Final Report

Economic Values of National Park System Resources Within the Colorado River Watershed: Phase II

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Prepared for:

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By,

Dr. John Duffield, Chris Neher, and Dr. David Patterson
Department of Mathematical Sciences
The University of Montana
Missoula, MT 59812

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Executive Summary

This report presents the results of the Phase II investigations of the Economic Values of National Park System Resources along the Colorado River.

For purposes of planning and participation in water resource allocation decisions, the National Park Service (NPS) needs to know the economic values of the resources it manages within park units along the Colorado River system (including major tributaries). At present, the NPS does not have recent or comprehensive values to represent their current water-related activities within these Colorado River park units. The purpose of this report is to synthesize economic estimates relevant to these resources in the Colorado River Basin, provide analysis of several existing data bases, and identify comprehensive estimates for all relevant resource uses in the basin. Uncertainty and data gaps are identified in these estimates to guide future research in Phase III of this study.

The NPS Colorado River park units that have significant water-related visitor use include Canyonlands National Park, Curecanti National Recreation Area, Dinosaur National Monument, Glen Canyon National Recreation Area, Grand Canyon National Park, and Lake Mead National Recreation Area. These parks are nationally-important recreation and conservation resources, and in 2005 had a total of about 10.5 million recreational visits to reservoir and river sites. Other NPS Colorado River park units are Arches National Park, Black Canyon of Gunnison National Park, and Rocky Mountain National Park.

Existing economic studies of NPS Colorado River park units and related economics literature can be grouped into four main areas: 1) estimates of visitor expenditures and associated regional economic impacts, 2) estimates of direct recreational use values (net economic benefits as measured by willingness to pay (WTP) over and above trip costs, 3) the influence of changing water levels (reservoir elevations and river flows) on participation (number of visitors), value per trip, and the regional economy, and 4) passive use values, which include the benefits individuals derive from simply knowing that a unique natural environment or species exists even if the individual does not visit or see the resource. These are sometimes called existence and bequest values. Additionally, this report summarizes the economic values associated with other uses of Colorado River water including hydroelectric generation, irrigation, and municipal uses.

Table 1 provides a summary of the available information across these economic measures for each of the primary NPS Colorado River recreation resources including: the Yampa and Green River sections in Dinosaur National Monument; Blue Mesa, Morrow Point, and Crystal Reservoirs in Curecanti National Recreation Area; the Cataract Canyon section of the Colorado through Canyonlands National Park; Lake Powell and the Colorado River through Glen Canyon (between Glen Canyon Dam and Lee’s Ferry) in Glen Canyon National Recreation Area; the Colorado River through the Grand Canyon; and Lake Mead and Lake Mojave in Lake Mead National Recreation Area.

With respect to regional economic impact estimates, the main limiting factor is whether relatively recent survey-based data is available on visitor expenditures. This data is used to derive regional economic impacts using input-output economic models, such as the county-level models available in the IMPLAN software. Only two NPS recreational resources in the Colorado River basin (Lake Powell and Lake Mojave) have survey-based expenditure data collected within the last ten years. Expenditure estimates and associated regional economic impact assessments are available for Glen Canyon day float use, and for both commercial and private boaters through the Grand Canyon, but this data is now over 20 years old. No survey-based estimates are available for half of the resources/units listed in Table 1. Estimates have been developed based on analyst and park manager judgment; however, where these judgmental estimates can be compared with survey-based estimates, the former appear to be overly conservative.

With respect to net economic benefits derived from visitor use, relatively current estimates are available only for Lake Powell. A partial and quite dated (1978 survey year) study is available just for fishing use at Lake Mead, and a high quality study, now twenty years old (Bishop et al. 1987) was conducted as part of the Glen Canyon Environmental Studies for floating in Glen and Grand Canyon, and fishing in the Lee’s Ferry river section. An additional, even older study (Richards et al. 1985) also examined the latter use. Additionally, a 1986 survey of Blue Mesa Reservoir visitors (McKean et al. 1995) estimated per trip net economic values under several different travel cost parameter assumptions. No survey-based estimates of visitor WTP have been conducted for Lake Mead, Dinosaur, or Canyonlands park units. These uninvestigated sites support over 75 percent of water-related visits to NPS Colorado River basin park units.

The impacts of water levels on recreational values occur through two influences: water levels influence the quality of the recreational trip and accordingly the WTP per trip, and water levels affect visitor participation. Additionally, there are different measures of water for reservoirs (a stock amount, stable over a given period of time) and rivers (a flow amount of water passing a point per a period of time). For example, on river sections use drops to zero at very low (impassable or quite dangerous) flow levels and also to near zero in extreme floods. Participation and trip quality are generally optimized at intermediate flow levels. By contrast, use on some reservoirs increases continuously with reservoir elevations and is maximized at full pool. By identifying the relationship of participation and value to water levels, it is possible to estimate the marginal value of water associated with recreational use. This is typically in terms of dollars per acre-foot (af) of storage on reservoirs and dollars per cubic foot per second (cfs) or per acre-foot per year on rivers.

Only one previous study was identified that empirically estimated marginal values for Colorado River park units. This was again the Bishop et al. 1987 study, which was limited to the influence of river flows through Glen and Grand Canyon on the value per trip. Because of considerable excess demand for floating trips in the Grand Canyon, participation is not correlated with river flows. This study is somewhat dated, as the survey was conducted over twenty years ago. Marginal recreation values were reported for Colorado River basin reservoirs in a 1995 study (Booker and Colby), but the estimates were based on the assumption that use would decline with the square of reservoir surface area. The authors, using data for 1980 to 1992 on visitation and reservoir elevations and surface area, were unable to estimate significant correlations.

For purposes of this report, existing Bureau of Reclamation (Reclamation) and U.S. Geological Survey data on reservoir levels and NPS visitor data were used to estimate models that explain visitation as a function of water levels and other data. Statistically significant relationships and (generally) high proportions of the variation in monthly visitation were estimated for Lake Powell, Lake Mead, Lake Mojave, and for the Cataract section of the Colorado and Green Rivers in Canyonlands. No models could be estimated for the Dinosaur National Monument section of the Green and Yampa Rivers or the Grand Canyon due to excess demand and limits on participation. Additionally, no model was estimated for Curecanti due to a lack of time-series data on water-based recreational visitation to that park unit.

Given the development of models of the influence of water levels on visitation, partial marginal recreation-related values could be developed only for park units with the existing expenditure and/or WTP estimates described earlier in this summary. Partial estimates of the net economic benefit per acre foot could be developed for this report only for Lake Powell and Lake Mojave. It needs to be emphasized that these are partial marginal estimates in that the variation in trip value with reservoir elevation has not been investigated at any of these parks.

Similarly, meaningful regional economic impacts per acre foot could only be derived at park units that had both survey-based expenditure data and estimates of the influence of water levels on visitation. Such estimates could only be developed for Lake Powell and Lake Mojave.

The last measure of the economic significance of NPS Colorado River park units is passive use value. Only one previous study, Welsh et al. 1995 was identified for these resources. This study was completed as part of the Glen Canyon Dam Operation EIS, and measured national and Western regional values for improved conditions to Grand Canyon endangered fish and associated river ecosystems through modified flow regimes. Estimated values were on the order of several billion dollars for the national sample. Similar studies have been undertaken for nine other Western river ecosystems, as described in the main report. Two such studies were identified that related to lake levels and lake water quality, at Mono Lake in California and Flathead Lake in Montana. The Mono Lake study (Loomis 1989) investigated the willingness of California residents to pay increased water bills to increase inflow (and reduce irrigation diversions) that would benefit the Mono Lake ecosystem, including bird life. The aggregate estimated value to eliminate diversions would be about $1.1 billion per year or $11,400 per acre foot in 1990. The Welsh et al. (1995) and Loomis (1989)studies indicate that passive use values are potentially a large share of the value associated with NPS-related uses in the Colorado River basin. To summarize, to date only one such study exists.

In addition to the data gaps discussed here and summarized in Table 1, there is additional uncertainty in the direct recreational use estimates in that the studies identified were all for single sites. Substitution among sites, for example in response to changing water levels, could also affect the estimates, and would require a regional recreational model to investigate. The estimated models that relate visitation to water levels are based on historical data. There is some uncertainty, which is difficult to quantify, associated with factors that were not quantified in the model and could change in the future. Additionally, the relationship between some types of use, particularly fishing, and the associated impact of water levels on fish habitat, fish populations and distribution, and angler catch rates are likely to be complex and not captured in the relatively simple models reported below. The survey data summarized below generally had acceptable response rates, which should minimize (but not eliminate) non-response bias. Many of the studies did not explicitly address this issue, which is an additional source of uncertainty. Finally, several of the survey-based studies reported are based on relatively small samples, as reflected in the size of the confidence intervals for the estimates, as reported below.

A preliminary conclusion is that most (perhaps in excess of 80 percent) of the economic significance (whether in terms of regional economic impacts, visitor economic benefits, marginal values per acre foot, or passive use) of the water-related NPS uses in the Colorado River Basin park units cannot be measured reliably with existing studies and existing data sets.

Table 1. Is Sufficient Information Available Now to Produce the Necessary Analysis Tools for Phase III?

Park Unit	**Produce Regional Economic Impacts for Water-based Visitation?**	**Estimate Marginal Impacts of Water level on Regional Economics?**	**Produce Direct Use Total Value Estimates for Water-based Visitation?**	**Estimate Marginal Impacts of Water level on NEV?**	**Estimated Passive Use Values?**
Glen Canyon NRA Lake Powell	YES	YES	YES	PARTIAL	NO
Colo. River (Glen-Lee's)	DATED	DATED	DATED	NO	NO
Lake Mead NRA Lake Mead	NO	NO	NO	NO	NO
Lake Mojave	YES	YES	NO	NO	NO
Curecanti NRA	PARTIAL	NO	NO	NO	NO
Grand Canyon NP Grand Canyon Float	YES	YES	DATED	PARTIAL	DATED
Dinosaur NM Yampa & Green River	NO	NO	NO	NO	NO
Canyonlands NP Cataract Canyon	NO	NO	NO	NO	NO

1.0 Introduction

This report presents the results of the Phase II investigations of the Economic Values of National Park System Resources along the Colorado River.

For purposes of planning and participation in water resource allocation decisions, the National Park Service (NPS) needs to know the economic values of the resources it manages within park units along the Colorado River system (including major tributaries). At present, the NPS does not have recent or comprehensive values to represent their current water-related activities within these Colorado River park units. The purpose of this report is to synthesize economic estimates relevant to these resources in the Colorado River Basin, provide analysis of several existing data bases, and identify comprehensive estimates for all relevant resource uses in the basin. Uncertainty and data gaps are identified in these estimates to guide future research in Phase III of this study.

The organization of this paper follows the task description outline of the Statement of Work. Task 1 is a synthesis of the existing literature of the relevant economic values of the National Park System resources along the Colorado River. This review of the literature is presented in Section 1, below. Task 2 calls for additional analyses of existing data that are relevant to the economic values of National Park System resources along the Colorado River. These analyses are presented in Section 2 of this paper. Section 3 of the paper addresses Task 3: identify comprehensive estimates of the relevant economic values from the existing literature where appropriate, and presenting marginal values of water flows, where feasible. Finally, Section 4 of this paper presents a discussion of the remaining data gaps and uncertainties in the comprehensive estimates. This discussion provides a guide to future research needs for Phase III of this study.

The policy context for this report is that water planning and allocation decisions are made in the Colorado River Basin based in part on quantitative estimates of alternative policy impacts on river uses. For example, hydropower production and values, irrigation production and associated employment and output, and municipal uses are routinely quantified. However, to date the impacts on NPS resources, including recreation use and associated economic impacts, have generally not been quantified. An important exception is the Glen Canyon Dam EIS in which impacts of alternative flow regimes on recreational and passive use values (Bishop et al 1987; Welsh et al 1996) were quantified (as detailed below). As an example of a recent policy analysis, during the year 2000, the Secretary of the Interior, acting through the Bureau of Reclamation (Reclamation) considered alternative interim surplus criteria under which surplus water would be declared in the lower basin for a 15 year interim period to 2016. An EIS was prepared to evaluate the potential impacts of alternative criteria. Figure 1 (Fulp and Harkins 2001) shows, for example, the impacts on Lake Mead elevation by year across policy alternatives. As can be seen, the policies result in significantly different elevations, with a range, for example in year 2016, of about 30 feet (equivalent to roughly 3.3 million acre feet of storage) in the median projected elevation. In the surplus EIS (Reclamation 2000), the impacts, if any, of such an elevation change on recreational visits at Lake Mead, possible associated economic impacts on the regional economy, or any loss in recreational or passive use benefits were not quantified.

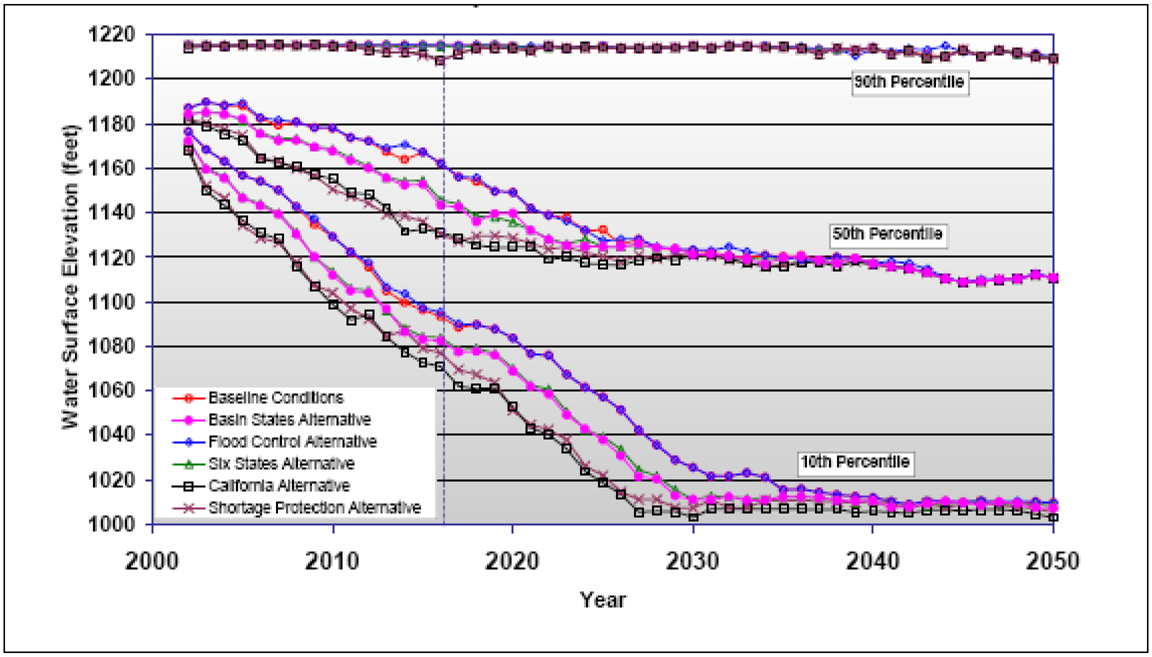

Figure 1. Lake Mead Elevation: Interim Surplus Criteria Alternatives. (Source, Wheeler et al. 2002)

In part, the purpose of this report is to summarize existing information that can shed light on whether such impacts, at Lake Mead and other NPS Colorado River units, are in fact negligible or substantial when quantified in economic terms.

It is useful to note that the hydrology computer model now being used by Reclamation is the RiverWare modeling platform (Fulp and Harkins, 2001). For basin-wide planning over decades (to inform water allocations as embodied in the river Operating Criteria), the time step of these analyses is monthly. Accordingly, in the following, where possible estimates have been based on monthly data (for example, NPS visitation and water elevations or water storage levels). Where marginal values are identified, these are generally in units related to acre feet (af) storage or cubic feet per second (cfs), to facilitate possible integration of NPS resource quantification into the Reclamation modeling framework.

As further context, other recent studies by Reclamation based on the RiverWare platform include: California's Quantification Settlement Agreement and Reclamation's Inadvertent Overrun Policy; Multiple Species Conservation Program (MSCP), designed to conserve habitat and work toward the recovery of threatened and endangered species; the impact on water users of alternative approaches to supplying sustainable flows to restore biodiversity in the Colorado River Delta; and the operation of Flaming Gorge

Dam (Wheeler, et al. 2002). Figure 2 from the MSCP illustrates the impacts of policy alternatives, again in terms of Lake Mead elevations. In this case, the range across policies (using scenario means) for much of the 50 year analysis period is on the order of 50 feet elevation (or approximately 5 million acre feet). Most recently, the Reclamation modeling tool played a key role in negotiations among the seven Colorado River states to reach a consensus recommendation for managing the river under drought conditions (CADSWES, 2006).

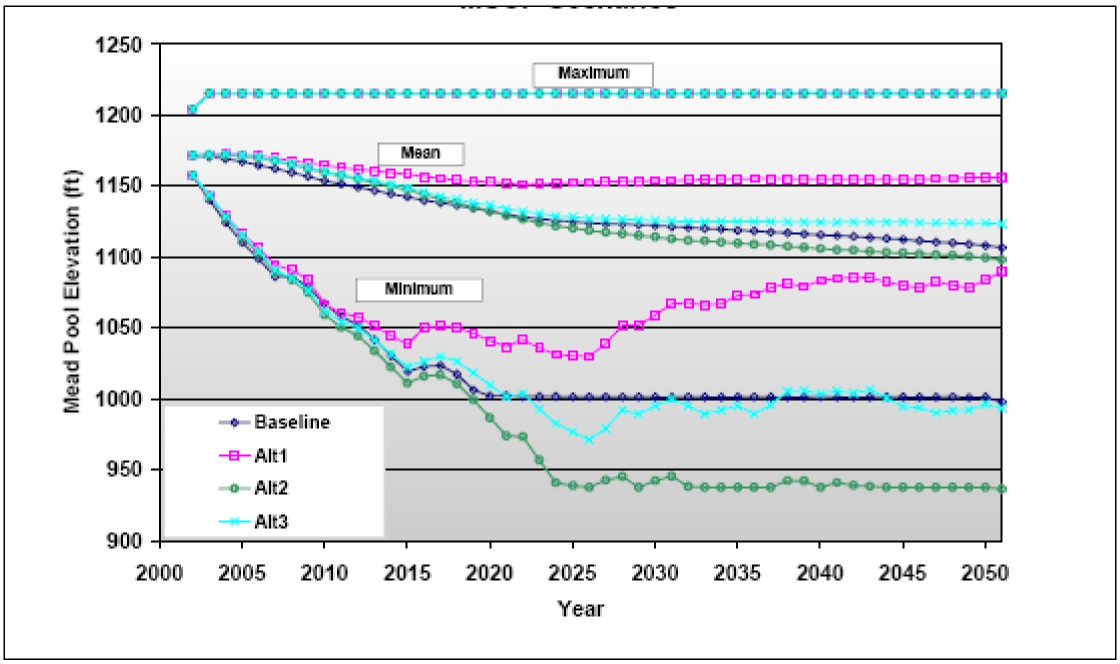

Figure 2. Lake Mead Pool Elevations, MSCP Scenarios. (Source Wheeler et al. 2002)

2.0 Review of Economic Literature

2.1 Economics of Recreation

The NPS units located along the Colorado River and its tributaries (shown in Table 2) accounted for nearly 20 million recreational visits in 2005. Of these, over 10 million visits were directly linked to water-based activities, and thus were dependent to some extent on water levels within the Colorado River system. Section 2.1, below, summarizes the economics literature relevant to recreational use of the Colorado River NPS units. Specifically, the literature review examines visitor expenditure estimates and related regional economic impacts, recreational use net benefit values, passive use values, and the impact of water levels on recreation.

Table 2. NPS Colorado River Units and Associated Visitation Characteristics.

Park Unit	Waters	Type of Water	Total 2005 Visitation[a]	Colorado R. Water-related 2005 visitation[a]
Arches NP	Borders Colorado R.	River	781,670	negligible
Black Canyon of Gunnison NP	Gunnison R.	River	180,814	46
Canyonlands NP	Colorado & Green R.	River	393,381	11,508
Curecanti NRA	Blue Mesa, Morrow Point and Crystal Reservoirs	Reservoir	882,768	882,768
Dinosaur NM	Green and Yampa R.	River	360,584	12,802
Glen Canyon NRA	Lake Powell Colorado R.	Reservoir River	1,863,055 45,671	1,863,055 45,671
Grand Canyon NP	Colorado R.	River	4,401,522	22,000[c]
Lake Mead NRA	Lake Mead Colorado below Hoover Dam Lake Mojave	Reservoir River Reservoir	7,692,438	7,692,438
Rocky Mountain NP	Headwaters of Colorado R.	River	2,798,368	negligible

[a] Total 2005 recreational visitation from the NPS Public Use Statistics Office http://www2.nature.nps.gov/mpur/index.cfm

[b] The NRA units (Curecanti, Glen Canyon, and Lake Mead) are assumed to be entirely water-based recreation.

[c] Total float use of Grand Canyon has been relatively stable at 20,000 to 24,000 visits in recent years (Grand Canyon NP Management Plan FEIS)

Recreational visitation to NPS units within the Colorado River System are associated with significant economic values. These values are generally described within two distinct accounting frameworks: net economic value, and regional economic impact. The first measure of value, net economic value describes the value associated with park visitation in the context of a benefit/cost framework, including both use values and passive use values. The second framework, regional economic impact analysis, describes the impact of visitor spending on a defined local or regional economic area. The net economic value (benefit/cost) framework presents the overall value of recreational visitation to a resource within the context of the entire national economy. The second framework (regional economic impact analysis) provides a much narrower analysis, only examining the impact of visitor spending on a local economic area.

2.1.1 Regional Economic Impacts

Regional economic impact analysis narrowly examines the effect of visitor spending to a site or area (such as Grand Canyon NP) on the local economy surrounding the site. The inputs to a regional economic impact analysis focus on visitor spending, and the outputs are generally presented in terms of changes in personal income or employment.

It should be noted that comparability between impact analyses, even for an identical site, is not assured. Each regional impact analysis defines a specific "impact area" (often a county, group of counties, or state) and only (or should only) counts expenditures made within that impact area by visitors coming from outside the impact area. Because definitions of the impact area and who constitute local or non-local visitors may vary across studies, care should be taken in comparing impact analyses for a specific site or park unit.

It should be further noted that regional economic impact analysis describes impacts on one local area only, and ignores expenditure impacts to the remainder of the national economy. Specifically, this type of analysis ignores the offsetting loss in spending in other areas of the economy that result from visitor spending in a specific site or park locale.

The economic impact of National Park System visitor spending on local economies has been previously investigated in a number of contexts. An example for the Colorado River is Douglas and Harpman (1995) who estimated the total expenditure by day use rafters, anglers, and commercial and private boaters in the Glen Canyon and Grand Canyon river corridor. In 2003, Hjerpe and Kim estimated the regional economic impact of Grand Canyon floater spending on the output of the local area economy. In addition to expenditures on commercial guides and outfitters, recreational visitors spend money on lodging, food, gasoline and other consumer items. These expenditures support retail and wholesale businesses and create induced spending throughout the regional economy. Douglas and Harpman defined their economic region as Coconino and Mohave Counties, and used an IMPLAN (Minnesota IMPLAN Group 2005) regional economic model to compute job creation. Loomis, Douglas, and Harpman (2005), updated the Douglas and Harpman 1995 estimates to 2004 dollars, and identified a total of $22 million in nonresident visitor expenditure in these two counties tied to Glen Canyon and Grand Canyon recreation. The estimated total number of jobs supported by this expenditure (based on the original study) is 586. This is consistent with more recent estimates by Douglas (2005) of 438 total jobs created by whitewater boating in the Grand Canyon.

Other studies of the regional economic impact of National Park System visitation include Neher and Duffield's (2000) study of the economic impacts of flooding in Yosemite National Park, the economic impacts of the 1995-96 federal government shutdown on park visitation (Duffield et al. 1996), and the regional economic impacts of changing winter use management (for example, banning snowmobile use) in Yellowstone and Grand Teton National Parks (Duffield and Neher 2000).

Visitors to NPS units spend dollars in the local area economies (both inside and outside the park boundaries) which stimulate local economic activity. In fact, these local economies can be in part dependent on local tourist-centered businesses and park management policies (Duffield et al. 1996; Duffield, Neher and Patterson 2006). Businesses provide eating, lodging and shopping opportunities for park visitors in gateway communities near the park boundaries.

The spending of visitors to the Colorado River units provide significant economic stimulus to the generally relatively rural economies found along the Colorado River. Studies of the impacts of visitor spending focus on the relative magnitude and type of spending by park visitors. The largest consistent database of park visitor spending is found through the NPS Visitor Services Project.[1] This data in conjunction with supplemental park-specific visitation data has been used within the framework of the NPS-sponsored MGM2 economic impact model[2] to estimate the local economic impact of recreational visitation to NPS units (Stynes and Probst, 2000). Table 3 summarizes the most current MGM2 estimated total regional economic impact on visitor spending, personal income and local area employment of recreational visitation to Colorado River NPS units. MGM2-estimated total visitor spending for the parks shown range from about 6 million dollars at the Black Canyon of the Gunnison NP to nearly 300 million dollars at Grand Canyon NP. The quality of the data these estimates are based on varies across parks. An important difference is whether visitor expenditure estimates are based on recent visitor survey data at the parks or analyst judgment. Where recent Visitor Services Project survey data or other visitor survey data is not available, the MGM2 model substitutes either generic visitor spending data from similar park units or from communication with park managers. Other empirical issues in regional economic modeling include: the accuracy of the survey data, including possible non-response or sample selection bias, the disaggregation of the survey data into relevant IMPLAN sectors, and whether the survey accurately identifies the share of total visitor expenditures being spent in the local economy. There can also be issues with how well the off-the-shelf IMPLAN county-level or, especially, zip code-level models used in MGM2 or other modeling efforts accurately characterize the structure of the local economy.

[1] The complete Visitor Services Project reports can be downloaded at http://www.psu.uidaho.edu/vsp.htm
[2] http://web4.msue.msu.edu/mgm2/

Table 3. MGM2 Estimated Regional Economic Impact of Visitor Spending, by Park Unit. (dollar figures are in millions of 2003 dollars, Jobs are number of full and part time jobs)

Park Unit	Estimated Annual Direct Visitor Spending	Estimated Indirect and Induced Spending	Estimated Total Spending Impact	Estimated Total Personal Income Impact	Estimated Total Jobs Impact (full & part time jobs)
Glen Canyon NRA	$86.09	$38.80	$124.88	$45.27	2,668
Lake Mead NRA	$176.82	$55.82	$232.64	$81.89	6,052
Curecanti NRA	$28.28	$12.58	$40.86	$14.89	887
Grand Canyon NP	$298.43	$135.58	$434.01	$169.81	7,812
Dinosaur NM	$7.01	$2.27	$9.28	$3.18	237
Canyonlands NP	$12.90	$4.23	$17.13	$5.79	433
Black Canyon NP	$5.92	$1.95	$7.87	$2.66	199
Arches NP	$54.11	$17.81	$71.92	$24.65	1,756
Rocky Mountain NP	$153.66	$50.21	$203.87	$69.22	5,178
Totals	**$823.22**	**$319.25**	**$1142.46**	**$417.36**	**25,222**

Source: MGM2 current impact estimates reported at http://web4.msue.msu.edu/mgm2/

The estimates of regional economic impacts for Grand Canyon NP presented in Table 3 are also reported and expanded with significant detail in Stynes and Sun (2005). In addition to Grand Canyon NP, the Visitor Services Project has completed surveys for Glen Canyon NRA (1989), and Arches NP (2003). However, the 1989 Glen Canyon NRA study did not collect visitor expenditure data.

Results of the MGM2 models using generic park expenditure and multiplier data have been used in a policy impact analysis for Curecanti NRA examining the use of personal watercrafts (Mactec Engineering and Consulting, Inc. et al. 2003).

In addition to the MGM2-Visitor Services Project regional economic impact data, a handful of studies of Colorado River park units (primarily focusing on grand Canyon NP) have been completed in recent years. A recent study by the Arizona Hospitality Research and Resource Center (2005) provides an in-depth study of the regional economic impact associated with visitation to Grand Canyon NP. Bishop et al. (1987) developed estimates of river-based recreational visitor expenditures within Grand Canyon NP. As noted earlier, Douglas and Harpman (1994) and Harpman (1995) utilized and adapted the Bishop expenditure estimates to provide measures of regional economic impact associated with Colorado River recreational use between Glen Canyon Dam and Lake Mead.

In a study of recreational use and impacts at Lake Mead, Graefe and Holland (1997) collected visitor expenditure data, both within the park unit and in nearby communities. The authors note that this data could be used to approximate regional economic impacts, but provide several limitations on the applicability of the data for such an analysis. Borden et al. (2003) conducted a survey of water-based recreationists below Hoover Dam though Lake Mojave. This study estimated the local regional economic impact of water-based recreation to these river and reservoir sections.

For Glen Canyon NRA two estimates pertaining to visitation impacts on regional economic activity were identified. As noted earlier, Douglas and Harpman (1995) included the stretch of the Colorado River between Glen Canyon Dam and Lee's Ferry in their analysis of floater and angler impacts. Additionally, Douglas and Johnson (2004) report visitor expenditure data for users of Lake Powell, collected during a 1997 visitor survey.

In 1998 Duffield and Neher conducted a 13-park survey of selected NPS units. The survey was designed as a visitor opinion survey of the Fee Demonstration Program. Included in this survey effort were surveys of visitors at Glen Canyon NRA and Grand Canyon NP. Since the primary purpose of the survey was to gather opinions on the Fee Demonstration Program, questions not specific to the program were limited in order to not unduly burden respondents. However, the surveys did include a limited number of questions on visitor expenditures and visitor net economic value per trip.

A 2004 study of Blue Mesa Reservoir recreation for the Bureau of Reclamation (Munger and Vinton 2005) reported visitor expenditure data for the largest reservoir within the Curecanti unit.

Sampling plans were developed for each park unit using maps of each park and the expertise of park managers. The final sample for the two Colorado River park units surveyed was 248 for Grand Canyon NP, and 150 for Glen Canyon NRA. Response rates for the two parks were 68% and 61%, respectively.

A summary of the recent literature of studies of visitor expenditures at Colorado River NPS units, with an emphasis on water-based recreation is detailed in Table 4. The estimates presented in the table represent a broad range of methods, dates, and study purposes. They are presented in their original study year dollars and metric (e.g., per party or per person, per day or per visit) as well as in updated constant 2005 dollars per visit.

Table 4. Summary of Recent Estimates of Visitor Expenditures at Colorado River NPS Units.

Park Unit	Studies	Expenditure Estimates (study year $)	Expenditure Estimates (2005 $ per person visit)	Notes and Limitations
Glen Canyon NRA	MGM2	$77 per party day (2003)	$43	Key parameters based on park management judgment
	Douglas and Harpman (1994)	$61 - $187 per person (1985)	$111 - $340	River users between Lee's Ferry and Glen Canyon Dam - Dated estimates based on 1985 survey
	Douglas and Johnson (2004)	$119.77 per person (1997)	$146	Lake Powell visitor data
	Duffield and Neher (1998)	$202 per party day (1998)	$187	Somewhat dated
Lake Mead NRA	MGM2	$100 per party day (2003)	$56	Key parameters based on park management judgment
	Broden et al. (2003)	$59.02 per person day (2003)	$174	Lake Mead NRA water users below Hoover Dam (river and Lake Mojave)
	Martin et al. 1982	$43.00 per angler	$122	Only Lake Mead anglers
Curecanti NRA	MGM2	$75 per party day (2003)	$42	Based on default parameters
	Munger and Vinton 2005	$52 per party day (2005)	$24	Summer estimate for primary site in the NPS unit
Grand Canyon NP	MGM2, Visitor Services Project	$1,388 per visit (2003)	$1,471	Grand Canyon floaters
	Arizona Hospitality Study	$1,131 per party (2005)	$333	All Grand Canyon visitors
	Harpman (1995)	$215-$510 per person (1995)	$275 - $652	Grand Canyon Float below Diamond Creek – Based on Dated estimates from 1985 user survey
	Douglas and Harpman (1994)	$517 - $1427 per person (1985)	$941 - $2,597	Grand Canyon Float below Lee's Ferry - Dated estimates based on 1985 survey
	Duffield and Neher (1998)	$198 per party day (1998)	$197	All Grand Canyon Visitors - Somewhat Dated
Dinosaur NM	MGM2	$58 per party day (2003)	$32	Based on default parameters
Canyonlands NP	MGM2	$70 per party day (2003)	$39	Based on default parameters
Black Canyon NP	MGM2	$75 per party day (2003)	$42	Based on default parameters
Arches NP	MGM2, Visitor Services Project	$172 per party day (2003)	$89	All Arches Visitors
Rocky Mountain NP	MGM2	$132 per party day	$74	Key parameters based on park management judgment

Note: The expenditure estimates presented in the above table for a given park unit do not necessarily present strictly comparable measures of visitor spending per person visit. There may be differences in the definition of the local spending area, and which visitors are included in the estimates (local v. non-local).

2.1.2 Direct Recreational Value Estimates

To date the number of published estimates of the value of recreational visits to National Park System units is somewhat limited. Kaval and Loomis (2003) identified eleven studies that provided 49 activity-specific net economic value (NEV) estimates. The activities included sightseeing, boating, picnicking, hiking and wildlife viewing. Updating the Kaval and Loomis (2003) average estimates from 1996 dollars to 2005 dollars indicates an average value per day across all 49 observations of $53.88. The updated average that Kaval and Loomis report for the Southwest Region national parks is $28.16. As noted earlier, studies of boating in Glen Canyon and Grand Canyon indicate net economic values on the order of several hundred dollars per trip and higher. A recent study, using a travel cost model, also provides estimates of values for a subset of seven National Parks along the Colorado River (Markowski et al. 2004). The results of this study, which are still preliminary, indicate that net economic benefits per trip may be higher than indicated by earlier work. Studies specific to Colorado River National Parks include Bishop (1987), Douglas and Harpman (2004), Douglas and Johnson (2004), Martin (1982), Duffield and Neher (1999), and Markowski et al. (2004). These are discussed further below and are summarized in Table 5.

To date there have been two major economic studies related to NPS-related uses in the Colorado River corridor, both in the context of the Glen Canyon studies. These studies had a fairly narrow geographic scope (just the river corridor through Glen Canyon and Grand Canyon). Both of these earlier studies focused on identifying marginal values, in the sense of measuring the change in value associated with moving from the base case or no action alternative in the EIS planning process for Glen Canyon Dam to some specific alternative. By having these marginal values, it was possible in the EIS process to compare the tradeoffs of alternative uses, including recreation and power generation values.

The economic context of these studies is that historically the monthly allocation of flow releases at Glen Canyon was based on maximizing the value of power, subject to the constraints imposed by other purposes. In the early years of operation, the main constraints were providing sufficient available storage for flood control and river regulation. Typically this has meant that releases are higher in the months when power is most valuable, during the winter heating season and the summer cooling season. For example, given the markets for power in the Southwest in the mid-1990’s, releases were about 20 percent greater in a typical water year during the months of December, January and February and June, July and August, compared to the spring and fall months (Harpman 1999a).

Hourly releases at Glen Canyon Dam historically were driven largely by hydropower economics. Prior to 1991, Glen Canyon was operated as a more or less unconstrained load following (or peaking) plant, with higher releases during the day and early evening when power demands (and values) were highest and lower releases during the night. This could mean a change from releases as high as 31,500 cfs (plant capacity prior to the late 1980's) during the day to as low as 1,000 to 3000 cfs (the historical minimum release in winter and summer, respectively). There were no constraints on how quickly these flow changes occurred (e.g., no constraint on ramp rates or allowable daily fluctuations). For the first several decades of Glen Canyon's operations, this led to flow level fluctuations below the dam on many days on the order of 7 to 12 feet.

The first Glen Canyon economic study focused on recreational use and was undertaken by Bishop et al. (1987). The second study focused on passive uses, and will be discussed in a following section. This study was conducted as part of the Glen Canyon Environmental Studies program during 1984 and 1985. The overall goal of the Bishop study was to evaluate the impacts of alternative flow release patterns from Glen Canyon Dam on white-water boating, day-use rafting, and fishing on the Colorado River below the dam. The 1987 study authors conducted a several phase investigation in order to address their goal. First, user surveys were conducted to identify the attributes of fishing and floating trips that provided value to users. A second, more comprehensive contingent valuation survey of river users addressed potential changes in resource values associated alternative flow release patterns. While Bishop et al. found no statistically significant relationship between flow levels and values associated with day-use floating below Glen Canyon Dam, they found a strong link between flows and both fishing and whitewater boating values. The study found that for whitewater rafters relatively constant flows between 20,000 and 25,000 cfs yielded the highest satisfaction and associated values. For anglers, a similarly constant flow regime in the 10,000 cfs range yielded improved recreational trip values over current flow regimes (Bishop et al. 1987, pp. 170-178). As an example of the range in values, the net economic value per trip (willingness to pay over and above trip costs) for commercial whitewater boaters was estimated at $127 per trip ($236 in 2005 dollars) at a 5,000 cfs flow level and rose to a maximum value of $888 per trip ($1,653 in 2005 dollars) at higher flows.

With respect to the significance of recreation use values in the Glen Canyon operations context, the influence of flows on recreational values is primarily through the effect on the quality of the trip. There is excess demand for river recreation below Lee's Ferry (use is basically always at the permitted capacity in the main season). This limits the potential magnitude of changes in use values in response to changing flow regimes. By contrast, the nonuse value effects are quite large relative to the foregone power revenues for the alternatives examined, and have allocative significance, as noted below.

For reservoir recreation within Colorado River Basin NPS units, Douglas and Johnson (2004) utilized 1997 survey responses for Lake Powell recreational visitors to estimate a travel cost model of WTP for trips to the reservoir. The authors estimated that per visit consumer surplus for Lake Powell visits ranged from $70.83 (based on a log-log model specification) to $159.36 (based on an inverse-price model specification).

Douglas and Harpman (2004) report dichotomous choice contingent valuation results for the same 1997 survey data set as Douglas and Johnson (2004). The dichotomous choice question valued improvements in angler harvest, water quality (reduced beach closures relative to the 1991-1996 period), and archeological site protection and restoration. The payment vehicle was the season pass. A current trip valuation question was not included. For the authors' preferred model, household benefits across the summer ranged from $396 (1997 dollars) to $1,100 per household per year. On a per visit basis, this implied a range in value of $8.63 to $38.92 per visit. It appears from the paper that this is just the incremental value of the improved trip. The value, particularly for the archeological site scenario, may include passive use, as well as recreational use value. In any case, these scenarios are bracketed by the angler harvest values (lowest) and the water quality improvement values (highest).

Martin (1982) estimated NEV per trip for anglers at Lake Mead. A zonal travel cost model was estimated for this warm water fishery on data collected on anglers between July 1978 and June 1979. In this period, there were an estimated 1.3 million individual fishing days of use at Mead, mostly targeting striped and largemouth bass. Estimated mean net benefits per individual fishing day were $44.63 to $61.44, depending on the specification of the model. Martin et al. (1982) also report angler expenditure per day with a mean value of $43 and a median of $29 (1978-79 dollars).

In 1998, visitors to two Colorado River NPS units (Glen Canyon NRA and Grand Canyon NP) were surveyed within the context of a study of visitor attitudes about the NPS Fee Demonstration Project. In addition to the survey questions related to the fee program, the surveys included a dichotomous choice WTP question designed to elicit per-trip NEV responses. These NEV responses were not part of the Fee Demonstration Program study objectives, and thus an analysis of the responses was not included within the study report (Duffield and Neher 1999). A subsequent analysis of these responses indicates that for park visitors who said that visiting the units was the primary purpose of their trip away from home, visitors to Glen Canyon NRA have a mean NEV per party trip of $383 ($460 in $2005). The 95% confidence interval for the Glen Canyon non-parametric NEV mean is $336 to $584 ($2005). Visitors to Grand Canyon NP had a mean NEV per party trip of $319 ($383 in $2005). The 95% confidence interval for the Glen Canyon non-parametric NEV mean is $295 to $470 ($2005). The estimated mean NEV per visit estimates for this study are Glen Canyon NRA ($109 with a 95% confidence interval of $80 to $138), and Grand Canyon NP ($142 with a 95% confidence interval of $109 to $174).

A 1986 survey of visitors to Blue Mesa Reservoir (Curecanti) was undertaken by McKean, Johnson, and Walsh. The authors reported net economic value per trip estimates under several different sets of assumptions regarding construction of the travel cost parameters. The study found NEV per trip for the unit to range from $38 to $101 (1986 dollars) for the Blue Mesa site.

Table 5. Summary of Literature and Estimates of Colorado River NPS Units Direct Recreational Value Estimates.

Study	Description	NEV Estimate	NEV Estimate (2005 $ per visit)
Bishop et al. (1987)	Study of values of Grand Canyon - float boaters (CVM)	$236-$1,653 per trip depending on river flow level (1985$)	$430 - $3,000
Hammer (2001)	Study of Grand Canyon – Floaters (TCM)	$134 per trip (private) $314 per trip (commercial)	$157 (private) $368 (commercial)
Martin (1982)	Study of Lake Mead - Fishing Values (TCM)	$44.63 to $61.44 per angler day (1978-9$)	$643 - $887
Douglas and Johnson (2004)	Travel Cost study of Lake Powell – Recreationists (TCM)	$70.84 - $159.35 per visit consumer surplus (1997 $)	$86 - $194
Duffield & Neher (1999)[a]	Visitor survey of Glen Canyon NRA and Grand Canyon NP Visitors. (CVM)	Glen Canyon NRA - $384 per party trip Grand Canyon NP - $319 per party trip (1988$)	Glen Canyon $109 Grand Canyon $142
Douglas and Harpman (2004)	Survey of Glen Canyon - improved trip quality scenarios (angler harvest, water quality)	$8.63 to $38.92 per visit[b] (1997 $)	$11 - $47
McKean et al. (1995)	Survey of Blue Mesa Reservoir visitors (TCM)	$37 to $101 per visit (1986$)	$69 - $187

[a] Consumer surplus estimates were derived in an analysis subsequent to the preparation of the primary report on visitor attitudes regarding park fee increases.
[b] Not total value of current trip, but incremental values due to improvement.

Just as there is an economic literature on instream flow values, there is a related literature on the effect of reservoir levels on recreation. Huszar et al. (1999) developed and estimated a joint model of fish catch and recreation demand, both of which depend on water levels, to assess the losses and gains from water level changes tied to events in the Humboldt River Basin of Northern Nevada. Additionally, Eiswerth and Englin, et al. (2000) estimated recreation values for preventing a decline in water levels at, and even the total loss of, a large western lake that is drying up.

2.1.3 Passive Value Estimates

Passive use values are an indication of the national significance of NPS resources. These values are associated with knowing that these resources are in a viable condition and with wanting future generations to also be able to enjoy this heritage.

These motives for nonuse values were first described by Weisbrod (1964) and Krutilla (1967) as existence and bequest values. Existence values can derive from merely knowing that a given natural environment or population exists in a viable condition. For example, if there was a proposal to dam the Grand Canyon, many individuals could experience a real loss, even though they may have no expectation of ever personally visiting the river corridor through the Grand Canyon. Other individuals might similarly suffer a loss if the grizzly bear were to be made extinct in the Northern Rockies, even though those individuals may have no desire to directly encounter a grizzly. Bequest motives derive from ones' desire to provide for future benefit to children and others in future generations. There may be many possible motives for nonuse values, and these motives may or may not be mutually exclusive.

The methods used to estimate nonuse values are so-called stated preference methods (including contingent valuation and conjoint analysis (National Research Council 2005)). Individuals are asked in a survey to indicate directly the value they place on nonuse services or resources. These methods are generally accepted and applied in policy analysis, as evidenced by their endorsement as a recommended method in regulatory guidelines. These include the Department of the Interior regulations for implementing the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (or CERCLA, at 43 CFR part 11) and in the U.S. Environmental Protection Agency's *Guidelines for Preparing Economic Analysis* (2000).

These methods have now been widely applied and reported in the published economics literature. When contingent valuation as a recommended approach was challenged in court (Ohio v. United States Department of Interior, 880 F.2d 432, 474 (D.C. Cir. 1989), the court affirmed its usefulness for natural resource damage assessment. Additionally, in the context of the development of related regulations for implementation of the Oil Pollution Act of 1990 by the National Oceanic and Atmospheric Administration (NOAA), the use of contingent valuation was reviewed by a panel which included several Nobel laureates in economics. The panel endorsed the use of contingent valuation in a litigation setting, subject to the caveat that studies meet certain recommended guidelines (Arrow et al 1993).

The National Research Council (2005, at p. 6) offers the specific guidance that: "Economic valuation of changes in ecosystem services should be based on the comprehensive definition embodied in the TEV [total economic value] framework; both use and non-use values should be estimated."

Table 7 provides a summary of passive use studies relevant to water-related NPS resources including lakes and rivers (instream flows and endangered fisheries). These selected studies are generally in the Southwest or Intermountain West. All of the studies use stated preference methods, such as contingent valuation. Data is collected through surveys, generally of a resident population in a given geographic area. The choice of geographic area should correspond to the "market area" for the passive use service; that is to say, an area big enough to include most people expected to hold passive use values for the resource at issue. This area may be small for a county or city park of only local historical significance, but possibly national in scope for nationally significant resources such as the Grand Canyon or Yellowstone. A more complete characterization of the set of studies potentially relevant to passive use values for NPS resources is provided in

Appendix B. This includes not only water resource-related river and lake studies, but also wetlands, riparian areas, and wilderness areas.

Key characteristics of the studies summarized in Table 7 include: 1) the resource service being valued, generally a change such as increased lake elevations or populations of an endangered fish, 2) the payment mechanism (e.g. increase in monthly water bill, increase in annual taxes, a one time donation, etc.), 3) the population surveyed, 4) the estimated values.

The only previous estimate of passive use values for Colorado River park units have all been for Grand Canyon National Park resources including visibility, river flow-related habitat, and wilderness. The first such studies were focused on visibility impacts of the Navajo Generating Station and include Schultz et al. (1980), Randall and Stoll (1983), Schultz (1983), and Hoehn (1991) as summarized in Appendix B. These and other studies eventually led the U.S. Environmental Protection Agency on October 3, 1991, to issue a regulation requiring the Navajo Generating Station coal-fired power plant to reduce sulfur emissions. In a 1990 study, the annual benefits of achieving 90% emission control was estimated to be between $130 and $150 million annually, compared to the estimated costs of this control of $89.6 million (1990 dollars). Deck (1997) describes both the benefit and cost studies that were the basis of this decision.

The only passive use study relating to water resources is the Welsh et al. (1995) contingent valuation study undertaken as part of the Glen Canyon EIS process (Table 6). Harpman, Welsh, and Bishop (1995) describe the importance of nonuse economic values as a policy analysis tool, with specific reference to water-influenced resources in the Grand Canyon.

In the Welsh et al (1995) study, contingent valuation methods were applied to estimate willingness to pay to improve native vegetation, native fishes, game fish (such as trout), river recreation, and cultural sites in Glen Canyon NRA downstream of Glen Canyon Dam and in Grand Canyon NP (Welsh et al. 1995). This study utilized a population survey of two groups, Western U.S. households within the marketing area for Glen Canyon power, and households in the entire U.S. Respondents were asked questions of their willingness to pay either increased electric power rates (Western U.S. sample) or higher taxes (national sample) to reduce flow fluctuations from Glen Canyon Dam to protect wildlife, beaches, and cultural sites. The study results (Table 6) show that the "steady flow" scenario that was presented as being most beneficial to resource protection also had the highest associated values.

Table 6. Welsh et al. (1995) Estimates of Nonuse Values for Three Glen Canyon Flow Scenarios. (2005 dollars)

Flow Scenario	National Sample		Western US Sample	
	Per Household	Annual Value (millions)	Per Household	Annual Value (millions)
Moderate Fluctuations	$17.74	2,791	$29.05	79
Low Fluctuations	$26.19	4,386	$28.25	80
Steady Flow	$26.91	4,474	$38.02	107

While the nonuse study for the Colorado River corridor in Grand Canyon NP (Welsh et al. 1995) was completed too late to be fully utilized in the 1995 EIS (Reclamation 1995), the study findings did have an influence on the EIS outcome. The National Research Council panel that reviewed the Glen Canyon Environmental Studies commented favorably on this study. Their report stated: "The GCES nonuse value studies are one of the most comprehensive efforts to date to measure nonuse values and apply the results to policy decisions. … While not completed in time to be reported in the final EIS, the nonuse value results are an important contribution of GCES and deserve full attention as decisions are made regarding dam operations." (National Research Council, 1996, at p. 135)

The estimates of the Welsh (1995) contingent valuation study are conservative in that Welsh chose in his methodology to count only those "yes" respondents that also indicated they would "definitely yes" pay the stated amount. The use of only "definitely yes" responses has been shown in other CV validity studies to provide a valid estimate of actual willingness to pay. Champ et al. (1997) also found this result in assessing the nonuser social value of a program at Grand Canyon NP to remove compacted dirt roads on the North Rim of the Canyon to create a wilderness setting. A more recent study by Champ and her colleagues that is focused on riparian ecosystems (Duffield, Neher, Patterson, and Champ 2006) also found that CV responses with a self-rated high certainty of actual contribution corresponded well with actual levels of cash donations. The application in this case was to purchases of instream flow rights on dewatered Montana streams, primarily to benefit riparian ecosystems, fishery species of special concern, and other wild fish.

As can be noted in Table 7, there have been considerably more studies related to river flows and related fisheries (8) than to lakes and reservoirs (2).

A feature of this literature is that the range of values per household or respondent is quite large, and the range in aggregated values would be even greater. For example, the Duffield and Patterson study estimated a $2.24 payment per licensed angler, based on a one-time cash donation. By contrast, Hanemann, Loomis and Kanninen estimated $181 per California household per year. To compare these, one would have to compute the one-time equivalent (present worth) for the California study, for example at 3% over the indefinite future, the implied value is $6,033 per household. (One could also correct for inflation to a common year purchasing power.) Additionally, the California number would be multiplied by the number of California households (about 11.5 million in

2000), while the other estimate is aggregated over only several thousand resident Montana license holders.

For the two lake studies, values range from about $45 per household for the preservation value of Flathead Lake in Montana, to about $5 per month (or $60 per year) for an increment of lake elevation at Mono Lake, California.

Of the two, the Mono Lake study has the relevance as far as informing passive use value estimates for changing lake levels. Mono Lake is a hyper-saline lake just east of the Sierra Nevada Mountains in California. The saline water makes the lake unsuitable as a sport fishery but a very productive habitat for nesting gulls and migratory waterfowl. About 100,000 acre-feet of freshwater that would normally flow into Mono Lake is diverted each year by Los Angeles Department of Water and Power (Loomis 1989). Continuing of these diversions will reduce the lake level and likely eliminate the bird's food supply. However, the lake is not well known or heavily visited. One of the survey populations was California households. Respondents were asked to indicate their willingness to pay for two different increments of lake level: the difference of a low ecologically damaging level and a level achieved by cutting diversions and half, and the improvement still further by cutting diversions entirely to achieve an optimal lake condition. Payments averaged about $5 in a 1986 survey for each increment, and in a re-test, statistically similar results were found in a 1987 follow-up to the same respondents. Accordingly, in 1986 dollars, about $10 per household was the value per month placed on going from the present diversion of 100,000 AF per year to an optimal lake condition (or $120 per year). Aggregated over about 9.5 million California households in 1990, the total value is about $1.14 billion per year or $11,400 per acre foot.

Table 7. Empirical Estimates of Passive Use Values for Water-related Resources.

Authors	Survey year	Payment vehicle	Resource	Survey region	Value Estimate	Value (2005 $)
(A) Lakes						
Sutherland and Walsh (1985)	1981	Annual Payment into trust fund (per household)	Flathead Lake and River	Montana households	$19.99 existence $26.48 bequest	$36.38 existience $48.19 bequest
Loomis (1989)	1986-7	Monthly water bill increase (per household)	Mono Lake	CA households and Mono L. visitors	$4.12-$5.89 (households) $9.97-$12.15 (visitors)	$6.51-$9.31 (households) $15.75-$19.20 (visitors)
(B) Rivers						
Hanemann. Loomis & Kanninen (1991)	1989	Annual household WTP (per household)	San Joaquin Valey	California	$181	$259
Duffield and Patterson (1991)	1990	One-time donation to trust fund (per person)	Instream flows in Montana trout streams	Montana resident and nonresident fishing license holders	$2.24-$4.64 (residents) $12.60-$17.36 (nonresidents)	$3.20-$6.64 (residents) $18.02-$24.82 (nonresidents)
Welsh et al. (1995)	1994	Increased electric power rates or increased taxes (per household)	Colorado R. riparian ecosystem	Western U.S. households and all U.S. households	$17.74-$26.91 (U.S. sample) $29.05-$38.02 (Western sample)	$22.70-$34.44 (U.S.) $37.18-$48.67 (Western)
Brown and Duffield (1995)	1988	Annual WTP into trust fund (per household)	Bitterroot, Bighole, Clark Fork, Gallatin and Smith Rivers	Phone directory listings for major MT cities and Spokane WA	$6.70 (one river) $12.43 (five rivers)	$8.57 (one river) $15.91 (five rivers)
Berrens, Ganderton and Silva (1996)	1995	Annual donation to trust fund for 5 years (per household)	Middle Rio Grande, Gila, Pecos, Rio Grande, and San Juan Rivers	New Mexico residents	$28.73 - $89.68	$35.63 - $111.20
Loomis (1996)	1994-5	Additional taxes for 10 years (per household)	Elwah River system	Challam Co. WA, rest of WA and rest of U.S. households	Challam $59 Rest of WA $73 Rest of U.S. $68	Challam $73 Rest of WA $91 Rest of U.S. $84
Berrens et al. (1998)	1995-6	Annual payment into trust fund (per household)	Major rivers in NM	NM residents	$74	$89
Berrens et al. (2000)	1995-6	Annual payment into trust fund (per household)	Gila, Pecos, Rio Grande, and San Juan Rivers	NM residents	$55	$62
Duffield, Patterson, Neher & Champ (2006)	2005	One-time donation to trust fund (per person)	Small MT trout streams	Resident and Nonresident MT fishing license holders	$5.73 (residents) $31.07 (nonresidents)	$5.73 (residents) $31.07 (nonresidents)

2.1.4 Impact of Water Level on Recreation

The Bishop et al. (1987) economic study, discussed above, is one of a number of such studies reported in the economics literature that relate changes in streamflow levels to use or nonuse values. Table 8 shows estimates of marginal values of flows at several alternative flow levels, based on the Bishop et al. (1987) and Boyle (1993) results. Studies such as those by Bishop et al. (1997) usually include recreation, but also may include other environmental services such as endangered species. For example, Brown (1991) lists nine studies of the value of instream flow for recreational activities including fishing, boating, and general shoreline activities. Ward, Roach, and Henderson (1996) examined the relationship between reservoir level and recreational levels at several Corps of Engineer Reservoirs in the Sacramento, California District. The authors' travel cost modeling showed per acre foot values of reservoir water for recreation ranging from $6 at Pine Flat Reservoir to $600 at Success Lake. Duffield et al. (1992) estimated marginal WTP per acre foot for a range of flows at two sites, the Bitterroot River in Western Montana, and the Big Hole River in the headwaters of the Missouri River system. A related study in cooperation with the U.S.D.A. Rocky Mountain Experiment Station in Fort Collins estimated nonuse values for these same resources based on a random sample of regional households (Brown and Duffield, 1995).

Table 8. Marginal NEV Estimates for Alternative Grand Canyon Float Colorado River Flow Levels.

Flow	Value per Trip		Value per Day	
	Commercial passengers	Private boaters	Commercial passengers	Private boaters
(A) Study year dollars				
5,000 cfs	127	111	21	7
29,000-33,000 cfs	898	688	150	43
45,000 cfs	732	376	122	24
(B) 2005 dollars				
5,000 cfs	235	206	39	13
29,000-33,000 cfs	1664	1276	277	80
45,000 cfs	1357	697	226	44

Source: Boyle et al. 1993; Bishop 1987.

Little empirical study has been done regarding the relationship between reservoir and river levels within the Colorado River Basin and recreational visitation. Booker and Colby (1995) reported estimated annual net economic benefits of flatwater recreation within Colorado Basin reservoirs (Table 9). These estimates utilize a transfer of benefits from other recreation studies and a general weighting by type of recreational activity at each reservoir.

Table 9. Booker and Colby (1995) Benefit Transfer for Flatwater Colorado River Basin Net Economic Value Estimates.

Reservoir	Visitation (million/year)	Fishing ($/day)	Weight	Other ($/day)	Weight	Total ($1992 /day)	Total ($2005 /day
Flaming Gorge	1.65	12.04	0.5	21.21	0.5	16.63	23.11
Curecanti Unit	0.78	29.22	0.4	21.21	0.6	24.41	33.93
Navaho	0.59	29.22	0.4	21.21	0.6	24.41	33.93
Powell	3.20	29.22	0.2	24.21	0.8	25.21	35.04
Mead	6.76	30.17	0.2	36.16	0.8	34.96	48.59
Mojave	2.05	30.17	0.2	36.16	0.8	34.96	48.59
Havasu	1.99	30.17	0.2.	36.16	0.8	34.96	48.59

Source: Booker and Colby 1995, Table 3, p. 884.

Booker and Colby (1995) noted that within the Colorado River Basin use of reservoirs is assumed to be a declining function of reservoir area or volume. They found no significant relationship between Colorado River Basin visitation and reservoir water levels for the period 1980-92. Instead, they assumed that visitation at Colorado River Basin reservoirs declined as a function of the square root of the reservoir contents. They additionally assumed that per trip use benefits did not vary with reservoir levels. Ward and Fiore (1987) estimated changes in visitation across New Mexico reservoir sites as a function of the square root of reservoir area, but did not examine the effect of reservoir levels. Booker and Colby presented estimates of marginal recreational benefits associated with water levels at the Basin reservoirs (Table 10).

Table 10. Booker and Colby Estimated Marginal Recreational Net Economic Value per Acre Foot of Reservoir Storage.

Dam and Reservoir	**Total Recreation Benefits (million 1992$)**	**Marginal Recreation Benefits (annual 1992$ per acre foot)**	**Marginal Recreation Benefits (annual 2005$ per acre foot**
Flaming Gorge	23	8.7	12.09
Curecanti Unit	17	19.5	27.11
Navaho	12	10.0	13.90
Glen Canyon Dam/Lake Powell	71	3.7	5.14
Hoover Dam/Lake Mead	199	10.4	14.46
Davis Dam/Lake Mojave	72	39.6	55.04
Parker Dam/Lake Havasu	70	112.4	156.24

Source: Booker and Colby (1995), Table 4, p. 885.

While there is support for the ad hoc use of a certain functional relationship between water levels and visitation (as reported by Booker and Colby), estimating relationships based on observed data for each reservoir or river reach within the Colorado River Basin provides a stronger park-specific basis for predicting changes in park visitation as a function of fluctuating river and reservoir levels. In Section 3.1, existing datasets are used to estimate the impact of water levels on recreation for NPS Colorado River park units.

Platt and Munger (1999) authored a report for the BOR reviewing a series of methods for evaluating the effect of changing reservoir water elevations on recreation use and value. In a follow-on BOR study, Platt (2001) presented a series of use estimation models developed to address recreational impacts from fluctuating water levels at two Kansas reservoirs. The analysis included models of both water-based recreational activities such as boating, fishing, and swimming, and water-associated activities such as picnicking at reservoir sites.

2.2 Other Colorado River Uses: Hydropower, Irrigation and Municipal

The Colorado River and its tributaries are the most significant source of freshwater in the arid Southwestern United States. The benefits of this resource include the provision of approximately 15 million acre feet of highly valued western water, supplying, among other uses, a good share of the agricultural production of California's Imperial and Cochella valleys and municipal and industrial water to several of the West's largest cities including Los Angeles, San Diego, Phoenix, and Las Vegas. Through the hydroelectric developments at numerous dams, including Glen Canyon and Hoover Dams, hundreds of millions of dollars worth of electric energy are provided annually.

The most comprehensive estimates of the value of the various Colorado River resource uses are in Booker and Young (1991), Booker and Young (1994), Booker (1995) and Booker and Colby (1995). These studies identify the marginal values for major Colorado River uses and use them in several policy analysis (in the context of a river-reservoir simulation model developed for the studies) including the total cost due to a hypothetical 500-year drought and the economic benefits of interstate transfers between irrigators and municipal users. Actual Reclamation depletion schedules for each use are the baseline for the analysis. A feature of this study is that values are estimated specific to each major facility and user group in the basin.

Booker and Colby (1995) summarize the valuation parameters (economic benefit functions) used in the drought analysis. For example, hydropower value estimates are generated for each major hydropower unit in the basin (Table 11) and for marginal values per acre-feet. In the following discussion, the Booker and Colby (1995) estimates are updated to 2005 values based on existing data and other studies.

Table 11. Annual Economic Hydropower Benefits of Colorado River System Dams.

Dam and Reservoir	Total Hydropower Benefits (million 1992$)	Marginal Hydropower Value 1992$/acre foot	Marginal Hydropower Value 2005$/acre foot[a]
Flaming Gorge	18	19.8	22.57
Curecanti Unit	109	45.2	51.53
Navaho	24	17.0	19.38
Glen Canyon Dam/Lake Powell	223	26.3	29.98
Hoover Dam/Lake Mead	201	23.6	26.90
Davis Dam/Lake Mojave	46	5.8	6.61
Parker Dam/Lake Havasu	23	3.3	3.76

Source: Booker and Colby (1995)

[a] 2005 adjusted values based on percent change in California statewide weighted average retail electricity prices between 1992 and 2005. www.energy.ca.gov/electricity

The economic value of water in hydroelectric power generation is based on the avoided cost of the next best alternative (Harpman 1995; 2005). Hydropower values reported are based on the cost saving of hydropower compared to alternative thermal energy production. Hydropower production in the lower basin during peak loading is constrained at the upper limit by plant capacities, and more generally by water available for discharge. The physical effect of marginal decreases in water flow is then dominantly a decrease in base load production. In Booker and Colby (1995) the marginal value of lower basin hydropower is conservatively valued at the avoided cost of base load production at thermal facilities. Upper Basin hydropower is modeled after the preferred alternative in the 1995 final Glen Canyon Dam operation record of decision, roughly valuing this hydropower at the average of peaking and baseload. The relative upper and lower basin values estimated were $52.40 and $46.90 dollars per megawatt hour ($/MWhr), respectively.

Table 12. Comparison of Alternative Electric Generating Plant Operating Costs (2003$)

Plant Type	Variable O&M ($/MWh)	Average Fuel Cost ($/MWh)
Coal	4.09	10.59
NGCT	2.80	49.04
NGCCCT	1.77	40.25
Nuclear	0.44	4.53
Hydropower	4.80	none

Source: Harpman (2005) Table 2, p. 11.

Note: NGCT=natural gas combustion turbine; NGCCCT=natural gas combined cycle combustion turbine.

Given these values and based on the technical hydrological production relationship between hydraulic head (the difference of tailwater and reservoir elevations) , flows, and generation, one can generate schedules for each reservoir of the hydropower value at each facility as a function of alternative reservoir levels. These estimates are updated here with an electric price index, showing just a modest (about 14 percent) increase 1992 to 2005.

An alternative and closely related approach is to use hourly spot market prices. Harpman (1999) provides an application in valuing the change in hydropower generation due to the flow restrictions introduced since 1995 at Glen Canyon Dam. Reclamation (2005) uses a similar model in evaluating a change in flows for endangered fisheries and the impact on hydroelectric generation values at Flaming Gorge. Actual recent historical spot market prices and projected prices over the period of analysis (based on Reclamation's Aurora model) are reported in this the Flaming Gorge EIS as ranging from $60.00 $/MWhr in 2002 to a low of $42.60 in 2004 and rising to $65.40 by 2012 (nominal dollars). These estimates are in the same range as the updated values estimated by Booker and Colby (1995). The actual yearly variation in spot market prices is strongly influenced by fuel prices and water availability in the major hydroelectric producing areas, including the Pacific Northwest. Variation by season tends to exceed variation across years. For example, summer peak prices may be higher than shoulder season (spring fall) prices by a factor of three.

Hydroelectric generation values are probably the best understood and most predictable of the various competing water uses in the Colorado River basin.

Irrigation values are estimated in Booker and Colby (1995) for each major producing region, ranging from Western Colorado to the Central Arizona Project to California (Table 13). Additionally, municipal benefits are estimated for each major municipal user in the basin including Denver, Las Vegas, and Southern California (Municipal Water District or MWD) (Table 15).

Table 13. Marginal Per Acre Foot Values for Irrigated Agricultural Water Use in the Colorado River Basin.

Region	**Marginal Value at Full Use[a]**	**Elasticity of Demand[a]**	**Marginal value at 25% reduction ($/acre-foot)[b]**	**Marginal Value at 50% reduction (%/acre-foot)[b]**
(A) 1992 dollars				
Western Colorado	12.20	-0.57	20.18	41.03
Central Arizona Project	27.10	-2.44	30.49	36.00
California	27.1	-0.52	47.08	102.55
(B) 2005 dollars				
Western Colorado	17.32	-0.57	28.66	58.26
Central Arizona Project	38.48	-2.44	43.30	51.12
California	38.48	-0.52	66.85	94.93

[a] from Booker and Colby (1995)
[b] Derived
[c] Based on crop price index for Imperial County (CA,AZ) and Mesa County (CO), derived from county level agricultural statistics.

Table 14. Estimated Marginal Agricultural Water Values (1992 dollars)

Agricultural Region	Marginal Agricultural Value at Full Use (1992$/af)	Marginal Agricultural Value at Full Use (2005$/af)	Price Elasticity of Demand
Western Colorado	12.2	17.32	-0.57
Colorado Front Range	13.4	19.03	-0.45
Wyoming	12.5	17.75	-0.65
Utah	12.5	17.75	-0.65
New Mexico	12.2	17.32	-0.57
San Juan-Chama Export	12.2	17.32	-0.57
Nevaho IIP	53.9	76.54	-14.77
CAP	27.1	38.48	-2.44
Colorado River Indian Tribe	14.5	20.59	-1.79
Yuma	20.0	28.40	-1.32
California	27.2	38.62	-0.52

Source: Booker and Colby 1995.
Note: 2005 updated values based on average percent change in Imperial County, CA and Mesa County, CO crops between 1992 and current year.

Table 15. Estimated Municipal Water Benefits: Marginal 1992 Values.

Region	Marginal Value at Full Use (1992$/af)	Marginal Value at Full Use (2005$/af)	Price Elasticity of Demand
Denver	455.1	632	-0.45
Central Utah Project	453.9	631	-0.45
Albuquerque	479.8	667	-0.38
Las Vegas	403.9	561	-0.44
Central Arizona	362.9	504	-0.43
MWD (South California)	343.9	478	-0.38

Source: Booker and Colby 1995.
Note: marginal 2005 values based on CPI-U change from 1992 to 2005.

The methodologies for these estimates are widely used (Gibbons 1986; Young 2005). Irrigation water is valued as an input in the production of agricultural commodities. Accordingly, values will depend on the crop type and its production relationship to water, on crop prices, and other inputs such as climatic setting, soils, management, and irrigation technology. Booker and Colby (1995) summarize and interpret the literature based on linear programming models that assume irrigators optimize among these various inputs.. Municipal demand functions were estimated based on current average prices and estimated elasticity of demand.

Booker and Colby's estimates for irrigation are updated with a crop price index for Imperial County (California) and Mesa County (Colorado) using county specific crop mix and price changes for 1992 to 2005. For both these representative Lower and Upper Basin irrigation areas, the increase is about 42 percent.

The updated (2005 dollars) irrigation marginal values in these tables are similar to values estimated in a recent Reclamation EIS (2000) on allocation of water supply and long-term contract execution for the Central Arizona Project. This EIS evaluates the effect of changing water allocations and prices between Indian and non-Indian irrigators necessitated in part by settlement of Indian water right claims. Reclamation (2005) identifies the variable net return (contribution to fixed costs) per acre foot for various crops for specific irrigation districts in the Central Arizona Project. For example, the maximum amount a farmer would pay for irrigation water per acre foot for grain in Pinal County is $41.13 – the level at which it is economic to either switch to groundwater or fallow the ground. Forage in Pinal County is $52.12 and cotton is $69.19. These estimates have conceptually the same basis as Booker and Colby's and are in a similar range.

With respect to municipal values, Gibbons (1986) observes that: "One implication of this analysis of municipal water values is clear: at the limit, as supply approaches zero, the marginal value approaches infinity. When water scarcity is so extreme that people are faced with shortages of drinking water, the marginal value of water is certain to be greater for this use than for any other water use…" (at p. 20). As an example, a transaction recently reported in the Water Strategist (April 2006) was for residential water in Pebble Beach, California at a price of $250,000 per acre foot. The equivalent acre foot per year value based on a capitalization rate of 6 percent is $15,000. At an average of 140 gallons per capita per day, this would imply a monthly utility bill of about $200. This is not unimaginable when homes in this area will be selling for many million of dollars.

More specific to Colorado River basin municipal water values, recent water transactions between the San Diego County Water Authority and the Imperial Irrigation District (IID) are on the order of $375/acrefoot-year at present and escalation to around $600 nominal dollars/acre foot in fifteen years. Estimated costs of irrigation efficiency improvements in the IID are around $115 per acre foot.

All of these estimates are for net benefits, not regional economic impacts. Other relevant benefits and costs in comparing among alternative uses include conveyance costs and salinity damages. Booker and Colby (1995) estimate conveyance costs at $10/af for Navajo Indian Irrigation Project users, $87 for CAP, $107 for MWD municipal users and $123 for CAP municipal users. Given the range of values for irrigation water, net benefits after conveyance are marginal for some regions. Salinity damages are also important in interpreting net benefits to irrigation. Damage estimates (in terms of dollars per unit of salinity (micrograms per liter) from Booker and Young (1991) are used. These parameters imply, for example, municipal damages on the order of $130/af.

In Booker (1995), these parameters are modeled in the context of a 38 year drought sequence from Tarbolton (1995) representing one estimate of the worst extended drought (based on tree ring data) occurring during the last 500 years. Table 16 indicates the marginal value of instream flow for hydropower (in dollars per acre foot) for different years in this sequence. Most striking is that in a severe drought, upper basin reservoir production goes to zero (reservoirs are at or below minimal intake structures for the generation units, the head is zero) while production at lower basin reservoirs is not significantly impacted. This table illustrates that hydropower and recreation uses are in part complementary in that both benefit from higher reservoir elevations.

Table 16. Hydropower Production at Basin Reservoirs During Sustained Drought (1992 $)

Dam and Reservoir	**Marginal Value of Instream Flow for Hydropower ($/af)**		
	Base Period	**Year 16**	**Year 19**
(A) 1992 dollars per acre-foot			
Flaming Gorge	20.6	16.6	0
Curecanti Unit	46.9	0	0
Navaho	17.7	0	0
Glen Canyon Dam/Lake Powell	27.1	20.9	0
Hoover Dam/Lake Mead	24.7	24.0	23.0
Davis Dam/Lake Mojave	5.9	5.9	5.9
Parker Dam/Lake Havasu	3.4	3.4	3.4
(B) 2005 dollars per acre-foot			
Flaming Gorge	23.48	18.92	0
Curecanti Unit	53.47	0	0
Navaho	20.18	0	0
Glen Canyon Dam/Lake Powell	30.89	23.83	0
Hoover Dam/Lake Mead	28.16	27.36	26.22
Davis Dam/Lake Mojave	6.73	6.73	6.73
Parker Dam/Lake Havasu	3.88	3.88	3.88

Source: Booker and Colby 1995.
Note: 2005 adjusted values based on percent change in California statewide weighted average retail electricity prices between 1992 and 2005. www.energy.ca.gov/electricity

There is a very extensive literature on hydropower, irrigation, and municipal uses. Other works specific to the Colorado River basin on irrigation economics include Oamek (1990), and Lee (1993).

As noted, we update the Booker estimates with a crop price series and electric cost and price data. Electric utility costs were relatively stable through 2005 (except for the temporary spike in electric prices due to the West Coast power crisis). Table 17 summarizes the range in Booker and Colby's estimates, and, for comparison, shows more recent estimates for the Columbia River Basin based on a National Academy of Sciences study (NRC, 2004). Columbia River Basin hydropower estimates are relevant given the interconnected West Coast energy market, the homogeneity of baseload and peaking electric power technology, and a national market for fossil fuels. Irrigation estimates are relevant given national market for crops and produce.

Table 17. Marginal Values for Other Uses ($/af)

Competing Use	Columbia River (1999 $)	Booker Colorado River (1992 $)	Booker Colorado River (2005 $)
Agriculture	3 – 200	12 – 58[a]	17 – 82
Minicipal	34 – 403	344 – 479	478 – 666
Hydropower	4 – 62	3 – 45	3 - 51

[a] Range includes full use and marginal change in drought.

An important conclusion is that there is a considerable range in hydropower and irrigation benefits, depending on the specific characteristic of a facility and region. Municipal marginal values tend to be the highest.

Other evidence of relative values can be observed in water market transactions, which in the Colorado River Basin are typically from the main consumptive user, irrigation, to the municipalities (Loomis 1992). Brown (2006) summarizes transactions in Western water markets 1990-2003. Median prices for leases (2003 dollars per acre-foot) by use are: $69 bought for municipal use, $15 for irrigation, and $47 for environmental purposes.

All of the above estimates relate to a benefit-cost accounting framework. The direct regional economic impacts related to hydropower production and municipal uses are likely to be negligible to non-existent in the local economies where the diversion takes place and the hydropower production occurs. Impacts on relative costs for end-consumers are likely to be negligible in the large economies where these are concentrated. The local regional economic impacts of changes in water allocations for irrigators are likely to be significant. These are being quantified by Reclamation in the context of the current shortage EIS (Alan Kleinman and Margo Selig, personal communication, 2006).

3.0 Conduct Additional Analysis Using Existing Data

As noted earlier, valuation associated with the relationship between water levels and recreational value has two primary components: 1) the impact of water levels on the number of trips taken to a site (the quantitative effect), and 2) the impact of water levels on the quality, and therefore value, of recreational experiences at a site (the qualitative effect) (Duffield et al. 1992). While the effect of varying water levels on the number of trips can be modeled from existing historical use and water level data, estimation of the impact of water levels on recreational value per trip generally requires specifically designed visitor valuation studies.

The following sections present estimated models of the first type: impact of varying water levels on visitation levels for Colorado River NPS resources.

3.1 Analysis Using NPS Visitation and Reclamation Water Quantity Data

The degree to which changes in water levels impact changes in recreational visitation is reflected in estimated relationships between water levels and use levels. This section reports preliminary estimates of recreational use functions for the primary NPS managed water-based recreational resources along the Colorado River System. The relationship of recreational use to water levels is estimated where existing data was available, and qualitative descriptions of likely use relationships are presented where data is lacking.

In order to estimate recreational use functions for water-based recreation associated with NPS units in the Colorado River Drainage two primary data series are necessary: data on recreational visitation and corresponding data on water levels or flows. Recreational visitation data for the following modeling came from NPS gathered data.[3] Water level data was drawn from Reclamation historical data[4], and USGS surface water data.[5]

Use of aggregated visitation data in the following models supports only a limited interpretation of individual behavior and motivation. Other factors may in fact play a part in explaining decisions to participate in water-based recreation. As it becomes practicable or doable, other factors will be examined in future phases of this work.

3.1.1 Lake Powell Case Study

Water-based recreation within Glen Canyon NRA has two primary components: reservoir use above Glen Canyon Dam, and river use between the dam and Lee's Ferry. A model of Glen Canyon NRA visitation was estimated based on monthly reservoir volume data.

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[3] NPS Visitation Statistics are available at http://www2.nature.nps.gov/mpur/index.cfm
[4] Bureau of Reclamation historical data can be accessed at http://www.usbr.gov/uc/crsp/GetSiteInfo
[5] USGS Water flow data is accessed at http://waterdata.usgs.gov/nwis

Figure 3 displays trends in monthly visitation and average lake volume over the period from 1996 through 2006. The variability across months in visitation shown in this plot reflects the very low levels of winter visitation to the NRA compared to summer and shoulder season visitation. Figure 4 shows only the relationship between lake levels and visitation for the heavy use summer (June-August) season. These plots suggest that declining lake levels are associated with reduced visitation. Figure 5 plots the relationship of seasonal visitation at Glen Canyon NRA to average seasonal lake storage levels. This plot suggests three distinct approximately linear relationships between visitation and water levels within the data. The uppermost line of data points represents summer season (June-August) visitation and lake levels. This data suggests a positive relationship between lake levels and visitation. The second line of data points is a combination of spring and fall season visitation and lake level data. Again the relationship suggests a slight positive relationship. The bottom line of data shows the winter season visitation and lake level points. In this season, the relationship is less clearly positive between the two variables.

It is possible to model recreational use as a function of reservoir level or per acre feet of storage (or some other variable, such as surface area). We report some results below on a reservoir elevation basis, but most results are in terms of acre feet of stored volume, to facilitate direct comparison to competing and complementary uses including irrigation, hydropower, and municipal and industrial use.

Table 18 reports the parameters for a linear regression model explaining Glen Canyon NRA monthly recreational visitation as a function of Lake Powell water storage, monthly indicator variables, and average high air temperature. The estimated adjusted r-square statistic shows that the model as specified explains approximately 98% of the variation in visitation through the inclusion of the explanatory variables. All of the variables have the expected sign. The key variables and coefficients for explaining the relationship between changing lake levels and changing visitation are the “Lake Powell Volume”, “summer-volume interaction”, and “shoulder-volume interaction” variables. The interpretation of these coefficients is as follows. The coefficient on “Lake Powell Volume” (0.0000) indicates that during the off-season months (November-March) there is no estimated statistically significant relationship between water volume and visitation. This coefficient is the only non-significant coefficient of the water level variables, indicating that the relationship between use and water levels in the off-season is much weaker than in the shoulder or summer seasons.

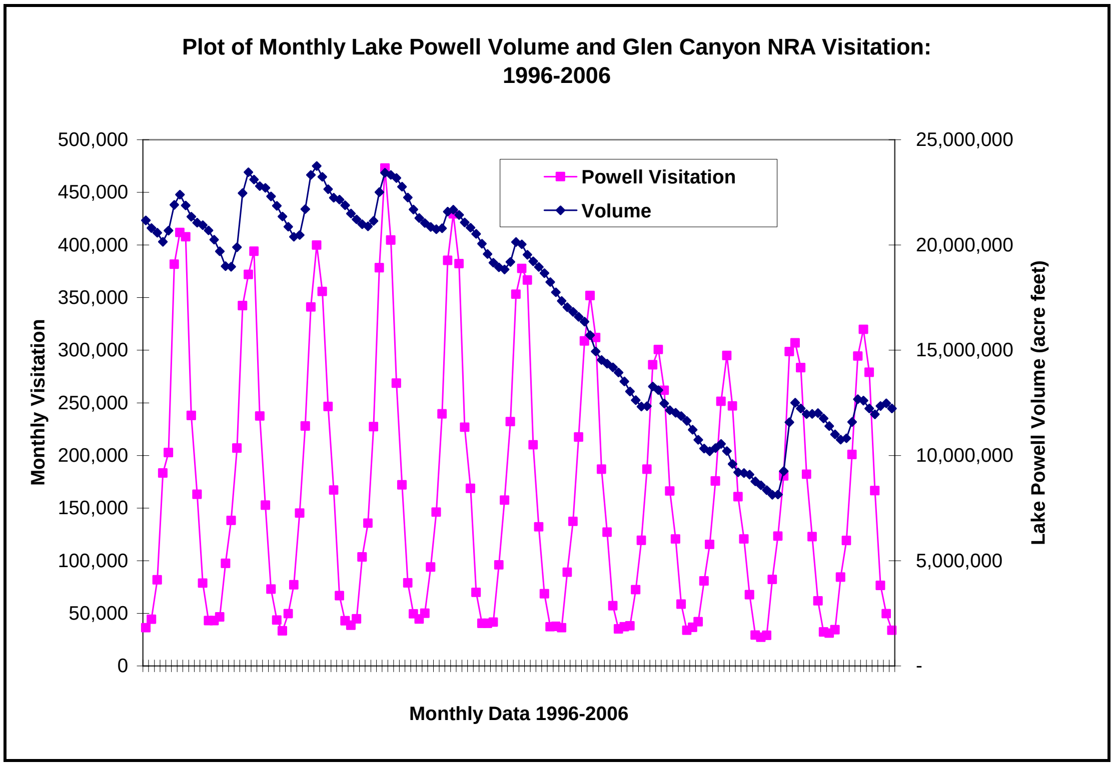

Figure 3. Monthly Plot of Glen Canyon NRA Visitation and Lake Powell Volume: 1996-2006.

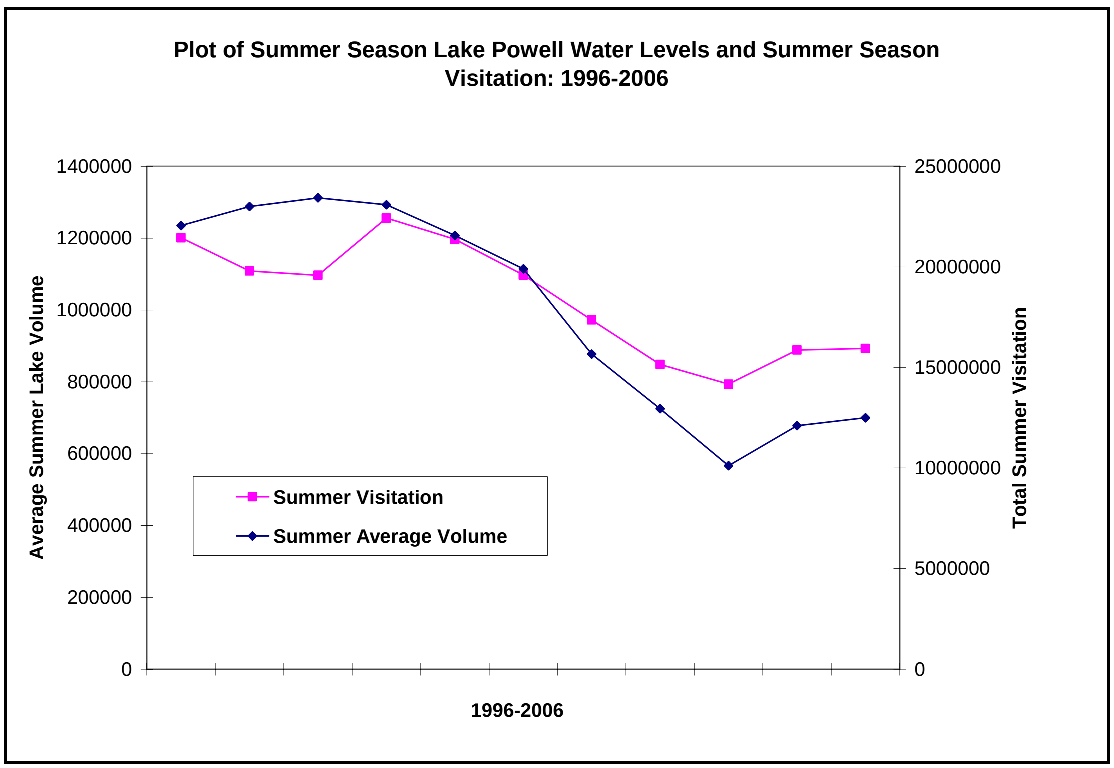

Figure 4. Plot of Summer Season Glen Canyon NRA Visitation and Lake Powel Volume: 1996-2006.

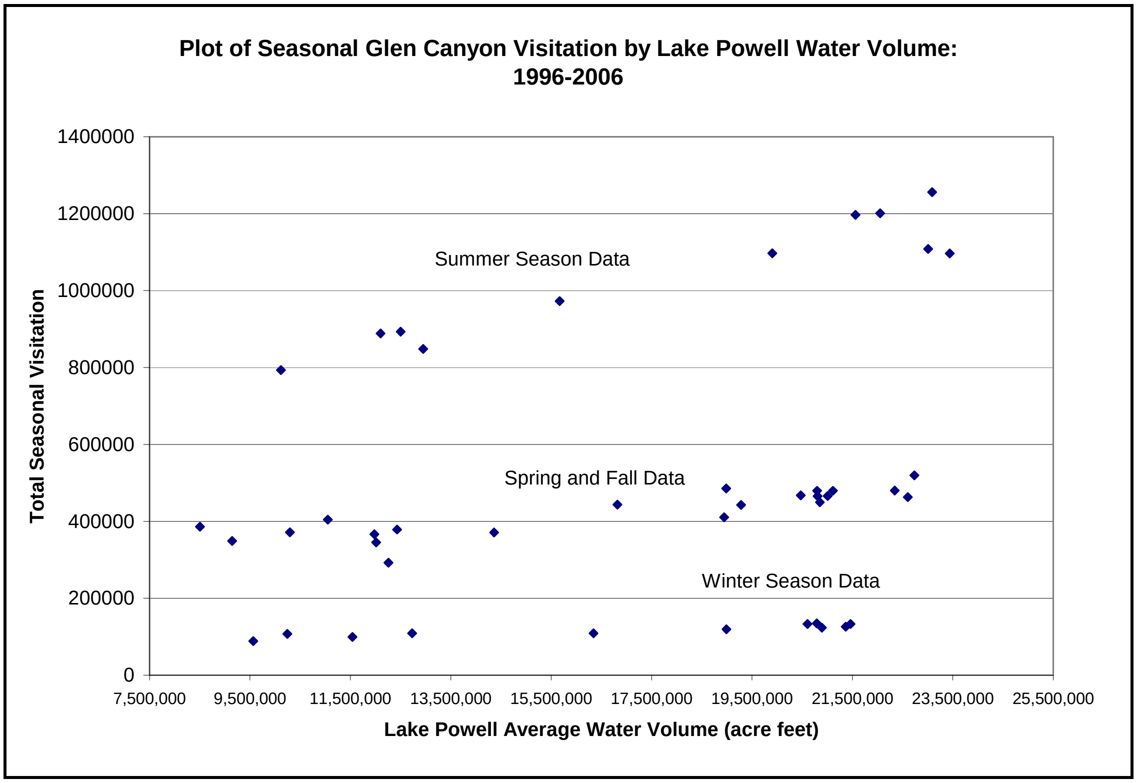

Figure 5. Plot of Seasonal Glen Canyon NRA and Lake Powell Visitation and Water Volume Data: 1996-2006.

The other water level variables, "summer-volume interaction" representing levels in the June-August months, and "shoulder-volume interaction" representing levels in April and May and September and October, are highly statistically significant (at the 99% level of confidence). The "shoulder-volume interaction" coefficient indicates that during the four "shoulder season" months 1,000 acre feet of storage is associated with 4.1 visits per month (the coefficients 0.00405 times 1,000). The "summer interaction" coefficient shows that during the June through August period an additional 1,000 acre feet of Lake Powell storage is associated with an additional 9.2 recreational visitors per month. Table 19 shows the marginal effects of volume on Glen Canyon NRA recreational visitation.

Overall, the Powell/Glen Canyon model provides a statistically significant estimate of the marginal impact of varying lake levels on visits during two primary visitation seasons. As would be generally expected, the greatest impact is found in the summer months. The shoulder season showed the next largest marginal impact, and the off-season no significant marginal impact (Table 19). Within the range of data used in the explanatory model, it is predicted that an additional 1,000 acre feet of water in Lake Powell during the entire year would be associated with an increase in recreational visitation to Glen Canyon NRA of an estimated 44.0 visits.

In addition to the variables reported in Table 18, additional variables were modeled including monthly regional gasoline prices, and indicator variables for critical lake levels which impact visitor use (such as the lake level at which Castle Rock Cut becomes passable and the level at which the Hite Marina access (now closed) was accessible). While models including only reservoir volume or only indicator variables for Castle Rock Cut were individually significant, models including both variables were not. The two models can be viewed as alternative ways of modeling use. The model presented in Table 18 describes marginal changes in visitation throughout the full range of observed lake levels, while a model including only the indicator variable for the lake level at which Castle Rock Cut is passable describes a step function showing only two water level-dependent levels of visitation, that above lake level 3620, and that below. The continuous model had more explanatory power.

Table 18. Explanatory Model of Glen Canyon NRA Visitation as a Function of Lake Powell Water Volume and Air Temperature: Monthly 1996-2006 Data.

Lake Powell Visitation-Water Volume Model:

Monthly Data 1996-2006

Regression Statistics	
Multiple R	0.992
R Square	0.983
Adjusted R Square	0.982
Standard Error	16,416.17
Observations	132

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	11	1.91503E+12	1.74E+11	646.0113	3.584E-101
Residual	120	32338889868	2.69E+08		
Total	131	1.94737E+12			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	(63,642.959)	16112.45761	(3.95)	0.00	(95,544.48)	(31,741.44)
Volume	0.0000003	0.000485283	0.00	1.00	(0.000961)	0.000961
april	(19,506.720)	13950.69353	(1.40)	0.16	(47,128.10)	8,114.66
may	19,516.654	16185.44679	1.21	0.23	(12,529.38)	51,562.69
june	22,829.816	19146.27904	1.19	0.24	(15,078.46)	60,738.09
july	47,217.525	20289.00488	2.33	0.02	7,046.74	87,388.32
august	30,434.792	19186.35037	1.59	0.12	(7,552.82)	68,422.40
september	13,254.564	16578.48033	0.80	0.43	(19,569.65)	46,078.78
october	(25,550.088)	14352.27159	(1.78)	0.08	(53,966.57)	2,866.39
Summer interaction	0.00919	0.000744446	12.35	0.00	0.007717	0.010665
Shoulder Interaction	0.00405	0.000696059	5.82	0.00	0.002674	0.005430
Ave High Temp	2,195.989	298.7846071	7.35	0.00	1,604.42	2,787.56

Note: Dependent variable is monthly recreational visitation; summer interaction variable=(1,0) indicator variable for summer months (June, July, Aug) x volume; shoulder interaction variable=(1,0) indicator variable for shoulder months (April, May, Sept. Oct.) x volume.

It is interesting to note that average high air temperature is a highly significant explanatory variable. When this variable is omitted, however, there is very little change in the volume-related variable coefficients.

Table 19. Estimated Marginal Impact of Reservoir Elevation Changes, Lake Powell and Lake Mead.

Season	Months	Marginal impact of 1000 acre feet change in volume (recreational visits per month)
(A) Lake Powell		
Summer	June-August	9.2
Shoulder	April, May, September, October	4.1
Off-season	November-March	0.0

Analysis Based on Commercial Expenditure Data

A secondary analysis of the implied economic impact of varying Lake Powell water levels was done comparing annual gross receipts reported by the Wahweap Lodge and Marina to average annual Lake Powell Storage.[6] Figure 6 shows the relationship over the 1995-2005 period of Wahweap receipts and lake levels. This plot shows a strong relationship in recent years with receipts closely tracking trends in lake levels.

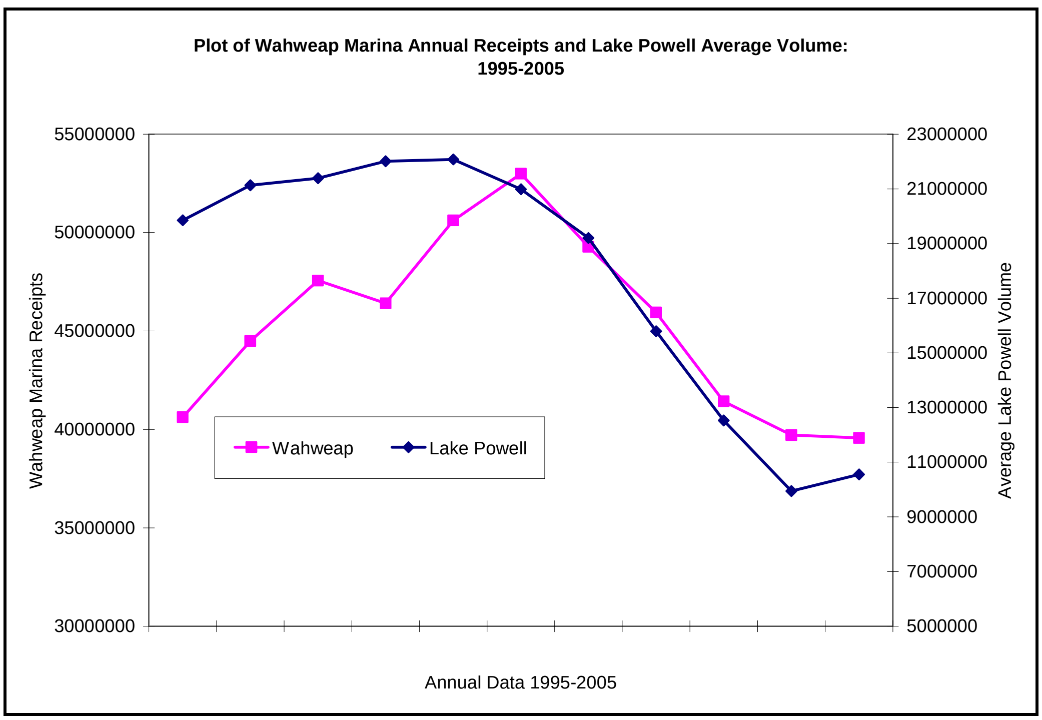

Figure 6. Plot of Wahweap Marina Annual Receipts and Average Lake Powell Levels.

[6] Gross Receipt data from, Wahweap Lodge and Marina, Schedule G, Detail of Gross Receipts, Years 1995-2005.

Figure 7 shows a scatter plot of Wahweap gross receipts by Lake Powell average annual water volume. This plot shows a strong linear relationship throughout the past decade between water levels and economic activity at the Wahweap Lodge and Marina. A simple linear regression model of Wahweap receipts as a function of lake volume showed that changes in annual average lake volume explained about 93% of the variation in Wahweap receipts over the 1995-2005 period. Additionally, the highly significant coefficient on Lake Powell Volume indicates that on the margin a 1000 acre foot of storage in Lake Powell leads to an increase in Wahweap sales of $1,470.

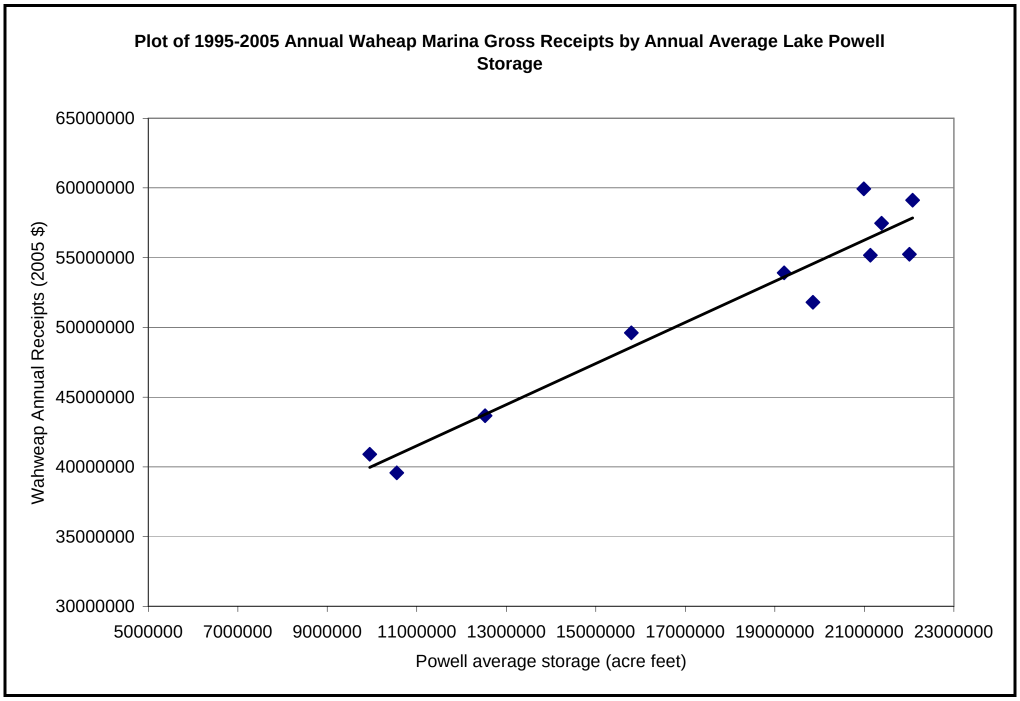

Figure 7. Plot of Wahweap Annual Receipts by Lake Powell Average Volume: 1995-2005.

3.1.2 Lake Mead Case Study

There are two reservoirs within the Lake Mead NRA: Lake Mead, and Lake Mojave. The following discussion presents an analysis for the two recreational resources separately and discussion of possible interactions between the two reservoirs and their recreational use.

Lake Mead

Plots of the relationship between recreational visitation for this park and Lake Mead water levels on a monthly, and annual basis are shown in Figure 8, and Figure 9, respectively. Although it is less clear than in the case for Lake Powell, the plots for Lake Mead show a general pattern of moderately declining visitation associated with declining lake levels. Figure 10 shows a scatter plot of summer season Lake Mead NRA visitation and average Lake Mead water elevation. Included in this plot is a fitted linear trendline showing a moderate positive relationship between summer lake levels and visitation.

As was done in the case of Lake Powell, above, an explanatory model of the relationship between Lake Mead NRA visitation and Lake Mead volume (in acre feet) was also developed. The estimated regression model for this reservoir is presented in Table 20. The regression model results for the Lake Mead relationship show a model that explains 63% of the variation in visitation as a function of the included explanatory variables. Additionally, all of the included explanatory variables are statistically significant at the 99% level. Inclusion of interaction terms for the summer and shoulder seasons did not yield statistically significant results. Therefore, for the Lake Mead NRA model the modeled marginal effect of changes in lake volume is applicable to the entire year. This marginal impact of a change of 1,000 acre feet in lake volume is 9.5 visits per month or 114 recreational visits per year.

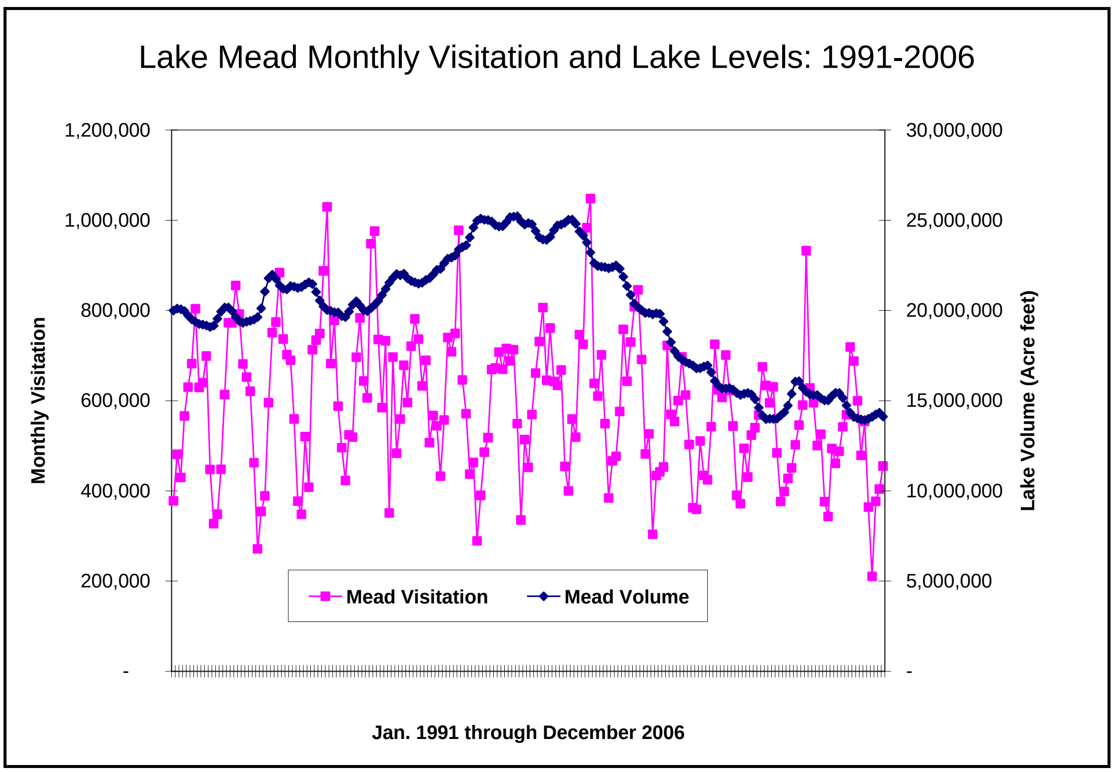

Figure 8. Plot of Monthly Lake Mead Visitation and Lake Mead Reservoir Volume: 1991-2006.

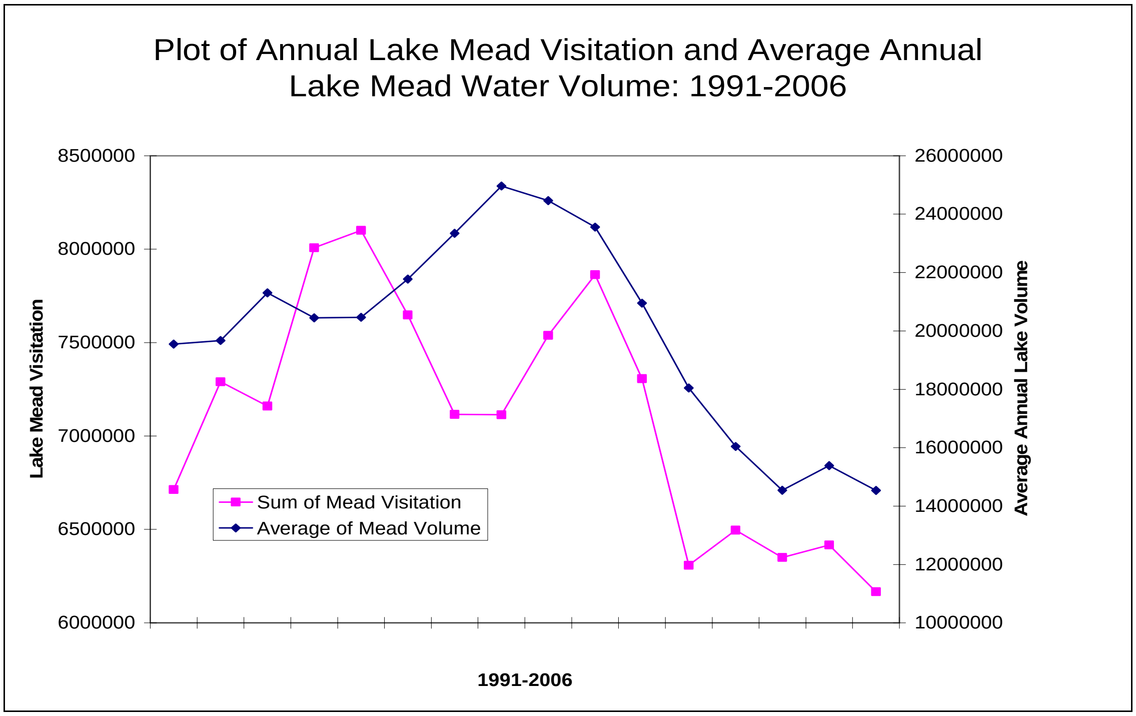

Figure 9. Plot of Annual Lake Mead NRA Visitation and Average Lake Levels.

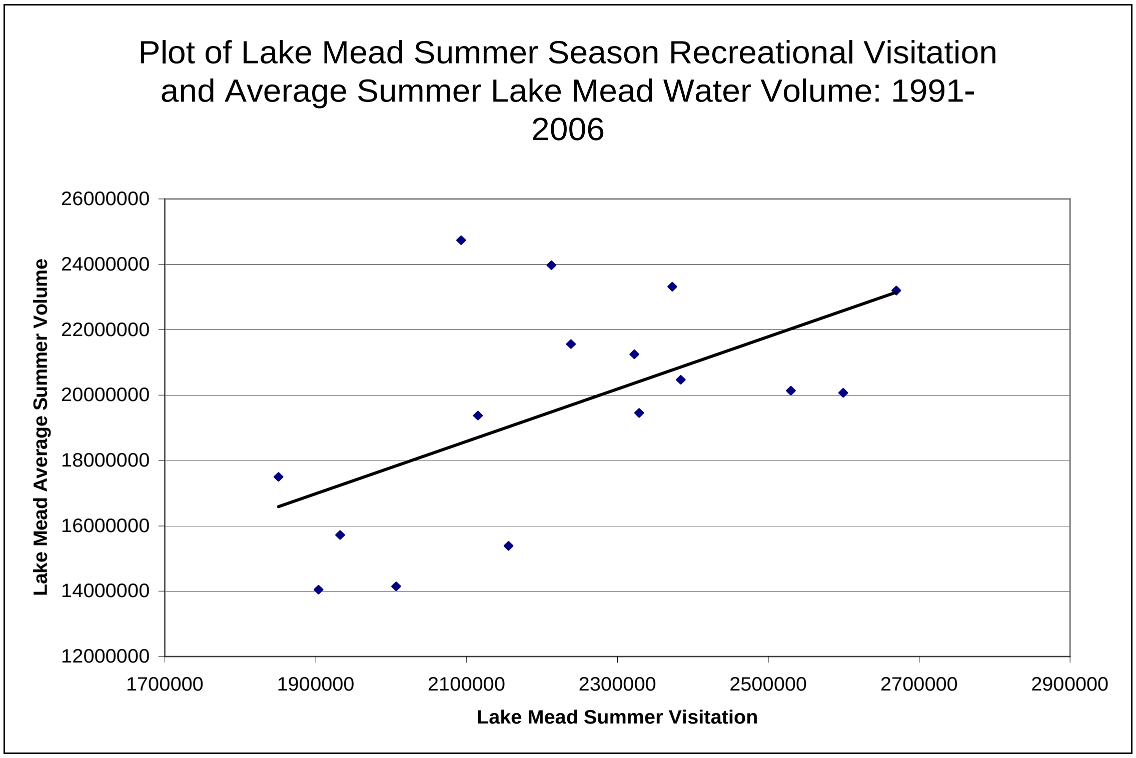

Figure 10.Plot of Lake Mead NRA Summer Season Visitation by Average Summer Lake Mead Water Level: 1991-2006.

Table 20. Lake Mead Visitation Lake Volume Model: Monthly Data, 1991-2006

Variable Statistic	Coefficient	T-Statistic	P-value
Intercept	292,642	5.06	0.00***
Lake Mead Volume	**0.00948**	**3.92**	**0.00*****
April	207,866	7.99	0.00***
May	205,600	7.90	0.00***
June	298,799	11.48	0.00***
July	317,701	12.20	0.00***
August	243,444	9.34	0.00***
September	178,962	6.87	0.00***
October	124,973	4.80	0.00***
Trend	-2867	-1.63	0.10
Adjusted R-square	0.63		
*** significant at 99% level.			

As in the case of the Lake Powell modeling described previously, alternative model specifications were examined including additional indicator variables for time of year, and interaction terms between the indicator and water level variables. Additionally, indicator variables for critical lake levels affecting recreational use were also included. An indicator variable for lake elevation 1175, the level at which Pearce Bay Launch Ramp is closed, and for 1150, the level at which the Las Vegas Bay and Government Wash public launch ramps are closed were included in the modeling. While models including only reservoir volume or only an indicator variable for Lake elevation 1175 were individually significant, models including both variables were not. The two models can be viewed as alternative ways of modeling use. The model presented in Table 20 describes marginal changes in visitation throughout the full range of observed lake levels. A model was also estimated including only the indicator variable for the lake elevation of 1175. This model describes a step function showing only two water level-dependent levels of visitation, that above lake level 1175, and that below. The later model did not provide a significantly better fit to the data than did the model using visitation as a continuous function of lake volume.

<u>Lake Mojave</u>

Lake Mojave, which lies downstream of Lake Mead, and within the NRA also has significant recreational use levels. Lake Mojave is operated primarily as a re-regulation reservoir for Lake Mead releases. As a result, lake levels at Mojave tend to fluctuate less than at Lake Mead. Figure 11 and Figure 12 show plots of Lake Mojave monthly and annual visitation and lake levels. An estimated linear regression model explaining monthly visitation as a function of lake level and monthly indicator variables is shown in Table 21. The estimated model explains about 87% of the variation in Mojave visitation. The lake volume variable is statistically significant at the 99 percent level. Inclusion of interaction terms for the summer and shoulder seasons did not yield statistically significant results. Therefore, for the Lake Mojave model the modeled marginal effect of changes in lake volume is applicable to the entire year. This marginal impact of a change of 1,000 acre feet in lake volume is 75.2 visits per month or 902 recreational visits per year.

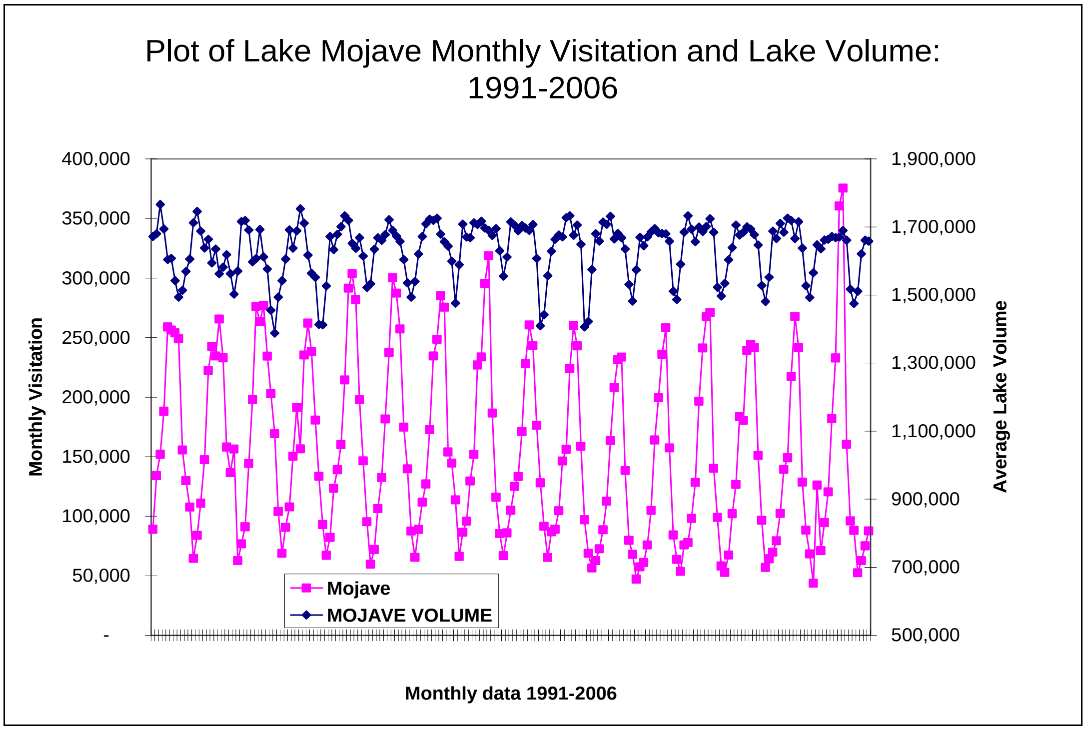

Figure 11. Plot of Monthly Lake Mojave Visitation and Lake Levels: 1991-2006.

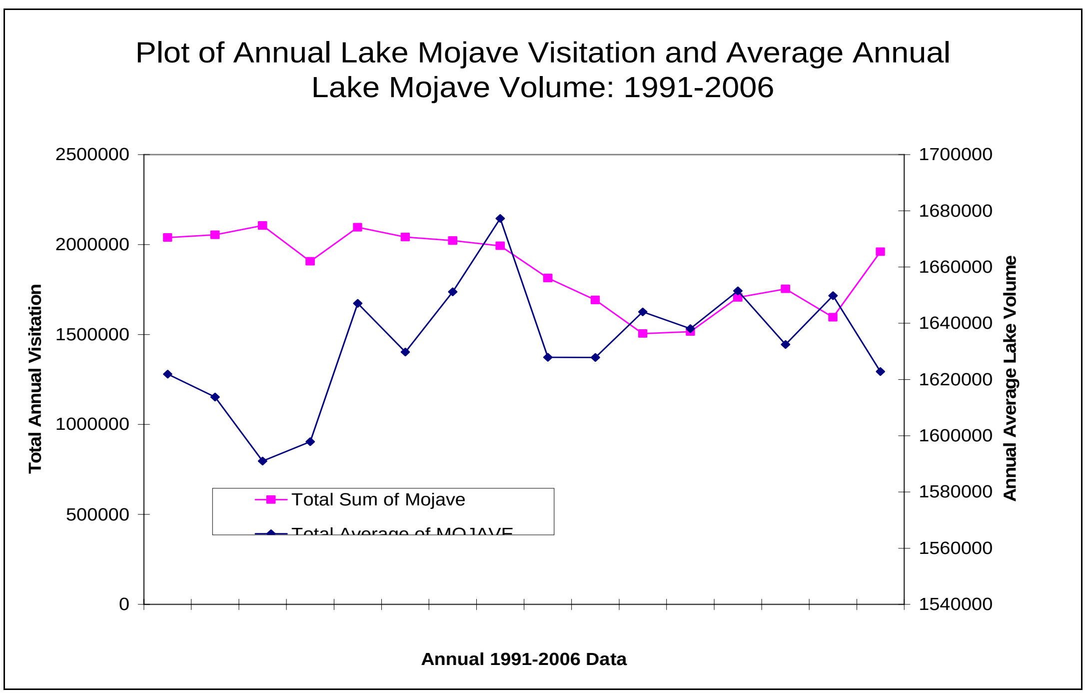

Figure 12. Plot of Annual Lake Mojave Visitation and Average Lake Level: 1991-2006.

Table 21. Lake Mojave Visitation Lake Volume Model: Monthly Data, 1991-2006.

Variable Statistic	**Coefficient**	**T-Statistic**	**P-value**
Intercept	-10,911	-0.23	0.79
Lake Mojave Volume	**0.0744**	**2.57**	**0.01*** **
April	64,310	8.33	0.00***
May	105,580	13.53	0.00***
June	146,021	18.73	0.00***
July	180,138	23.76	0.00***
August	170,298	22.52	0.00***
September	74,306	9.92	0.00***
October	35,603	4.46	0.00***
Trend	-2682	-6.21	0.00***
Adjusted R-square	0.87		
*** significant at 99% level.			

Comparison of Lakes Mead and Mojave

Lakes Mead and Mojave comprise the two reservoirs of the Lake Mead NRA. As noted above, an examination of historical water volume and recreational use statistics for these two water bodies both show significant positive relationships; increased reservoir levels are associated with increased recreational visitation. A comparison of summer season visitation trends for the two reservoirs shows a relatively high level of correlation over the 1991 through 2006 seasons (Figure 13). Further examination of visitation for the entire year, however, shows no correlation between non-summer visitation and very weak correlation between year-round visitation levels to the two reservoirs (Table 22).

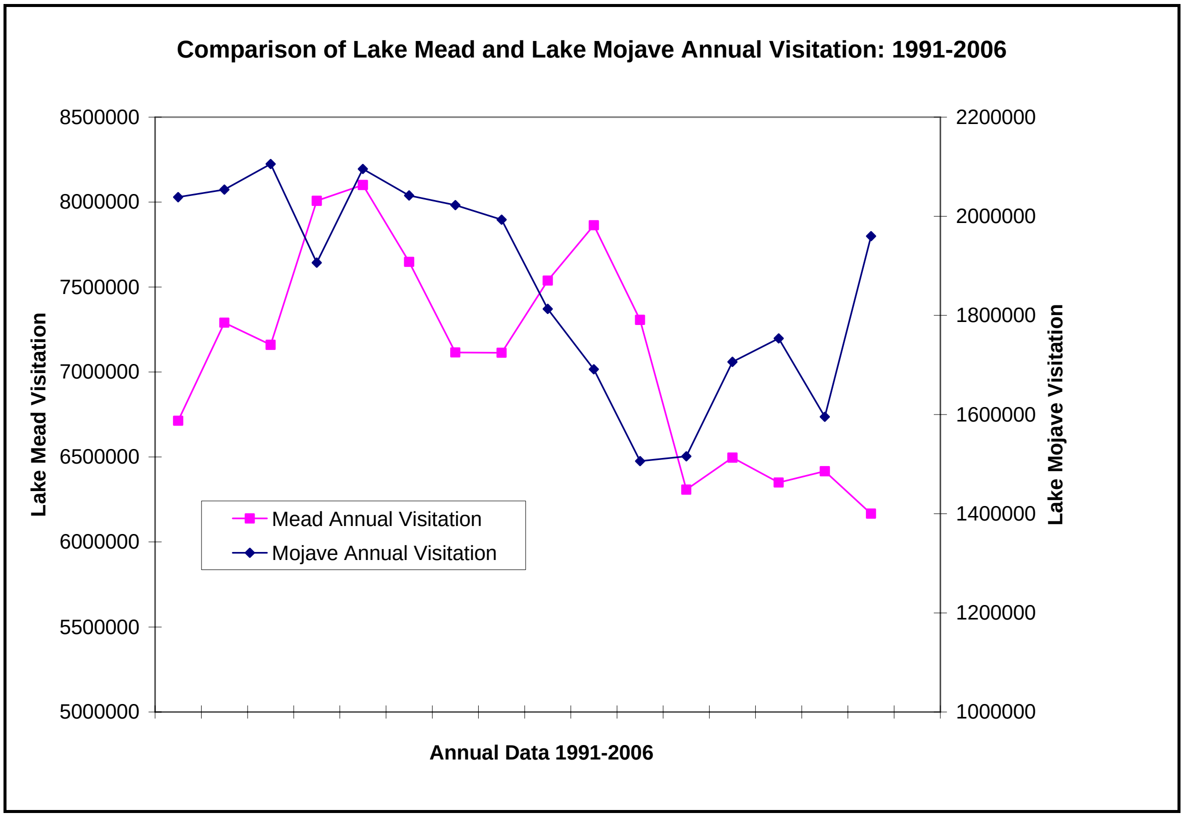

Figure 13. Comparison of Lake Mead and Lake Mojave Annual Visitation 1991-2006

Table 22. Correlation between Lake Mead and Mojave Visitation: 1991-2007

Statistic	**Result**
Correlation – summer months visitation	0.82
Correlation – non-summer visitation	-0.07
Correlation – year-round visitation	0.34
Year-to-year visitation changes	
Number of years where Mead and Mojave visitation moves in the same direction	8 out of 15 years
Number of years where Mead and Mojave visitations move in opposite directions	7 out of 15 years

A comparison of the estimated marginal impact of an acre foot of reservoir storage shows water at Lake Mojave to have roughly eight times the impact on visitation as an acre foot at Lake Mead. This comparison, however, is to a degree an artifact of the differences in absolute size of the two reservoirs. When converted to a metric more directly experienced by reservoir users, changes in water elevation, the estimated marginal impact at Mojave of a one foot change in lake elevation is roughly 2 times that estimated for Lake Mead (Table 23).

Table 23. Implied Change in Visitation to Lakes Mead and Mojave from a One Foot Change in Lake Level, at Alternative Lake Levels.

Lake Level	Change in Acre Ft. from one foot change in lake level	Visitation/volume Model Coefficient on water volume	Predicted change in visitation per month due to one foot change in lake level
Lake Mead			
1115	97,000	0.0093	906
1205	148,000	0.0093	1,382
Lake Mojave			
644	27,700	0.0752	2,082
630	24,900	0.0752	1,871

Analysis Based on Concessionaire Annual Receipt Data

Another method which can be used to examine the relationship between lake levels and recreational visitation is to examine records of NPS concessionaire receipts, such as that earlier estimate for Wahweap Marina on Lake Powell. Since recreational visitors to the park units spend money on their trips, it would be expected that decreases in lake levels that lead to decreases in recreational visitation will also lead to decreases in concessionaire receipts.

Data for Lake Mead NRA concessionaire annual receipts for the period 2001-2006 (Per. Comm. Leisa Cook, Lake Mead NRA) were examined in the context of annual average reservoir levels. The data used included total annual receipts for three Lake Mojave Concessionaires and eight Lake Mead concessionaires. While the majority of the concessionaire data showed no statistical relationship between inflation adjusted annual receipts and water volume, a strong relationship between annual receipts and annual average Lake Mead water volume was estimated for Echo Bay Resort on Lake Mead (Figure 14). An estimated explanatory regression model explaining Echo Bay annual receipts as a function of average lake volume showed a highly explanatory estimated model (adjusted R-square of 0.91) with a significant coefficient estimated for the water volume variable (significant at the 99% level of confidence (Table 24). The model suggests that within the range of the data (2001-2006) an increase of 1000 acre feet of water volume is associated with approximately 340 dollars of visitor spending at Echo Bay Resort.

In addition to Echo Bay Resort, two additional concessionaires' annual receipts data showed significant correlation with Lake Mead water volume in the estimated 2001-2006 models. Table 25 shows the summary results for the estimated models along with estimated changes in annual receipts associated with an average one foot Lake Mead level change. A more comprehensive explanation of changes in concessions receipts would require information on changes in services and facilities and changes in prices. This data was not readily available.

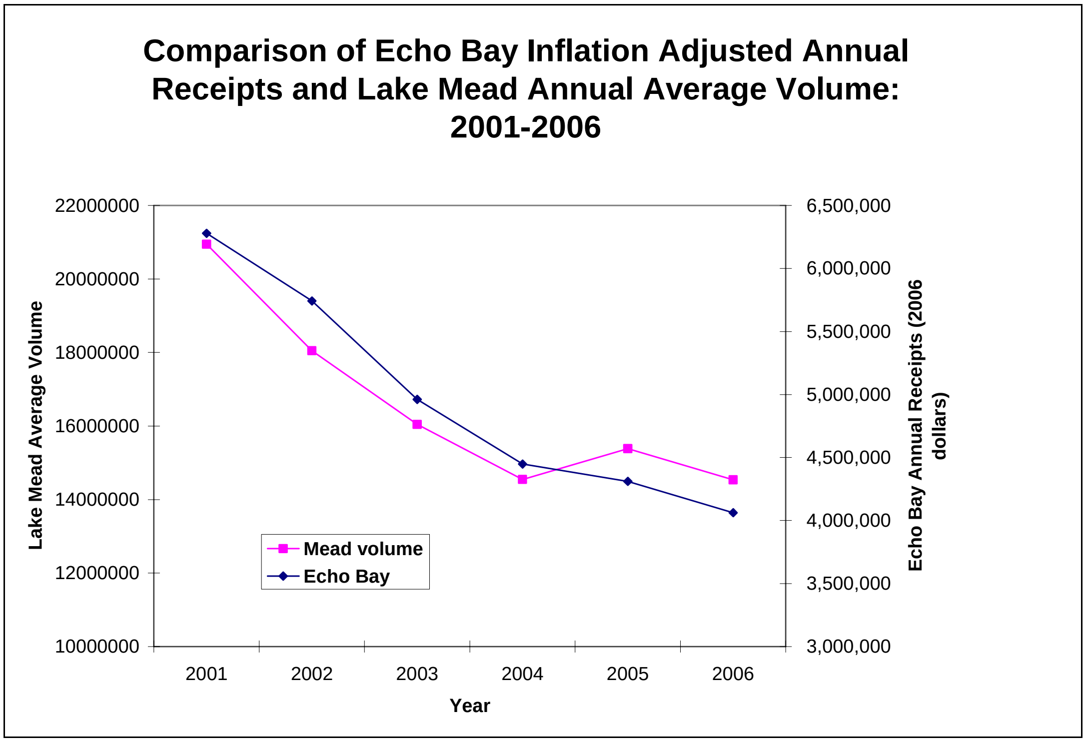

Figure 14. Comparison of Echo Bay Resort Annual Receipts and Lake Mead Average Annual Water Volume: 2001-2006.

Table 24. Explanatory Model of Echo Bay Resort Annual Receipts as a Function of Average Lake Mead Volume: 2001-2006.

Echo Bay Marina (Lake Mead) Annual Gross Receipts as a function of average Lake Mead Water Volume

Regression Statistics	
Multiple R	0.964
R Square	0.929
Adjusted R Square	0.911
Standard Error	261906.0932
Observations	6

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	3.5698E+12	3.57E+12	52.04257	0.0020
Residual	4	2.7438E+11	6.86E+10		
Total	5	3.8442E+12			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	(635,680.34)	783,987.67	(0.81)	0.46	(2,812,383.58)	1,541,022.90
mead volume	0.338	0.047	7.214	0.002	0.208	0.468

Table 25. Estimated Model Results and Changes in Concessionaire Receipts Associated with Lake Mead Volume Changes.

Concessionaire	Estimated Lake Mead Volume Coefficient	P-statistic	Model Adj. R-square	Predicted change in Receipts from 1 Foot Lake level Change[a]
Echo Bay Resort	0.338	0.00	0.91	$33,800
Lake Mead Ferry Service	0.106	0.00	0.84	$10,600
Lake Mead Resort	0.048	0.12	0.36	$4,800

[a] Based on 100,000 acre foot change at the 1115 foot water level for Lake Mead. At Lake Mead level 1115 a change of 1 foot represents approximately 97,000 acre feet of volume.

3.1.3 Curecanti-Blue Mesa Reservoir Case Study

Curecanti NRA is comprised of three bodies of water, Crystal Reservoir, Morrow Point Reservoir, and Blue Mesa Reservoir. Blue Mesa, the largest of the three is the largest body of water in Colorado. The storage of water in Blue Mesa was examined in relation to visitation to Curecanti NRA. Figure 15 shows a plot of monthly recreational visitation to Curecanti NRA associated with alternative levels of water contained in Blue Mesa Reservoir. The plot shows a general trend of higher visitation levels being associated with higher volumes of water storage in Blue Mesa.

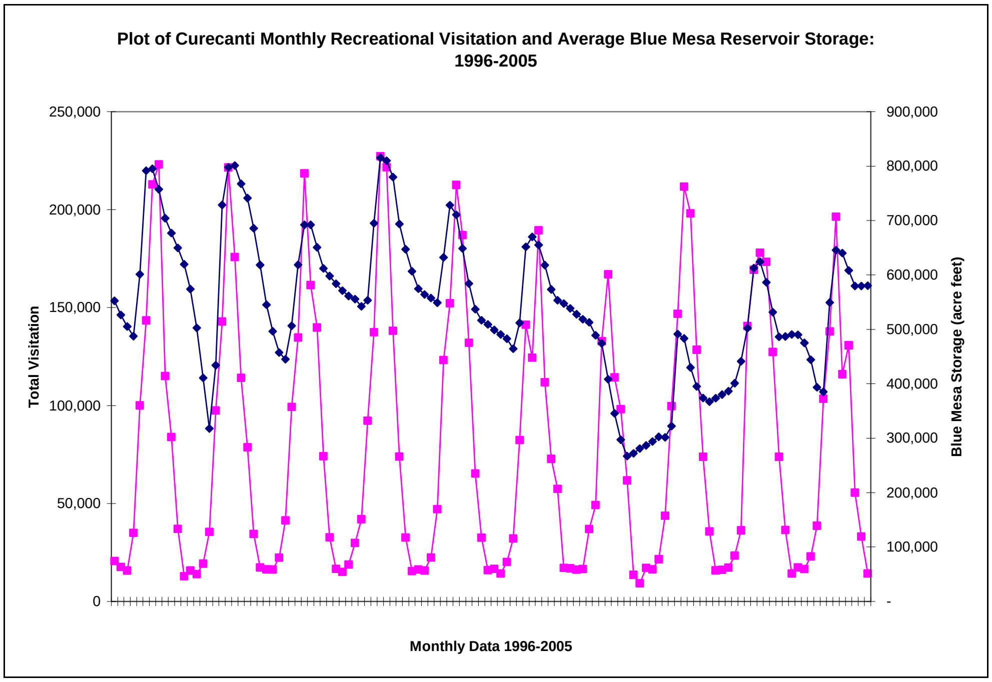

Figure 15. Plot of Monthly Curecanti NRA Visitation and Blue Mesa Reservoir Average Storage: 1996-2005.

While the graphical relationship, shown in Figure 16, between summer Curecanti visitation and average Blue Mesa Reservoir storage suggests a positive relationship between water levels and visitation, there are a number of confounding factors in this relationship. While Blue Mesa is the largest reservoir in the Curecanti unit, comparing visitation to all three units to only Blue Mesa storage leads to the potential for significant measurement error. Additionally, not all Curecanti visitation is "water-based."   Munger and Vinton (2005) found that approximately 68% of use at Blue Mesa Reservoir during the summer of 2004 was related to water-based recreation. No time series exists showing the level of reservoir-based visitation to the Curecanti Unit on a monthly, seasonally, or even yearly basis. This type of data would be needed for any statistical modeling of the relationship between water levels and water-based recreation at the unit.

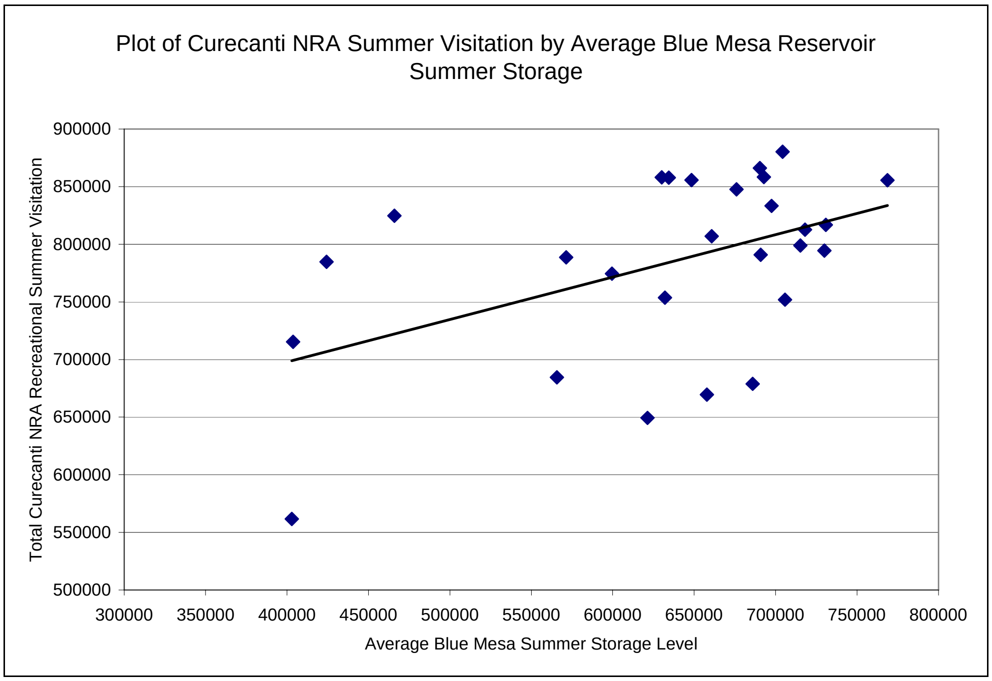

Figure 16. Plot of Summer Season Curecanti NRA Visitation by Blue Mesa Reservoir Average Summer Storage.

3.1.4 Grand Canyon NP - Colorado River through the Grand Canyon Case Study

The previous three sections have described the relationship between reservoir-based recreational visitation and water levels. Three additional NPS units within the Colorado River watershed have significant river-based recreational use. These waters are the Colorado River through Grand Canyon NP, the Cataract Canyon section of the Colorado River through Canyonlands NP, and the Green and Yampa Rivers through Dinosaur NM.

The estimation of a relationship between water and recreational use on these river reaches is fundamentally the same as was done for reservoir recreation, with the exception being that water levels are measured as flows in cubic feet per second, rather than as a stock in acre-feet, or reservoir level. Additionally, the functional form is generally different. While lake and reservoir models may show recreation increasing with lake levels throughout the range of the data, existing literature shows quantity as a quadratic relationship with low use at both very low river flows and at very high flows and with use optimized at some middle level of flows.

There is a second major difference between use levels on Lake Powell, Lake Mead, and Curecanti and on the three river sections. Use on the reservoirs is generally unconstrained by administrative maximum use levels. On two of the three river stretches (Grand Canyon NP and Dinosaur NM), however, use is limited and demand (at least during most of the year) significantly exceeds the supply of available floating opportunities. The administrative caps placed on the supply of recreational float days available masks any relationship between flow levels and use levels.

In the case of the Colorado River through the Grand Canyon, supply of available float opportunities are notoriously constrained for non-commercial floaters. This group may sign up to float up to 10 years prior to their float. Clearly, in these cases water levels, unknowable that far in advance, are not significant in determining levels of demand. For commercial floaters, many recreationists also sign up for the trip one of two years in advance. Given the significantly constrained supply of Grand Canyon float permits relative to the demand for these permits, fluctuating flow levels have little impact on the quantity of river use.[7]

While flow fluctuations through the Grand Canyon may not significantly impact the number of river floaters, the quality of their floats are impacted (Bishop 1987). Figure 17 shows the estimated relationship between flows on the Colorado River through the Grand Canyon and NEV (Surplus value) per trip. This relationship shows values increasing with flows to a point and then declining at extremely high flows.

[7] The 2005 Grand Canyon Management Plan FEIS noted this constraint in Chapter 3 (pp.198-99), "Multiple sources indicate that demand exceeds supply for both commercial and noncommercial trips in the Grand Canyon. Concessionaires report that they turn away prospective users because their trips are full, and some maintain informal waiting lists for those interested in future trips. Pricing also helps balance supply and demand for commercial permits, although concession contracts impose some constraints on trip prices (see Section 3.5 Socioeconomic Conditions for more information). On the noncommercial side, the long waitlist clearly indicates demand exceeds supply, but for several reasons, it does not provide an accurate or reliable indicator of exact demand:…"

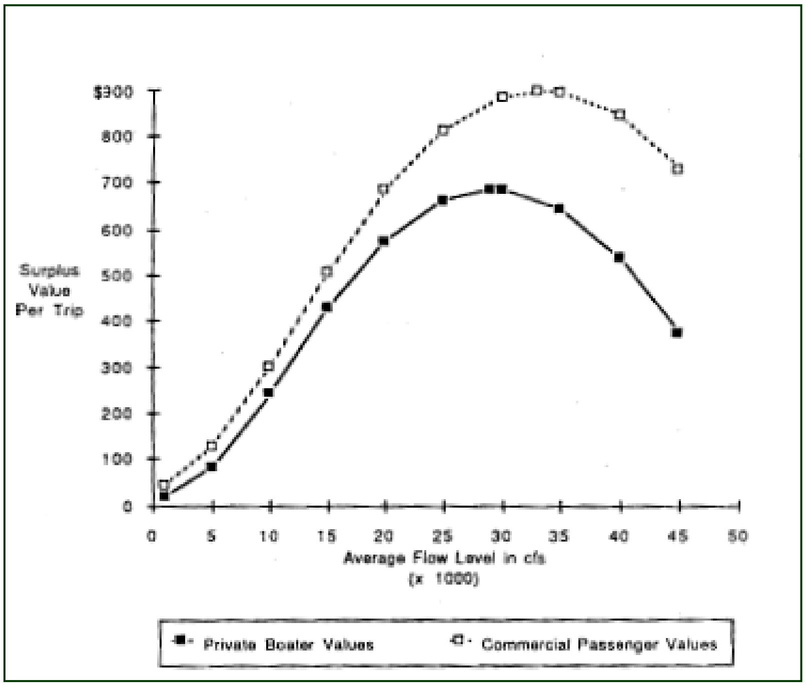

Figure 17. Bishop (1997) Relationship Between NEV and Flow Levels on Grand Canyon Float (source: Bishop, Figure 5-1).

3.1.5 Dinosaur NM – Green and Yampa Rivers Case Study

As was the case for the Colorado River float through Grand Canyon NP, use of the Green and Yampa River floats is also seriously constrained during the high-use May through September season. For the 2005 float season, NPS data shows that there were about 4,800 applications received by the NPS for approximately 300 trip permits. Approximately 6% of trip requests were granted during the season. Even allowing for multiple applications per float group, these statistics indicate that demand on the Yampa is severely constrained during the entire float season. On the Green it is moderately constrained during much of the summer season.[8]

As was the case with the Colorado River through the Grand Canyon, the administrative constraints placed on Green and Yampa River use make estimation of statistical relationships between flows and use levels impossible.

[8] The full river permit statistics for Dinosaur NM are available at http://www.nps.gov/dino/planyourvisit/upload/06-APP%20web%20stats04.doc

3.1.6 Canyonlands NP – Colorado River through Cataract Canyon Case Study

One NPS-administered Colorado River float section that does not have use limits is the Colorado River through Canyonlands NP and Cataract Canyon. Table 26 shows the estimated model of Canyonlands NP river visitation as a function of river flows and other explanatory variables. The model was estimated on monthly June through October river visitation. The coefficients (all statistically significant at the 99% level of confidence or greater) show that and increase of 100 cfs in flow (at the maximum marginal rate) is associated with about 38 recreation visitors per summer month to float the river, or 190 visitors over the 5 month high-use season. The June indicator variable shows that use in that month is on average 1583 visits lower than during the other months, all other variables held constant. The flow variable used was the sum of flows from the USGS monitoring stations on the Green River near Jensen, UT and the Colorado River near Cisco, UT. The flow variable was specified as a quadratic functional form, indicating that recreational use as a function of flows increases at a decreasing rate and levels off and decreases at very high water flows. This is consistent with the general findings in the literature.

The quadratic specification of the Cataract Canyon float demand model allows direct calculation of the implied optimal flow level for maximizing float visitation. The implied optimal flow is calculated at approximately 21,000 cfs, all other variables held constant.

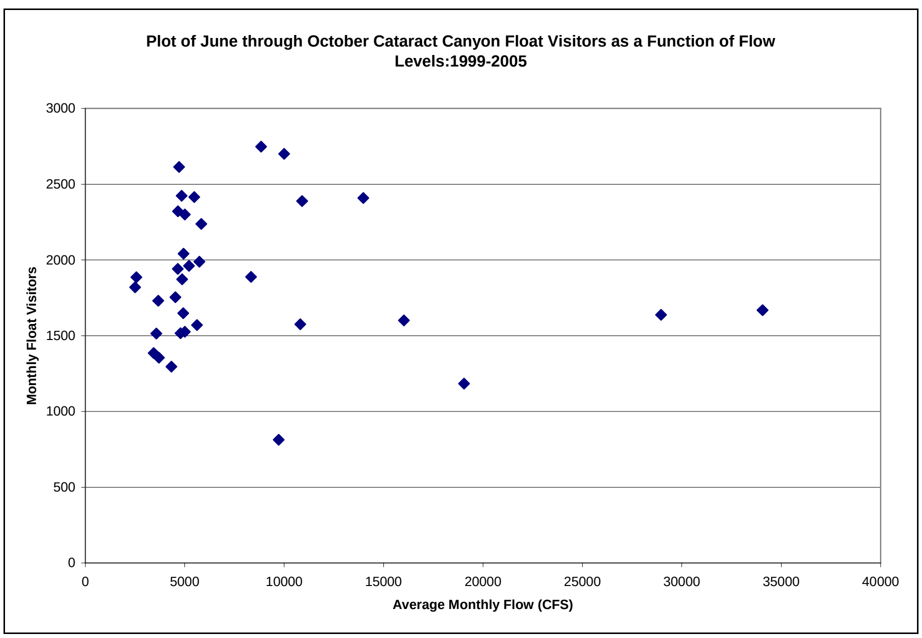

Figure 18. Plot of Cataract Canyon Float Visitation by Monthly Average Flow Levels: June through October, 1999-2005 Data.

Table 26. Explanatory Model of June-October Cataract Canyon Float Visits as a Function of Flow Levels: 1999-2005 data

Cataract Canyon June through October 1999-2005 Visitation Model

Regression Statistics	
Multiple R	n/a
R Square	n/a
Adjusted R Square	n/a
Standard Error	640.0093245
Observations	34

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	-5726416.9	-1908805.	-4.6600342	n/a
Residual	31	12697970	409611.93		
Total	34	6971553.059			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0	n/a	n/a	n/a	n/a	n/a
Flow	0.3775	0.024986916	15.109	0.000	0.32657	0.42849
Flow sq	(0.0000090)	9.44908E-07	(9.486)	0.000	(0.00001)	(0.00001)
June	-1583.056855	367.6132586	(4.306)	0.000	(2,332.80946)	(833.30425)

Note: The model is estimated without an intercept, reflecting the implicit assumption that at zero flows the river floater use is also zero.

3.1.7 Black Canyon of the Gunnison Case Study

Black Canyon of the Gunnison NP reports a very low level of river use in its visitor statistics. Specifically, generally less than 100 visits per year are reported for floating the Gunnison River through the park. This is due to the extreme difficulty of the float through the Black Canyon. While river use in the park is likely correlated with river flows, the use level through the park is too low to estimate such a relationship with confidence. Additionally, marginal changes in use associated with increased flow levels would be extremely small in the context of total park visitation. The Gunnison Gorge section below the Black Canyon is a popular float section, and is administered by the BLM.

3.2 Marginal Impacts of Water Levels on NPS Management Costs

Access facilities at NPS-administered Colorado River reservoirs are designed when built for operations within a certain range of reservoir levels. The drawdown of reservoir levels below the design levels of these facilities necessitates either modifying the access areas, or closing them pending higher lake levels. Reservoir access points are discrete and limited in number. These characteristics do not lend themselves to modeling access management costs as a function of lake levels as was done in the case of recreational use. Rather, NPS is faced with management decisions specific to individual access facilities based on current and projected water levels. Decisions may be made to lengthen ramps, move facilities, of close facilities. These decisions are made based on weighing the benefits associated with maintaining access points as long as possible, against costs associated with access modification or relocation.

At Glen Canyon NRA, the NPS reported spending approximately $8 million to provide continued lake access between 2002 and May 2005. The projects funded with these expenditures included extending boat launch ramps, ferry launch ramps, walkways and utilities, developing shuttle and low water parking areas, and funding an up-lake development concept plan.[9]

At Lake Mead NRA, the NPS spent $6 million over three years to extend and move launch ramp facilities. The NPS anticipated spending an additional $8 million for access as the lake approached 1095 feet. The costs of ramp extensions at Lake Mead are estimated at $1,520/ft (for a 160 foot wide ramp). Low water access impacts at Lake Mead include Las Vegas Bay Marina moving to Hemingway due to low water in 2004, and alternative ramps being required at Callville, Government Wash, Stewart Point, South Cove, Boulder Harbor, and Echo Bay.

[9] NPS Briefing Statement, “Visitor Services- Low Water Facilities” Glen Canyon NRA, May 2005.

4.0 Comprehensive Estimates of Relevant Economic Values

4.1 Regional Economic Impact

As noted previously, regional economic impact analysis narrowly examines the effect of visitor spending to a site or area (such as Grand Canyon NP) on the local economy surrounding the site. The inputs to a regional economic impact analysis focus on visitor spending, and the outputs are generally presented in terms of changes in personal income or employment.

It should be noted that comparability between impact analyses, even for an identical site, is not assured. Each regional impact analysis defines a specific “impact area” (often a county, group of counties, or state) and only (or should only) counts expenditures made within that impact area by visitors coming from outside the impact area. Because definitions of the impact area and who constitute local or non-local visitors may vary across studies, care should be taken in comparing impact analyses for a specific site or park unit.

It should be further noted that regional economic impact analysis describes impacts on one local area only, and ignores expenditure impacts to the remainder of the national economy. Specifically, this type of analysis ignores the offsetting loss in spending in other areas of the economy that result from visitor spending in a specific site or park locale. The following impact estimates provide a “first blush” view of data and estimates currently available. Estimates may not be strictly comparable between park units due to different treatments in the studies in defining local and non-local spending, and in defining the area of impact. Rather the following data is presented as an indication of the estimates and data developed to date for the CRW units.

Table 27 shows a summary of estimates of regional economic impacts associated with recreational visitation to the Colorado River NPS units. While estimates are presented for all Colorado River Basin Units with significant water-based recreational visitation, the estimates vary in quality. Four of the five lowest estimates of per visitor trip spending ($43 at Lake Powell, $56 at Lake Mead, $32 at Dinosaur and $39 at Canyonlands) have been derived from 2003 MGM2 published estimates. These estimates are all parkwide estimates and are not based on recent visitor survey data. In the case of Dinosaur and Canyonlands, the MGM2 estimates of per visitor spending may not be representative of the river recreational visitors to the parks. A general trend is that estimates of per visitor spending based on visitor surveys are significantly larger than are the primarily default MGM2 estimates.

Table 27. Estimated Regional Economic Impact of Water-based Recreation Based on Available Data (Constant 2005 Dollars).

Park Unit	Estimated Direct Spending per Visitor Trip	Estimated Indirect and Induced Spending Multiplier[a]	Estimated Total Spending Impact per Visitor (2005$)	Water-based Visitation (000's)	2005 Total Direct, Indirect and Induced Spending (million 2005$)
Glen Canyon NRA					
Lake Powell	43[c] – 187[d]	1.45	62 – 271	1,392	86 – 377
Colo. River (Glen-Lee's)	111[e] – 340[e]		161 – 493	179	29 – 88
Lake Mead NRA					
Lake Mead	56[c]	1.32	74	6,287	465
Lake Mojave	174[f]		230	1,533	353
Curecanti NRA	24[c]	1.44	35	Uncertain	--
Grand Canyon NP					
Grand Canyon Float	1,471[e]	1.45	2,118	22	46
Dinosaur NM					
Yampa & Green River[b]	32[c]	1.32	42	13	0.6
Canyonlands NP					
Cataract Canyon[b]	39[c]	1.33	52	12	0.6
Black Canyon NP	Minimal water-based use				
Arches NP					
Rocky Mountain NP					

[a] Multipliers are based on MGM2 model estimated expenditure multipliers
[b] Expenditure estimates for Canyonlands and Dinosaur are for all visitors and may not represent spending by river-recreationists who make up a small part of total visitation.
[c] Munger and Vinton (2005).
[d] Duffield and Neher (1999)
[e] Stynes and Sun (2005)
[f] Borden et al. (2003)

4.2 Marginal Impacts of Water Level Changes

The derivation of the marginal effects of water level changes on park visitation are presented in the preceding Sections 3.1.1 – 3.1.7. A summary of these estimated marginal effects are shown in Table 28. There were three park units (four specific waters) where it was possible to estimate the marginal relationship between water levels and visitation. The marginal impact of a change of 1000 acre-feet of storage (in the case of the reservoirs) and 100 cfs average flow (in the case of river recreation) are shown in the table.

Table 28. Estimated Marginal Changes in Park visitation Associated with Marginal Changes in Water Levels.

Park Unit	Marginal Water Change	Marginal change in visitation
Glen Canyon NRA	1000 af	44
Lake Mead NRA – Lake Mead	1000 af	114
Lake Mead NRA – Lake Mojave	1000 af	902
Curecanti NRA	No estimated model due to lack of water-based visitation data	
Grand Canyon NP	No estimated model due to constrained supply of river permits	
Dinosaur NM	No estimated model due to constrained supply of river permits	
Canyonlands NP	100 cfs	190
Black Canyon NP	No estimated model due to very low river use	

Table 29 presents the resulting estimated changes in spending in the regional economy associated with the marginal impacts on visitation shown in Table 28.

Table 29. Estimated Marginal Changes in Regional Economic Activity Associated with Marginal Changes in Water Levels.

Park Unit	Marginal Water Change	Marginal change in total spending	Marginal change per acre-foot (2005$)
Glen Canyon NRA	1000 af	$2,700 - $11,900	$2.70 - $11.90
Lake Mead NRA – Lake Mead	1000 af	$8,400	$8.40
Lake Mead NRA – Lake Mojave	1000 af	$207,500	$207.50
Curecanti NRA	No estimated model due to lack of water-based visitation data		
Grand Canyon NP	No estimated model due to constrained supply of river permits		
Dinosaur NM	No estimated model due to constrained supply of river permits		
Canyonlands NP	1000 af (June – October)	$322	$0.32
Black Canyon NP	No estimated model due to very low river use		

4.3 Direct Recreational Value

Table 30 summarizes the best available estimates of total direct recreational value estimates for water-based recreation within the Colorado River NPS units. Where uncertainty regarding the magnitude of a consumer surplus estimate exists, that is noted and a range of values is presented.

Table 30. Summary of Direct Recreational Value Estimates for Water-Based Recreational visitation toColorado River NPS Units.

Park Unit	Resource	Visitation (2005) (000's)	NEV per visit	Total annual NEV (million 2005 $)
Glen Canyon NRA	Lake Powell Colorado R. – Lee's to Glen	1,392 179	86[c] – 109[c] n/a[a]	112 – 270 n/a
Lake Mead NRA	Lake Mead Lake Mojave	6,287 1,533	643– 887[b] n/a	4,042 – 5,577 n/a
Curecanti NRA	Blue Mesa Reservoir Morrow Point Reservoir Crystal Reservoir	531	69 – 187[e]	36 - 99
Grand Canyon NP	Colorado R.	22	430[d] – 3000[d]	1 - 66
Dinosaur NM	Yampa River & Green River	13	n/a	n/a
Canyonlands NP	Colorado R. – Cataract Canyon	12	n/a	n/a
Black Canyon NP	Minimal water-based recreation			
Arches NP				
Rocky Mountain NP				

[a] n/a indicates no site-specific estimate exists.
[b] based only on angler values (Martin 1982)
[c] Douglas and Johnson (2004); Duffield and Neher (1999). See Table 5 for details of sources.
[d] Bishop et al. 1987.
[e] McKean et al. 1995.

Table 31 shows available estimates of the marginal change in direct use net economic value associated with water-based recreation within NPS units resulting from changes in reservoir or river levels.

Table 31. Estimated Marginal Changes in Net Recreational Benefits Associated with Marginal Changes in Water Levels.

Park Unit	Marginal Water Change	Marginal change in Net Benefits (2005 $)	Marginal change in Net Benefits per acre-foot (2005 $)
Glen Canyon NRA	1000 af	3,800 – 4,800	3.80 – 4.80
Lake Mead NRA – Lake Mead	1000 af	73,300 – 101,100	73.30 – 101.10
Lake Mead NRA – Lake Mojave	1000 af	N/A	N/A
Curecanti NRA	No estimated model due to lack of water-based visitation data		
Grand Canyon NP	1000 af	243[a]	0.24
Dinosaur NM	No estimated model due to constrained supply of river permits		
Canyonlands NP	1000 af	n/a	n/a
Black Canyon NP	No estimated model due to very low river use		

Note: Lake Mead estimates are based only on angler survey responses.
[a] based on the maximum marginal flow value from Bishop (1987), Figure 8-3.

In addition to the estimated marginal impacts of water level changes on visitation shown in Table 31, marginal impacts of water level changes on the value of individual trips can also be modeled. This marginal effect can only be modeled through a site-specific user survey. To date estimates for this marginal effect of flows within the Colorado River

NPS units have been completed only for the Grand Canyon float reach of the river through Grand Canyon NP (Bishop et al. 1987). Lacking more site specific data on this marginal effect, no best estimate of marginal effects on value per trip are presented.

4.4 Passive Use Value

As summarized in Table 7, two passive use value studies of lakes and reservoirs and nine passive use value studies were identified as being potentially relevant to NPS resources in the Colorado River Basin.

With respect to the literature on rivers, only one set of passive use estimates is available for Colorado River park units, and that is the Welsh et al 1995 study of river flows in the Grand Canyon. This resource is sufficiently unique that it would be difficult to justify extending this estimate to other Colorado River sites. While the river-related literature is more extensive than the lake and reservoir literature, the available estimates are still relatively thin given the great variety in resources and services evaluated. Accordingly, the only useable estimate is for the Colorado River through the Grand Canyon, and no other sections.

With respect to lakes, there are only two studies, one of Flathead Lake in Montana and the other for Mono Lake in California. Both these studies are rather dated (1981 and 1986-1987 survey years). Additionally, these lakes are quite different in market setting, attributes, and national prominence compared to, for example, Lake Powell and Lake Mead. Accordingly, there is insufficient economics literature to undertake a benefit transfer estimate for Colorado River NPS lake and reservoir resources.

4.5 Other Competing Water Uses

Other uses are valued in the range summarized in Table 32. These values necessarily range across facility, region, and user population for hydropower, irrigation, and municipal users, respectively. These values are relatively well understood, and are generally computed specific to the policy issue at hand in water resource planning and related NEPA process publications in the Colorado River Basin.

Some related values, such as salinity damage estimates, are quite complex but have been well investigated relative, for example, to NPS resource recreation and passive use values.

Table 32. Change in Net Benefits for Other Uses ($/af)

Competing Use	Columbia River (1999 $)	Booker Colorado River (1992 $)	Booker Colorado River (2005 $)
Agriculture	3 – 200	12 – 58[a]	17 – 82
Minicipal	34 – 403	344 – 479	478 – 666
Hydropower	4 – 62	3 – 45	3 - 51

[a] Range includes full use and marginal change in drought.

5.0 Summary of Uncertainty Analysis and Existing Data Gaps

5.1 Regional Economic Analysis – Visitor Expenditure Data

Table 33 presents a more general summary of the availability of estimates and data associated with regional economic analyses of the visitor expenditure impacts for the nine Colorado River System NPS units. Specifically, whether estimates exist specific to differing water segments (river v. reservoir, for example) While three of the units (Grand Canyon NP, Arches NP and Curecanti NRA) have relatively up-to-date visitor data, these are generally parkwide estimates which obscure significant differences between water-based visitation and general visitation. Some units have specific water-based visitor data that is current and high quality (Lake Powell and Lake Mojave). Other units have water-based visitor expenditure data that is relatively dated (the Colorado River sections between Glen Canyon Dam and Lake Mead). Still others have no visitor expenditure data specific to water based recreation at the park units (Dinosaur NM, Canyonlands NP).

Table 33. Summary of Available Regional Economic Impact Data for Colorado River NPS Units.

Park Unit	Regional Impact Analyses	Expenditure Estimate Available?	Data gaps
Glen Canyon NRA	Lake Powell Colorado R. – Lee's to Glen	Yes Yes	Limited Samples Dated
Lake Mead NRA	Lake Mead Lake Mojave Colorado R. above Mojave	Limited Yes Yes	No estimates -- --
Curecanti NRA	Blue Mesa Reservoir Morrow Point Reservoir Crystal Reservoir	Yes No No	Water based est. No estimates No estimates
Grand Canyon NP	Colorado R. – Lees to Diamond Colorado R. – Diamond to L. Mead	Yes – Dated Yes – Dated	20 years old 20 years old
Dinosaur NM	Yampa River Green River	No No	No estimates No estimates
Canyonlands NP	Colorado R. – Cataract Canyon	No	No estimates
Black Canyon NP	Gunnison River	No	No estimates
Arches NP	Not Applicable		
Rocky Mountain NP			

Table 34. Summary of Uncertainty and Data Gaps Associated with Estimates of Changes in Visitation and Regional Economic Impacts with Marginal Changes in Water Levels.

Park Unit	Resource	Marginal Impacts on Visitation Estimate Available?	Regional Economic Impact Estimate Available?	Marginal Regional Economic Impact Estimate Available?
Glen Canyon NRA	Lake Powell Colorado R. – Lee's to Glen	Yes Yes – combined with Powell	Yes Yes	Yes Yes
Lake Mead NRA	Lake Mead Lake Mojave	Yes Yes	No Yes	No Yes
Curecanti NRA	Blue Mesa Reservoir Morrow Point Reservoir Crystal Reservoir	No No No	Yes-limited No No	No No No
Grand Canyon NP	Colorado R. – Lees to Diamond Colorado R. – Diamond to L. Mead	Constrained use Constrained use	Yes-dated Yes-dated	n/a n/a
Dinosaur NM	Yampa River Green River	Constrained use Constrained use	No	No
Canyonlands NP	Colorado R. – Cataract Canyon	Yes	No	No
Black Canyon NP	Gunnison River	Low use		
Arches NP	Not Applicable			
Rocky Mountain NP				

5.2 Direct Recreational Use Values

Table 35 summarizes the existing uncertainty and data gaps associated with estimation of direct recreational values of water-based recreation within the Colorado River NPS units.

Table 35. Summary of Uncertainty and Data Gaps Associated with Estimates of Direct Recreational Values of Colorado River Basin NPS Units.

Park Unit	Resource	Park-specific NEV per trip Estimate Available?
Glen Canyon NRA	Lake Powell Colorado R. – Lee's to Glen	Yes Yes – 20 years old
Lake Mead NRA	Lake Mead Lake Mojave	Yes – limited to fishing & 28 years old No
Curecanti NRA	Blue Mesa Reservoir Morrow Point Reservoir Crystal Reservoir	Yes - dated No No
Grand Canyon NP	Colorado R. – Lees to Diamond Colorado R. – Diamond to L. Mead	Yes – 20 years old No
Dinosaur NM	Yampa River Green River	No No
Canyonlands NP	Colorado R. – Cataract Canyon	No
Black Canyon NP	Gunnison River	Low use
Arches NP	Not Applicable	
Rocky Mountain NP		

Table 36. Summary of Uncertainty and Data Gaps Associated with Estimates of Changes in Visitation and Direct Recreational Use Values with Marginal Changes in Water Levels.

Park Unit	Resource	Marginal Impacts on Visitation Estimate Available?	NEV per Trip Estimate Available?	Marginal NEV Value Estimate Available?
Glen Canyon NRA	Lake Powell Colorado R. – Lee's to Glen	Yes Yes – combined with Powell	Yes Yes 20 years old	Yes Yes- dated
Lake Mead NRA	Lake Mead Lake Mojave	Yes Yes	Yes – limited to fishing and 28 yeas old No	Partial No
Curecanti NRA	Blue Mesa Reservoir Morrow Point Reservoir Crystal Reservoir	No No No	Yes - dated No No	No No No
Grand Canyon NP	Colorado R. – Lees to Diamond Colorado R. – Diamond to L. Mead	Constrained use Constrained use	Yes-20-years old No	n/a n/a
Dinosaur NM	Yampa River Green River	Constrained use Constrained use	No No	No No
Canyonlands NP	Colorado R. – Cataract Canyon	Yes	No	No
Black Canyon NP	Gunnison River	Low use		
Arches NP	Not Applicable			
Rocky Mountain NP				

Table 37. Summary of Uncertainty and Data Gaps Associated with Direct Use Net Economic Values per Trip.

Park Unit	Resource	Marginal Impacts on NEV Visitation level Values?	Marginal Impacts on NEV Value per Trip Values?	Combined Visitation and Marginal Impact on Value per Trip Values?
Glen Canyon NRA	Lake Powell Colorado R. – Lee's to Glen	Yes Yes- 20 years old	No Yes 20 years old	Partial Yes- 20 years old
Lake Mead NRA	Lake Mead Lake Mojave	Partial No	No No	No No
Curecanti NRA	Blue Mesa Reservoir Morrow Point Reservoir Crystal Reservoir	No No No	No No No	No No No
Grand Canyon NP	Colorado R. – Lees to Diamond Colorado R. – Diamond to L. Mead	n/a n/a	Yes-20-years old No	Partial No
Dinosaur NM	Yampa River Green River	No No	No No	No No
Canyonlands NP	Colorado R. – Cataract Canyon	No	No	No
Black Canyon NP	Gunnison River	Low use		
Arches NP	Not Applicable			
Rocky Mountain NP				

5.4 Passive Use Values

The available literature most relevant to Colorado River park unit water resources was summarized above in Table 7 and in Appendix B. This literature is too limited to support a benefit transfer. Nonetheless, the literature, particularly the Mono Lake study (Loomis 1989) and the Welsh et al (1995) study of the Grand Canyon suggest that significant passive use values may be associated with fluctuations and absolute levels of NPS lakes and reservoirs, perhaps especially Lake Powell and Lake Mead. There may also be significant values associated with river flows and the health of riparian ecosystems in the free-flowing Colorado River sections. This is a very significant data gap – monetarily perhaps the most important – in the set of comprehensive value estimates for Colorado River park units.

5.5 Other Competing Water Uses

Relatively speaking, data gaps and uncertainty are not significant for other uses. The range in values is based in differences across locations and facilities, and is relatively well understood.

5.6 Summary

Table 38 presents a summary of the availability of existing data and estimates needed for a comprehensive analysis of the impacts of water levels within the rivers and reservoirs of the Colorado River Basin NPS units on regional economic activity, direct use net economic value and passive use value. While data and estimates are available for a number of the cells in parks and tasks in the table, many cells show missing, dated, or only partial data.

Table 38. Is Sufficient Information Available Now to Produce the Necessary Analysis Tools for Phase III?

Park Unit	Produce Regional Economic Impacts for Water-based Visitation?	Estimate Marginal Impacts of Water level on Regional Economics?	Produce Direct Use Total Value Estimates for Water-based Visitation?	Estimate Marginal Impacts of Water level on NEV?	Estimated Passive Use Values?
Glen Canyon NRA					
Lake Powell	YES	YES	YES	PARTIAL	NO
Colo. River (Glen-Lee's)	DATED	DATED	DATED	NO	NO
Lake Mead NRA					
Lake Mead	NO	NO	NO	NO	NO
Lake Mojave	YES	YES	NO	NO	NO
Curecanti NRA	PARTIAL	NO	NO	NO	NO
Grand Canyon NP					
Grand Canyon Float	YES	YES	DATED	PARTIAL	DATED
Dinosaur NM					
Yampa & Green River[b]	NO	NO	NO	NO	NO
Canyonlands NP					
Cataract Canyon[b]	NO	NO	NO	NO	NO
Black Canyon NP	Minimal water-based use				
Arches NP					
Rocky Mountain NP					

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Appendices