An additional trip was completed during April-May, 1995 with intense collection of station data, concluding the field transect data collections for the downriver sites. These and earlier collected data were reduced and used in preliminary analysis during April-June. Early results show strong confirmation of hypotheses relating vegetation zones to distance and height from river; the role of canyon walls is particularly apparent as a control on, not only radiation receipt, but temperature regimes. Local variability of climatic elements was in many cases much greater than expected and may prove an influential forcing factor on vegetation.

Early results were recorded in four papers at (1) *Annual Meetings of the Arizona-Nevada Academy of Science* and two papers at (2) *Annual Meetings of the Association of American Geographers*:

(1) Energy balance studies over varying ground cover of the Colorado River riparian zone below Glen Canyon Dam, Part I: seasonal albedo relationships (Marcus, Brazel, Schiller);

Energy balance studies over varying ground cover of the

Colorado River riparian zone below Glen Canyon Dam, Part II: net radiation (Brazel, Brazel, Marcus);

Seasonal energy and radiation balance comparisons along a riparian transect: Glen Canyon, Arizona (Stanitski-Martin);

Soil moisture and riparian vegetation relationships at Kwagunt Marsh, Mile 55, Colorado River, Arizona (Schiller).

(2) Seasonal albedo variations: riparian habitat, Grand Canyon (Brazel, Marcus, Schiller);

Glen canyon dam impacts on downstream riparian climate (Stanitski-Martin).

A special seminar on Grand Canyon Bioclimatology was held during the Spring term at Arizona State University. Four graduate student research reports have been produced dealing with canyon area paleoclimatology, official weather station observations in the region, anecdotal reportage of climate by boatmen, and a review of air quality-related studies.

### Future Plans

Additional downloading of storage modules will be planned for late Summer and early Autumn. The currently-active research team -- which consists of two faculty, one Ph.D. student, one M.A. student, and two undergraduates -- are continuing analysis, climatic mapping, and have begun writing. Much of this should culminate in the late Autumn.

Two papers will be presented for the *Ecological Society of America Annual Meetings*, July 31 - August 2, 1995.

The Influence of Glen Canyon Dam Discharge on  
Riparian Climate Throughout Grand Canyon

Quarterly Report  
3rd Quarter, 1995

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Co=PI's:  
Melvin G. Marcus  
Anthony J. Brazel  
Diane Stanitski-Martin

Date of Report: October 1, 1995  
Project Start Date: March 12, 1994  
Project Funded By: National Geographic Society  
Project Supported By: National Park Service, Bureau of  
Reclamation, Arizona State University

12/1/95  
11/1/95  
6/1/95  
2/1/95

10/1/95 11/1/95

## THE INFLUENCE OF GLEN CANYON DAM OUTFLOW PATTERNS ON CLIMATE IN GRAND CANYON

Climatological data were collected in August from semi-permanent datalogged instrument sites along the Marble/Grand Canyon corridor of the Colorado River. Data analysis was performed. This represents the sixth quarter of work on the three-year research described in a proposal presented through our funding organization, National Geographic Society, and appropriate agencies concerned with the Glen Canyon Environmental Studies, especially the National Park Service and Bureau of Reclamation. The research was in accordance with NPS permits. Fifth quarter activities were included in the Annual Report submitted at the end of June.

### Progress To Date

Previous research completed by June 30, 1995 included: (1) establishment and operation of an energy balance cross-section in the boundary layer zone at RM -14.5, USGS cableway (mid-March, mid-June, late September, late December, 1994, and mid-March, 1995); (2) diurnal measurement of energy balance parameters over variable vegetation zone transects at RM -14.5, 43.1, 55 and 194 (mid-April [spring], late June [pre-monsoon], and mid-August [monsoon], January [winter]); (3) placement of datalogger-recorded thermistors and pyranometers at RM -14.5, 43.1, and 55 (late June, and in August, completion of the placement of datalogger-recorded thermistor, relative humidity sensor, and pyranometer profiles at the above mileage locations and on both sides of the river (nineteen new sensors and five dataloggers); (4) establishment of a six-sensor profile across Tapeats Creek and upstream from its gorge; (5) initiation of riparian habitat related studies to assess seasonal microclimatic interrelationships with plant productivity and changing surface cover (mid-April, late June, and mid-August); (6) the first comprehensive measurement of plant productivity, especially at RM 55; (7) field surveying of all research and transect sites, with subsequent data reduction and partial placement of the climate net into the GCES survey base; and (8) classification and reduction of data collected to date and initial analyses.

During this quarter, data storage modules were collected from the RM 43, 55.5, and 194 semi-permanent sites and downloaded. These and earlier collected data were reduced and used in continuing analysis during July-September. Six chapters of Stanitski-Martin's dissertation, which focuses on boundary layer climate/riparian zone climatology at the RM -14.5 cross-section, were completed. The entire study should be finished in December and available after the first of the year. Brazel and Marcus continued interpretation of downriver climatology and Marcus began to edit an ASU Office of Climatology Scientific Research Paper consisting of three review essays: Canyon Region Paleoclimates, Summary of all canyon region National Weather Service observations, and pollution/air quality studies to date.

Two papers -- were given at the *Ecological Society of America Annual Meetings*, July 31 - August 2, 1995 in Snowbird, Utah -- relating to cross-sectional and seasonal changes in albedo at RM 55.5 and cross-sectional changes in temperature, relative humidity and net radiation at RM -14.5.

### Future Plans

Additional downloading of storage modules will be planned for Winter, 1995/96. The currently-active research team -- which consists of two faculty, one Ph.D. student, one M.A. student, and two undergraduates -- are continuing analysis, climatic mapping, and have begun writing. Articles are underway for submission to *Weatherwise*, *Journal of Climatology*, and a meteorological instrumentation journal.

The Influence of Glen Canyon Dam Discharge on  
Riparian Climate Throughout Grand Canyon

Quarterly Report  
4th Quarter, 1995

Grand Canyon National Park  
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Co=PI's:

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Date of Report: December 31, 1995  
Project Start Date: March 12, 1994  
Project Funded By: National Geographic Society  
Project Supported By: National Park Service, Bureau of  
Reclamation, Arizona State University

## THE INFLUENCE OF GLEN CANYON DAM OUTFLOW PATTERNS ON CLIMATE IN GRAND CANYON

Climatological data continued to be recorded from semi-permanent datalogged instrument sites along the Marble/Grand Canyon corridor of the Colorado River. Data analysis and research writing were performed. This represents the seventh quarter of work on the three-year research described in a proposal presented through our funding organization, National Geographic Society, and appropriate agencies concerned with the Glen Canyon Environmental Studies, especially the National Park Service and Bureau of Reclamation. The research was in accordance with NPS permits. A continuation research grant for work through March, 1997, was received from National Geographic Society.

### Progress To Date

Previous research completed by October 1, 1995 included: (1) establishment and operation of an energy balance cross-section in the boundary layer zone at RM -14.5, USGS cableway (mid-March, mid-June, late September, late December, 1994, and mid-March, 1995); (2) diurnal measurement of energy balance parameters over variable vegetation zone transects at RM -14.5, 43.1, 55 and 194 (mid-April [spring], late June [pre-monsoon], and mid-August [monsoon], January [winter]); (3) placement of datalogger-recorded thermistors and pyranometers at RM -14.5, 43.1, and 55 (late June, and in August, completion of the placement of datalogger-recorded thermistor, relative humidity sensor, and pyranometer profiles at the above mileage locations and on both sides of the river (nineteen new sensors and five dataloggers); (4) establishment of a six-sensor profile across Tapeats Creek and upstream from its gorge; (5) initiation of riparian habitat related studies to assess seasonal microclimatic interrelationships with plant productivity and changing surface cover (mid-April, late June, and mid-August); (6) the first comprehensive measurement of plant productivity, especially at RM 55; (7) field surveying of all research and transect sites, with subsequent data reduction and partial placement of the climate net into the GCES survey base; and (8) classification and reduction of data collected to date and initial analyses; (9) eight papers have been presented at meetings of the Association of American Geographers, Arizona-Nevada Academy of Science, and Ecological Society of America.

During this quarter, collected data were reduced and used in continuing analysis during October-December. Seven chapters of Stanitski-Martin's dissertation, which focuses on boundary layer climate/riparian zone climatology at the RM -14.5 cross-section, were completed. The entire study should be finished in February and available in the next quarter. Brazel and Marcus continued interpretation of downriver climatology and began analysis for papers on albedo and shortwave radiation balance. Marcus did initial editing of an ASU Office of Climatology Scientific

Research Paper consisting of three review essays: Canyon Region Paleoclimates, Summary of all canyon region National Weather Service observations, and pollution/air quality studies to date. Schiller wrote two chapters of his M.A. thesis on RM 55.5 bio-productivity.

### Future Plans

Phase II research has been initiated and will include continued operation and maintenance of the observational cross-sections at four Colorado River sites and Tapeats Creek. Improved storage modules will be placed at the datalogging sites and all humidity sensors will receive new PCRC-11 replacement chips. In the event of the 45,000 cfs spring water release it is hoped to do a series of "after" transects across the riparian zones at RM -14.5, 43, 55.5, and 194, where detailed microclimatological and vegetation measurements have been made previously.

The currently-active research team -- which consists of two faculty, one Ph.D. student, one M.A. student, and two undergraduates -- are continuing analysis, climatic mapping, and research writing. Articles are underway for submission to *Weatherwise*, *Journal of Climatology*, *Proceedings of the Arizona-Nevada Academy of Sciences*, and *Climate Research*.

c.c. Kim Crumbo  
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Grand Canyon National Park  
Glen Canyon National Recreation Area

The Influence of Glen Canyon Dam Discharge on  
Riparian Climate Throughout Grand Canyon

Quarterly Report  
1st Quarter, 1996

Grand Canyon National Park  
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Co=PI's:  
Melvin G. Marcus  
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Date of Report: March 31, 1996  
Project Start Date: March 12, 1994  
Project Funded By: National Geographic Society  
Project Supported By: National Park Service, Bureau of  
Reclamation, Arizona State University

## THE INFLUENCE OF GLEN CANYON DAM OUTFLOW PATTERNS ON CLIMATE IN GRAND CANYON

Climatological data continued to be recorded from semi-permanent datalogged instrument sites along the Marble/Grand Canyon corridor of the Colorado River. Data analysis and research writing were performed. This represents the eighth quarter of work on the three-year research described in a proposal presented through our funding organization, National Geographic Society, and appropriate agencies concerned with the Glen Canyon Environmental Studies, especially the National Park Service and Bureau of Reclamation. The research was in accordance with NPS permits. A continuation research grant for work through March, 1997, was received from National Geographic Society.

### Progress To Date

Previous research completed by December 31, 1995 included: (1) establishment and operation of an energy balance cross-section in the boundary layer zone at RM -14.5, USGS cableway (mid-March, mid-June, late September, late December, 1994, and mid-March, 1995); (2) diurnal measurement of energy balance parameters over variable vegetation zone transects at RM -14.5, 43.1, 55 and 194 (mid-April [spring], late June [pre-monsoon], and mid-August [monsoon], January [winter]); (3) placement of datalogger-recorded thermistors and pyranometers at RM -14.5, 43.1, and 55 (late June, and in August, completion of the placement of datalogger-recorded thermistor, relative humidity sensor, and pyranometer profiles at the above mileage locations and on both sides of the river (nineteen new sensors and five dataloggers); (4) establishment of a six-sensor profile across Tapeats Creek and upstream from its gorge; (5) initiation of riparian habitat related studies to assess seasonal microclimatic interrelationships with plant productivity and changing surface cover (mid-April, late June, and mid-August); (6) the first comprehensive measurement of plant productivity, especially at RM 55; (7) field surveying of all research and transect sites, with subsequent data reduction and partial placement of the climate net into the GCES survey base; and (8) classification and reduction of data collected to date and initial analyses; (9) eight papers have been presented at meetings of the Association of American Geographers, Arizona-Nevada Academy of Science, and Ecological Society of America.

During this quarter: (1) storage modules were exchanged and/or downloaded at the semi-permanent temperature and humidity sites (improved storage modules were placed at the datalogging sites and all humidity sensors received new PCRC-11 replacement chips); (2) instruments placed below the anticipated high water mark of the March high water release from Glen Canyon Dam were moved to higher, safe positions; (3) data from all stations was further reduced and organized; (4) the first draft of Stanitski-Martin's dissertation, which focuses on boundary layer

climate/riparian zone climatology at the RM -14.5 cross-section, was completed (the final draft is scheduled for an April 30, 1996, defense and will be distributed to appropriate parties within the following month); (5) Brazel and Marcus continued interpretation of downriver climatology and analysis for papers on albedo and shortwave radiation balance; (6) Schiller finished the first draft of his M.A. thesis on RM 55.5 bio-productivity (he will defend sometime in May, with appropriate distributions to follow; (7) Stanitski-Martin, Marcus, Brazel and Cervený submitted a manuscript to the American Meteorological Society publication, *Weatherwise*.

### Future Plans

1. There will be continued Phase II operation and maintenance of the observational cross-sections at four Colorado River sites and Tapeats Creek. The lower instruments will be placed in their original position before the high water release.

2. In June, a series of "after-the-high-water" transects will be undertaken across the riparian zones at RM -14.5, 43, 55.5, and 194, where detailed microclimatological and vegetation measurements have been made previously.

3. The currently-active research team -- which consists of two faculty, two Ph.D. students, one M.A. student, and one undergraduates -- is continuing analysis, climatic mapping, and research writing. The full climatic data set through March, 1996, will be made available in a newly organized diskette and hard copy form. Draft manuscripts will possibly be completed during the next quarter for submission to the *Journal of Climatology*, *Proceedings of the Arizona-Nevada Academy of Sciences*, *Physical Geography*, and *Climate Research*.

c.c. Dave Wegner  
Robert Winfree  
Glen Canyon National Recreation Area

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Riparian Climate Throughout Grand Canyon

Quarterly Report  
2nd Quarter, 1996

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PI: Melvin G. Marcus  
Co-PI's: Anthony J. Brazel  
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Date of Report: July 15, 1996  
Project Start Date: March 12, 1994  
Project Funded By: National Geographic Society  
Project Supported By: National Park Service, Bureau of  
Reclamation, Arizona State University

DLM

## THE INFLUENCE OF GLEN CANYON DAM OUTFLOW PATTERNS ON CLIMATE IN GRAND CANYON

This was a particularly important field research quarter insofar as it followed on the controlled, high-water release in March. Work focused on identifying changes in boundary layer climatic environments subsequent to the high discharge. Also, climatological data continued to be recorded from semi-permanent datalogged instrument sites along the Marble/Grand Canyon corridor of the Colorado River. Data analysis and research writing were performed. One doctoral dissertation and one master's thesis were successfully presented and defended (see "During this quarter" below).

This represents the ninth quarter of work on the three-year research described in a proposal presented through our funding organization, National Geographic Society, and appropriate agencies concerned with the Glen Canyon Environmental Studies, especially the National Park Service and Bureau of Reclamation. The research was in accordance with NPS permits. A continuation research grant for work through March, 1997, is supported by National Geographic Society.

### Progress To Date

Previous research completed by March 31, 1995 included: (1) establishment and operation of an energy balance cross-section in the boundary layer zone at RM -14.5, USGS cableway (mid-March, mid-June, late September, late December, 1994, and mid-March, 1995); (2) diurnal measurement of energy balance parameters over variable vegetation zone transects at RM -14.5, 43.1, 55 and 194 (mid-April [spring], late June [pre-monsoon], and mid-August [monsoon], January [winter]); (3) placement and continuous monitoring of datalogger-recorded thermistors and pyranometers at RM -14.5, 43.1, and 55 (late June, 1994, and in August, 1994), completion of the placement of datalogger-recorded thermistor, relative humidity sensor, and pyranometer profiles at the above mileage locations and on both sides of the river (nineteen new sensors and five dataloggers); (4) establishment of a six-sensor profile across Tapeats Creek and upstream from its gorge; (5) initiation of riparian habitat related studies to assess seasonal microclimatic interrelationships with plant productivity and changing surface cover (mid-April, late June, and mid-August); (6) the first comprehensive measurement of plant productivity, especially at RM 55; (7) field surveying of all research and transect sites, with subsequent data reduction and partial placement of the climate net into the GCES survey base; and (8) classification and reduction of data collected to date and initial analyses; (9) placement of instruments below the anticipated high water mark of the March high water release from Glen Canyon Dam to higher, safe positions; (10) eight papers have been presented at meetings of the Association of American Geographers, Arizona-Nevada Academy of Science, and Ecological Society of America.

During this quarter: (1) storage modules were exchanged and/or downloaded at the semi-permanent temperature and humidity sites; (2) replication of the micrometeorological transects at RMs 43, 55 and 194 during late June, as a comparative reference base for before and after the high water release; (3) replacement of lower sensors to their original pre-high water positions; (4) data from all stations was further reduced and organized, including copying to standardized diskettes and printouts; (5) Diane Stanitski-Martin's successfully defended her dissertation, which focuses on boundary layer climate/riparian zone climatology at the RM -14.5 cross-section ; (6) Rick Schiller successfully defended his Master's thesis, which focuses on bio-productivity, climate and soilmoisture/chemistry at RM 55 (copies will be distributed to sponsors and the NPS when the volumes return from the binder); (7) three manuscripts are in preparation for submission to refereed journals.

### Future Plans

1. There will be continued Phase II operation and maintenance of the observational cross-sections at four Colorado River sites and Tapeats Creek.

2. The currently-active research team -- which consists of two faculty, two postdocs, one Ph.D. student, and one undergraduate -- is continuing analysis, climatic mapping, and research writing. Draft manuscripts will possibly be completed during the next quarter for submission to the *Journal of Climatology*, *Proceedings of the Arizona-Nevada Academy of Sciences*, *Physical Geography*, and *Climate Research*.

c.c. Dave Wegner, BR  
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