APPENDICES

LAS VEGAS WASH

COMPREHENSIVE ADAPTIVE MANAGEMENT PLAN

APPENDIX 8.2

EXHIBIT A

SCOPE OF SERVICES

Alternative Discharge Study

Wastewater generated in the Las Vegas Valley is treated by three separate agencies: the City of Las Vegas, the Clark County Sanitation District, and the City of Henderson, collectively identified as the Las Vegas Valley Dischargers (**Dischargers**). Currently, the Dischargers discharge treated municipal wastewater (effluent) into the Las Vegas Wash (Wash), which flows into inner Las Vegas Bay (Bay), a part of Lake Mead. As the population in the Las Vegas Valley continues to grow at a rapid pace, the quantity of effluent treated and discharged increases as well.

The effluent provides nutrients that increase the productivity of the inner bay, resulting in high concentrations of algae (as measured by chlorophyll a) and greater production of zooplankton and fish. Because of concerns about the concentrations of algae, the Nevada Division of Environmental Protection (NDEP) has imposed increasingly stringent phosphorus limits, and the Dischargers have complied with them by installing chemical treatment and then filtration.

Although the inner bay now complies with the applicable water quality standards for algae, concerns have been raised that algae may increase as wastewater flows increase in the future. Concerns have also been raised about bacteria and various chemicals, which may come from the Dischargers' treatment plants or from other sources such as shallow groundwater and urban runoff, that are carried by Las Vegas Wash into Lake Mead, and that may affect species and habitat in the Wash and Lake Mead.. Ammonia toxicity and the ability of the Dischargers to meet discharge standards that result from a finite Total Maximum Daily Load (TMDL) can also be problematic. Also, there is concern that

the daily discharge is contributing to erosion in the Wash. Finally, there are concerns that wastewater constituents flowing in to the inner bay may affect the drinking water supply withdrawn from Lake Mead at Saddle Island, which is about six miles away from the Las Vegas Wash.

For these reasons the Dischargers are interested in exploring whether the point of discharge for a portion or all of the effluent could be moved from the Wash to another location. In 1997 the Dischargers commissioned the Wastewater Needs Assessment Study (NAS) to review possible alternative discharge points and which identified two points in Lake Mead where alternate discharges might be located. This Alternative Discharge Study (Project) is a continuation and expansion of the findings in the NAS with the intent to provide engineering, scientific, and environmental solutions for effluent disposal, representing a plan that will be acceptable to the Dischargers and the other stakeholders.

The Project will be managed by the Dischargers' Steering Committee, composed of one representative from each Discharger. In addition, the Dischargers will provide a Working Group, composed of three (3) members from each Discharger. The Working Group will serve as the primary technical interface with the Project Team defined below.

The Dischargers have retained the BV+ Team (hereinafter referred to as the "Project Team") which consists of the firms of Black & Veatch; Kennedy Jenks Consultants; Post, Buckley, Schuh & Jernigan, and other local subconsultants. The Project Team also includes an Expert Advisory Panel which will participate in workshops, provide technical review of work products and work plans, provide technical oversight to the Project Team, and scientific validation of the recommendations.

OTHER STAKEHOLDERS

In 1997, a 21-member Water Quality Citizens Advisory Committee (WQCAC) was established by the Southern Nevada Water Authority (SNWA) to discuss, prioritize, and recommend actions to evaluate and protect the water quality of Las Vegas Wash and Lake Mead. One conclusion of the WQCAC was that the water quality issues related to the Wash are complex and not the responsibility of any one public entity. Therefore, an interagency and community-wide effort would be required to address the many issues. In June of 1998, the WQCAC recommended that the SNWA serve as the coordinating entity to identify and bring together all stakeholders to develop a comprehensive management plan for the Las Vegas Wash. Following that recommendation, the SNWA formed the Las Vegas Wash Coordination Committee (LVWCC) with the mission to evaluate all facts, issues, and concerns regarding the Wash in order to develop and implement a practical, comprehensive approach for managing the Wash in a timely manner. The three Dischargers are among the 29 agency, public, and corporate members of the LVWCC.

While this Project will interface with the on-going work of the LVWCC it is anticipated that the principal interface will be with the LVWCC's Alternate Discharge Study Team (referred to hereinafter as the "Study Team"). In addition, there will be opportunities to interface with the WQCAC, the SNWA, the Lake Mead Water Quality Forum, the Sewage and Wastewater Advisory Committee (SWAC), and the others..

The Study Team would meet with the Project Team on a monthly basis in order to serve in a review and advisory role on this Project and assist in developing the recommended plan. Through the work of the Study Team, the LVWCC would be briefed on a regular (perhaps quarterly) basis regarding the Project status.

Because of the complexity of the technical and regulatory processes, and the probability that new issues will arise as the work progresses, the Dischargers intend to conduct the Project in the following phases, which will generally occur sequentially:

I. Develop a plan for the Dischargers to address the issues identified above and other concerns which are raised, and to find the recommended plan for managing the treated effluent from a rapidly growing population;

II. Prepare the scope for any short-term and long-term studies which will need to be accomplished, and the scope for the environmental analyses;

III. Perform the recommended short-term and long-term studies and conduct the required environmental analyses; and

IV. Implement the selected alternative discharge plan.

The scope of work presented below covers the work in Phases I and II.

WORK PLAN

In the work plan below, Technical Memoranda (i.e., focused mini-reports and/or chapters of reports that will form the technical supplement and background for the Final Implementation Plan report to be delivered at the conclusion of Phases I and I1) for specific tasks are identified with the symbol **[TM]**. In each case, a Draft TM will be prepared and submitted to the Dischargers, Study Team, and any Workshop participants for review and comment two (2) weeks prior to a scheduled workshop date. Following the workshop, changes will be incorporated and a Final TM prepared and issued to the same distribution list.

The Phases I and II will be accomplished in the following sequence and the related tasks are described subsequently.

A. Project Initiation to put into place the tools and structure to conduct the work.
B. Compilation and assessment of existing data.
C. Develop Issues, Constraints leading to Workshop #1 where the Alternatives will be initialed ranked and an interim list selected for further evaluation.
D. Interim Alternative Evaluation, leading to Workshop #2 to rank the alternatives and select the three preferred ("short list") alternatives for final consideration.
E. Evaluation of the short list and prepared recommended Implementation Plan for final consideration
F. Concurrent with above steps, provide public outreach support, and
G. Participate in regular meetings and breifings associated with the Project.

A -- PROJECT INITIATION

Task A-1 -- Develop Project Work Tools

Prepare the following tools to be used in accomplishing work on the Project:

- Project Work Plan and Schedule,
- Project Procedures & Management Manual
- Project Specific Web Site (PSWS) – Will be used for posting project documentation for access by the Dischargers and members of the Project Team. Information made available for public use will be developed and placed on the LVWCC website.
- Project Information Management System (PIMS) – Will be used for cataloging, storing, and retrieval of the extensive volume of existing data as well as the data that will be collected and developed for the Project.
- Public Outreach Strategy
- Develop a flow chart presenting the project review and approval process.

Task A-2 -- Prepare Information for Partnering Workshop

This Partnering workshop will include the Dischargers' Steering Committee and Working Group and key members of the Project Team. The Project Team's Partnering Facilitator will work with the Dischargers' Steering Committee to prepare the plan for the partnering workshop including the list of objectives the Workshop participants would be expected to achieve, agenda, and any other materials. Participants in the Workshop will be interviewed beforehand by the facilitator.

Task A-3 – Conduct Partnering Workshop

This facilitated Workshop will have the following expectations :

- Establish Project Mission and Goals – Prepare a project mission statement and a joint list of goals to be achieved during the project. In very general terms, the mission statement could include *"disposal of all current and future wastewater flows either in-Valley or into Lake Mead, in an environmentally and technically sound manner, while assuring maximum return flow credits, and in a cost-effective manner."*
- Participant and role identification (clearly define roles early in the process to avoid miscommunication and unacceptable expectations).
- Vision – This step will include developing a "vision for the future" statement. This could include a vision of what the Las Vegas Wash and Las Vegas Bay would look like through the project planning period which will help better define goals for the Dischargers' resources and provide focus for the project.
- Process for conflict resolution
- Schedule for Partnering Updates

Task A-4 – Conduct "Informed Consent" Training

This will be a one-day training session -- Conducted by Hans & Annemarie Bleiker of the Institute for Participatory Management & Planning -- for the Dischargers' Steering Committee, Work Group, others as designated by the Dischargers, and key members of the Project Team in the techniques of "Systematic Development of Informed Consent" for use during the Project.

B. EXISTING DATA ASSESSMENT

This work consists of preparing a Technical Memorandum **[TM]** summarizing the status of existing reports and documents related to the Project.

Task B-1 – Definition of Existing Knowledge Base [TM]

The existing documents and records relative to the Project currently reside in many forms and in several locations, such as the Dischargers, the LVWCC, etc.. The intent of this task is to assemble the information into a single database for use during the Project. Work in this task will include:

- Collect, briefly review, and catalog the documents by topic areas such as Las Vegas Bay Water Quality, Las Vegas Wash Water Quality, Lake Mead Water Quality, Erosion, Fisheries, Lake Hydrodynamic, Wastewater, wetlands, etc.; and enter the information into the PIMS.
- The existing documents will be optically scanned and installed in PIMS database with document links. They will then be readily accessible by the Dischargers and Project Team. Electronic copies of the scanned and catalogued documents will be provided to the Dischargers and LVWCC on CD-ROM for their reference purposes. If technically feasible, public access to the database can be provided via the LVWCC Website.

The resulting TM will be a presentation of the bibliography and sources of data available for the Project.

C -- ISSUES, CONSTRAINTS, AND ALTERNATIVES

The Study Team has developed a set of alternatives and related issues for the alternative discharge. The work in the tasks below consists of further defining the alternatives issues, and constraints. Particular reference will be made to the previously prepared Needs Assessment Study, the current Las Vegas Valley 208 Water Quality Management Plan, and similar reports. This information prepared herein will be used in Workshop #1 (Task C-4) to refine the Study Team's alternatives and select an interim list from among them for further evaluation.

Task C-1 – Define Project Issues [TM]

This task involves the identification of, and meeting with, up to 30 key "stakeholders" interested in and/or impacted by the Alternate Discharge. The stakeholders will most likely include the LVWCC, but may also include other organizations, agencies and select individuals/groups with a direct interest in the discharge issue. The elements included in this task are:

- Prepare alternative descriptions
- Draft questionnaire
- Draft a stakeholder list, based on the LVWCC
- Conduct, schedule, participate, prepare meeting summary, and follow-up for 30 interviews
- Draft issues analysis and TM

The purpose of these interviews is threefold:

1. Obtain substantive input and feedback regarding issues of specific concern to these stakeholders on issues associated with each of the alternatives

2. Determine level of interest and potential ongoing involvement on the review, assessment, and ultimate input into the decision on the proposed alternatives for alternate discharge.
3. Based upon feedback obtained, review outreach and information plan with the LVWCC Public Outreach study team to ensure effective communication with the stakeholders and other publics.

Specific steps will include the following:

1. Prepare Alternative Descriptions. Develop a description of each of the Study Team alternatives consisting of no more than a 2-page presentation of the components of the alternative, with text, pictures, maps, and/or figures. The draft descriptions would be submitted to the Dischargers and the Study Team for review and comment. Comments would be incorporated into final descriptions and would be assembled into a brochure with a one-page introduction.
2. Develop Interview Data Gathering Forms. These would be issue forms that the two-person interview teams would use to collect information during the interviews
3. Develop Interview List. Prepare a list of the 30 recommended key stakeholders to be invited to participate in the issues survey. Submit the list to the Steering Committee and Study Team for review and approval. The individuals to be interviewed would be contacted, apprised of the process and a schedule for each of their interviews established.
4. Distribute Alternatives Brochures. The alternative descriptions would be distributed to the interview list.
5. Conduct Interviews. The two-person teams will meet with the interviewees and conduct the interviews.
6. Evaluate the Information and Prepare A Work Plan to Address the Issues. The issues information will be evaluated and the issues associated with each alternative grouped into similar categories.

Any recommended modifications to this work plan required to address the issues associated with each alternative will be prepared.

7. Prepare TM. The data gathering process, data collected, data evaluation, and recommended Work Plan for addressing the issues will be prepared in a draft TM and submitted to the Dischargers for review and comment. Copies of the TM will also be distributed to selected members of the Expert Advisory Panel for review and comment.

Task C-2 -- Develop Preliminary List of Probable Project Constraints [TM]

Based on the data assessment develop a preliminary list of probable constraints that will impact alternative development and selection. [These will be modified and expanded upon as the Project moves through the alternative evaluation/reduction process.] The issues information gather above will be evaluated and developed into constraints associated with each alternative which must be resolved for that alternative to be implemented. This work will include:

- Identify initial constraints that will limit the range of options to those that are practical and implementable. They are expected to be divided into the following categories, with some initial judgments of important constraints under each category:
  - Legal
  - Land ownership
  - Regulatory
  - Clean Water Act-based regulations and rules
  - "Stewardship" by NPS, BLM and other federal agencies
  - Environmental
  - Threatened and endangered species
  - Financial

- Political

Task C-3 – Prepare and Distribute TMs to Workshop #1 Participants.

The TMs prepared above – including Issues, and Probable Constraints -- will be assembled, reproduced, and distributed to participants in Workshop #1.

Task C-4 – Conduct Workshop #1

Meet in a one-day workshop with the Dischargers and Study Team to accomplish the following objectives:

- Review the Project Issues TM
- Review the Project Constraints TM.
- Conduct an initial evaluation of the issues and constraints associated with each of the Study Team alternatives. Rate and/or rank the issues and alternatives in priority to determine if any should be combined or removed from further evaluation, with a goal of arriving at an interim list of up to 8 to 10 alternatives for further assessment.
- Agree upon and endorse any changes in the work plan and schedule for the subsequent stages and tasks.

Task C-5 – Prepare Report on Workshop Findings and Recommendations

A report documenting and summarizing the work accomplished in Workshop #1 will be prepared and distributed to Workshop participants, and posted on the LVWCC Website.

D -- INTERIM ALTERNATIVE EVALUATION

The Study Team alternatives that remain under consideration from Workshop #1 will be further developed through preparation of conceptual engineering reports on each alternative as defined in the tasks below. The Project Team proposes to use a process for constructing and utilizing a Geographic Information System (GIS) populated with data from various sources to assist in the determination of alternative feasibility and the presentation of these findings. GIS hardware, software, (primarily UNIX and NT based ESRI ArcINFO, and ArcView) and GIS specialty staff will be used to perform these services.

Task D-1 – Obtain Data and Develop GIS for Alternative Evaluation

Data sources will be selected based on the specific alternative alignments as well as the alternative implementation at the terminus of each alignment. Data sources necessary for alternative evaluation may include:

- Land use
- Land ownership.
- Topography.
- Soils.
- Groundwater regimes.
- Existing infrastructure.
- Other appropriate data.

Identifying the proper data to be obtained for analysis will require close coordination with project engineers and planners to identify the key issues pertaining to each of the interim alternatives. A goal of this phase of work will be to identify potentially pertinent data sources so that there is no duplication of

effort when compiling the GIS database in subsequent tasks. Each route orientation will have to be considered to be flexible so that data compilation efforts allow for routes to be shifted without going into areas of "no data". This may result in the inclusion of some data that may not be used for the feasibility assessment, but past experience dictates that this is a necessary step in allowing for alternatives to vary slightly from their original position.

The result of this task will be a list of data (with sources) that will need to be obtained and used to evaluate the feasibility of each of the interim and short-listed alternatives. This GIS data will also be used for the analyses performed as part of Phases II and III.

Using the list of data to be obtained, digital GIS data sources will be acquired when possible. Some of these source data may need format changes, coordinate conversion and other GIS manipulation to assure co-registration of all data layers within the GIS database. As each set of source data is added to the database, the data source, repository location and contained information will be logged in a database dictionary in MS Word. In the event that data does not exist in a digital format, hardcopy maps will be input through digitization and/or scanning. If feature attributes (topology) is not required and spatial reference is necessary only for superimposing other data on top of this data, scanning and geo-referencing may be the preferred option. If topology is deemed necessary, digitizing of the dataset may be performed. As this process involves manually inputting the data and is a labor-intensive process, it will be considered only as a last resort and will be limited to 80 staff hours for data which is critical to alternative evaluation.

Upon completion of this task, a GIS database will have been constructed whose structure and content will have been documented in a database dictionary.

Task D-2 -- Develop Conceptual Plan for each Interim Alternative [TM]

This task consists of conceptual development of the Interim Alternatives in order to identify fatal flaws and to provide the basis for further evaluation and comparison of the alternatives to arrive at a short-list in Workshop #2. Conceptual development of each interim alternative is expected to consist of:

1. Identifying the engineering issues and considerations associated with each alternative, e.g. the need for pumping stations, tunneling, etc.
2. Identifying pipeline corridors
3. Identifying land ownership / availability
4. Identifying pumping station and other facilities locations/sites.
5. Identifying baseflow discharge to the Wash.
6. Identifying the locations/types of outfall and other point of the Dischargers' facilities.
7. Identifying impacts to the wastewater treatment processes at the Dischargers' facilities, including the current expansion plans.
8. Identifying environmental and permitting issues, constraints, and considerations.
9. Identifying geotechnical issues, considerations, and constraints associated with each alternative.
10. Developing a conceptual level cost estimate for each alternative.
11. Developing a conceptual schedule for implementing each alternative.
12. Identifying public perception issues/concerns

The GIS data prepared in Task D-1 will be used to assist in identifying various issues, considerations, and constraints associated with each alternative, and in evaluating the alternatives. As part of this task, the Project Team will also be identifying data sources for use in this and future tasks.

Following compilation of the GIS database, maps of existing conditions for each of the identified primary alternatives will be created. These maps will be used to evaluate feasibility of the proposed alternatives with respect to the data and issues pertinent to each.

A TM will be prepared for each Interim Alternative. The contents of each TM is expected to include:

- Description of the alternative.
- GIS Map of the alternative.
- Discussion of the engineering issues associated with the alternative, including geotechnical issues.
- Discussion of impacts on Dischargers' wastewater treatment process associated with implementing each alternative.
- Conceptual level cost estimate.
- Conceptual Regulatory/Permitting Assessment.
- Reconnaissance-level Environmental Evaluations to "Ground-Truth" the Environmental Issues.

Task D-3 – Prepare Recommended Evaluation Criteria

Prepare a detailed list and description of recommended evaluation criteria, based on the list developed by the Study Team. Criteria will be grouped by categories, and recommendations for weightings presented for use in Workshop #2.

Task D-4 -- Prepare and Distribute TM Packages for Workshop #2 Participants

The TMs prepared above – Conceptual Plan for each Alternative and Recommended Evaluation Criteria -- will be assembled, reproduced, and distributed to participants in Workshop #2.

Task D-5 -- Conduct Workshop #2.

This is anticipated to be a two-day workshop with the Dischargers and the Study Team. The objectives of the workshop are:

- Brief the participants on the Interim Alternatives Findings.
- Review the Recommended Evaluation Criteria.
- Conduct an evaluation of the Interim Alternatives List to arrive at a short-list of three (3) preferred alternatives, or combinations thereof for final consideration.
- Discuss issues associated with the short-list alternatives, identify specific data and criteria needs for the detailed investigations of the short-list.
- Agree on any resulting modifications to this work plan.

Task D-7 -- Prepare *DRAFT* Report on Workshop Findings and Recommendations

A *DRAFT* report documenting and summarizing the work accomplished in Workshop #2 will be prepared and distributed to all Workshop participants for review and comment, and posted on the LVWCC Website.

INTERIM NOTICE TO PROCEED

Following review and comment on the draft report on workshop #2, the Dishargers will issue an interim notice to proceed for work to begin on the subsequent work in Phases I and II.

E -- SHORT-LIST ALTERNATIVE EVALUATION

The three (3) short-list alternatives that emerge from Workshop #2 will be further developed through the preparation of preliminary engineering reports for each alternative as defined in the tasks below. A recommendation will be made regarding which alternative plan the Dischargers should implement.

Task E-1 – Prepare FINAL Report on Workshop #2 Findings and Recommendations

Incorporate review comments from the Dischargers and Study Team into the *DRAFT* short-list report and distribute the final report to Workshop #2 participants, and posted on the LVWCC Website. This report defines the short-listed alternatives for assessment in this stage of the project.

Task E-2 – Develop Preliminary Plan for Each Short-listed Alternative. [TMs]

A TM will be prepared for each of the three short-listed alternatives, and will include:

- Description of the alternative
- Routing alternatives, using the GIS information
- Engineering considerations
- Resulting modifications to the Dischargers' treatment plant processes
- Capital cost analysis
- Constructability analysis
- Permitting issues
- Environmental issues
- Schedule for implementation including the review and approval process

Task E-3 – Prepare Preliminary Phase II Scope, Based on a Review of the Short-list Alternatives. [TM]

A preliminary Phase II work plan will be prepared that describes the scope of services for short-term and long-term environmental, scientific, and engineering studies needed to meet NEPA requirements. This detailed work plan will identify additional studies that must be completed and describe the steps

and tasks needed to complete the NEPA process. A preliminary schedule and budget will also be prepared.

Task E-4 -- Conduct Stakeholder Interviews to Measure Stakeholder Response to the Short-list Alternatives [TM]

A similar approach will be undertaken in surveying the stakeholders as presented in Task C-1 above. The intention is to meet again with the same stakeholders to further discuss their responses and values directly associated with the short list of alternatives.

Task E-5 – Perform Final Screening, Evaluation, and Recommend Implementation Plan Report. [TM]

The Project Team will perform screening and evaluation of the short-listed alternatives and prepare a recommendation on an implementation plan. The evaluation and recommendation process and the recommended implementation plan will be presented in a draft TM.

Task E-6 – Prepare and Distribute TM Packages to Dischargers, Study Team, and LVWCC.

The draft TMs prepared above – Short-list Alternatives, Stakeholder Surveys, and Final Evaluation and Recommendation -- will be assembled, reproduced, and distributed to the Dischargers, Study Team, LVWCC, and posted on the LVWCC Website..

Task E-7 – Technical Presentation to Dishargers , Study Team, and LVWCC.

Prepare and make technical presentations to the Dischargers, Study Team, and LVWCC on the evaluation of the short-list alternatives, findings, and recommendations on an Implementation Plan. The presentations will be done in a format to solicit feedback from the groups regarding the findings and

recommendations. The feedback will be considered for inclusion in the final Implementation Plan Report.

Task E-8 – Prepare Final Implementation Report.

Incorporate comments received from the Technical Presentations into the final Implementation Plan Report. Reproduce and distribute the Final Implementation Plan as directed by Dischargers, and post the report on the LVWCC Website.

Task E-9 – Prepare Executive Briefing Report.

Prepare an Executive Briefing Report -- summarizing the project background, evaluation and selection process, and recommended implementation plan – suitable for general distribution to a wide audience. The report is anticipated to be an 8-1/2 x 11, color document, approximately 8 - 12 pages in length. Produce 200 copies for Dischargers' use.

F -- PUBLIC OUTREACH PROGRAM

Task F-1 – Public Outreach and Education,

This task includes providing support to the Dischargers, and interfacing with the LVWCC Public Outreach study team, in initiating a public outreach plan for the Alternative Discharge Study. It is anticipated the Public Outreach study team will appoint a subcommittee with the specific focus of supporting the Alternative Discharge work.

Using available research and the stakeholder assessment findings, primary audiences will be identified, key messages developed, and program components outlined. It is anticipated the program will fall into the following categories:

- Community Relations (i.e. speakers presentations)
- Media Relations (i.e. prepare selected press releases and briefings, in coordination with the LVWCC)
- Interface Public Affairs with the efforts of the LVWCC public information staff and study teams.
- Prepare a recommended public information program which the Dischargers may wish to implement as the project moves forward into Phases II and III.

G -- PROJECT MEETINGS, PRESENTATIONS & BRIEFINGS

Task G-1 – Meetings

- ***Monthly Progress Meetings***. Participate in the monthly Dischargers' meetings to review Project progress and exchange ideas and information. Prepare and post an agenda ahead of each meeting, and prepare and post minutes following project meetings. Monthly deliverables will include: meeting agendas and meeting minutes; updated project schedule, and an update on postings on the PSWS, with a record copy of all documents provided to the Dischargers' Steering Committee.
- ***Informal Project Meetings***. As required during the course of the Project, meet with the Dischargers and/or individual Dischargers' members to review TMs and other Project information.
- ***Other Stakeholders***. LVWCC, LMWQF, WQCAC, SWAC, etc.

Task G-2 – Presentations and Briefings

Prepare material and/or conduct regular presentations and briefings on the project status to the Dischargers' Senior Staff, Councils, and/or Boards, as requested by the Dischargers.

As requested by the Dischargers, make presentations to civic and other public groups in the Las Vegas Valley on the project, through the LVWCC Public Outreach program.

APPENDIX 10.1

DRAFT

Las Vegas Wash Soils

By Douglas J. Merkler, Resource Soil Scientist
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Southern Nevada Resource Area

Introduction

Las Vegas Valley covers an area of approximately 350 square miles in the southern portion of Nevada. Las Vegas Valley extends in a northwest-southeast direction and drains toward the south through a local system of tributary washes into Las Vegas Wash and finally into Lake Mead. The Las Vegas Wash floodplain consists of depositional areas of ancient lake-laid silt and clay and more recent deposits. The valley-filling process was influenced by the presence of shallow lakes during the Miocene and during the Pleistocene. Easily eroded silt and clay beds of the Muddy Creek Formation of Miocene age, Las Vegas Formation of Pleistocene age, and younger sedimentary deposits have been transported, mainly by water, and deposited on gently sloping basin floors and the floodplain of the Las Vegas Wash.

Stream flow originates from precipitation in the Valley and surrounding mountains. Stream flow in Las Vegas Wash was measured prior to 1928 and record ephemeral flows of 1 cubic foot per second (cfs) to present peak flows in excess of 6,000 (cfs) with perennial flows of approximately 40 (cfs).

In 1981 the major field work for the Las Vegas Valley Soil Survey was completed. Soil names and descriptions for Las Vegas Valley including Las Vegas Wash, were approved in 1982 and published in 1985. Deposition of alluvium is continuing today. In places, intermittent flows from convection storms and increasing perennial flows from other sources are cutting into the floodplain and forming stream terraces. Major events in the erosion of the floodplain have been documented in the 1997 Las Vegas Valley 208 Water Quality Management Plan, Table 6-1. This process has altered the present water table and internal soil drainage of the soils in the Las Vegas Wash floodplain from those mapped in 1981.

Existing Information

Currently three soil types (series) are mapped in four different mapping units within the Las Vegas Wash as part of the published 1981 field work for the Las Vegas Valley Soil Survey. While the soil moisture status may vary from the published survey, the profiles are fundamentally the same as long as they have not been (1) significantly eroded or removed, (2) deposited or back filled by recent alluvium (mainly sands and pebbles) in existing channels, silts and clays along the upper floodplain. The following soils and map units have been identified:

DRAFT

Soil Map Legend

Map Symbol	Soil Name		
134	Bracken very gravelly fine sandy loam, 4 to 30 percent slopes	206	Glencarb silt loam, flooded
278	Land very fine sandy loam, wet		
282	Land silty clay loam		

Data relating to soil properties are collected during the course of the survey. Soil properties are determined by field examination of the soils and by laboratory index testing of benchmark soils. Samples taken from soil profiles were tested in the laboratory. Tests are used to verify field observations and characterize properties that cannot be estimated accurately by field observation. Some of the most important properties and definitions are summarized below.

Chemical Properties of the Soils

Map symbol and soil name	Depth	Clay	Cation-exchange capacity	Soil reaction	Calcium carbonate	Gypsum	Salinity	Sodium adsorption ratio
	In	Pct	meq/100g	pH	Pct	Pct	mmhos/cm	
134:								
Bracken	0-1	4-10	1.0-7.0	7.4-8.4	1-10	–	0-2	0-5
	1-60	–	–	–	–	50-95	–	–
206:								
Glencarb	0-8	16-20	7.0-15.0	7.9-9.0	40-60	–	4-8	5-12
	8-60	20-35	15.0-25.0	7.9-9.0	40-60	0-5	8-32	13-60
278:								
Land	0-2	12-20	12.0-18.0	8.5-9.0	5-15	5-10	8-16	13-30
	2-10	15-20	12.0-18.0	7.9-9.0	5-15	5-10	16-32	13-60
	10-60	18-35	15.0-25.0	7.9-9.0	5-15	5-10	16-32	13-60
282:								
Land	0-2	27-35	20.0-30.0	8.5-9.0	1-10	5-10	16-32	13-90
	2-60	18-35	15.0-25.0	7.9-9.0	1-15	5-10	16-32	13-90

CLAY as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this report, the estimated clay content of each major soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter. The amount and kind of clay greatly affect the fertility and physical condition of the soil. They determine the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, permeability, and plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

CATION EXCHANGE CAPACITY (CEC) is the total amount of cations held in a soil in such a way

that they can be removed only by exchanging with another cation in the natural soil solution. CEC is a measure of the ability of a soil to retain cations, some of which are plant nutrients. Soils with low CEC hold few cations and may require more frequent applications of fertilizers than soils with high CEC. Soils with high CEC have the potential to retain cations, thus reducing the possibility of pollution of ground water.

SOIL REACTION is a measure of acidity or alkalinity and is expressed as a range in pH values. The range in pH of each major horizon is based on many field tests. For many soils, values have been verified by laboratory analyses. Soil reaction is important in selecting crops and other plants, in evaluating soil amendments for fertility and stabilization, and in determining the risk of corrosion.

CALCIUM CARBONATE is the percentage by weight of calcium carbonate in the fine-earth material, less than 2 millimeters in size.

GYPSUM is the percentage by weight of hydrated calcium sulfates 20 millimeters or smaller in size, in the soil.

SALINITY is a measure of soluble salts in the soil at saturation. It is expressed as the electrical conductivity of the saturation extract, in millimhos per centimeter at 25 degrees C. Estimates are based on field and laboratory measurements at representative sites of nonirrigated soils.

The salinity of irrigated soils is affected by the quality of the irrigation water and by the frequency of water application. Hence, the salinity of soils in individual fields can differ greatly from the value given in the report. Salinity affects the suitability of a soil for crop production, the stability of soil if used as construction material, and the potential of the soil to corrode metal and concrete.

SODIUM ADSORPTION RATIO (SAR) expresses the relative activity of sodium ions in exchange reactions in the soil. SAR is a measure of the amount of sodium relative to calcium and magnesium in the water extract from saturated soil paste.

PHYSICAL PROPERTIES OF SOILS

(Entries under "Erosion factors--T" apply to the entire profile. Entries under "Wind erodibility group" and "Wind erodability index" apply only to the surface layer)

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Map symbol and soil name	Depth	Clay	Moist bulk density	Permea-bility	Available water capacity	Shrink-swell potential	Organic matter	Erosion factors K	Erosion factors Kf	Erosion factors T	Wind erodi-bility group	Wind erodi-bility index
	In	Pct	g/cc	In/hr	In/In		Pct					
134: Bracton	0-7	4-10	1.40-1.55	2.00-6.00	0.06-0.11	Low	0.0-0.5	0.10	0.37	2	5	56
	7-60	–	1.10-1.30	0.00-20.00	–		–	–	–			
206: Glencarb	0-8	10-20	1.35-1.50	0.60-2.00	0.19-0.21	Low	0.5-1.0	0.55	0.55	5	4L	86
	8-60	20-35	1.30-1.50	0.20-0.60	0.18-0.21	Moderate	0.0-0.5	0.49	0.49			
278: Land	0-2	12-20	1.25-1.45	0.60-2.00	0.15-0.17	Low	0.5-1.0	0.28	0.28	5	3	86
	2-10	15-20	1.25-1.45	2.00-6.00	0.09-0.12	Low	0.5-1.0	0.24	0.43			
	10-60	18-35	1.35-1.55	0.20-0.60	0.19-0.21	Moderate	0.0-0.5	0.37	0.37			
282: Land	0-2	27-35	1.25-1.45	0.20-0.60	0.19-0.21	Moderate	1.0-2.0	0.37	0.37	5	4L	86
	2-64	18-35	1.35-1.55	0.20-0.60	0.17-0.19	Moderate	0.0-0.5	0.37	0.37			

CLAY as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this report, the estimated clay content of each major soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter. The amount and kind of clay greatly affect the fertility and physical condition of the soil. They determine the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, permeability, plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earthmoving operations.

MOIST BULK DENSITY is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, the moisture content at 1/3 bar moisture tension. Weight is determined after drying the soil at 105 degrees C. In this report, the estimated moist bulk density of each major soil horizon is expressed in grams per cubic centimeter of soil material that is less than 2 millimeters in diameter. Bulk density data are used to compute shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. A bulk density of more than 1.6 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

PERMEABILITY refers to the ability of a soil to transmit water or air. The estimates indicate the rate of downward movement of water when the soil is saturated. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Permeability is considered in the design of soil drainage systems, septic tank absorption fields, and construction where the rate of water

movement under saturated conditions affects behavior.

AVAILABLE WATER CAPACITY refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil for each major soil layer. The capacity varies, depending on soil properties that affect the retention of water and the depth of the root zone. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

SHRINK-SWELL POTENTIAL is the potential for volume change in a soil with a loss or gain of moisture. Volume change occurs mainly because of the interaction of clay minerals with water and varies with the amount and type of clay minerals in the soil. The size of the load on the soil and the magnitude of the change in soil moisture content influence the amount of swelling of soils in place. Laboratory measurements of swelling of undisturbed clods were made for many soils. For others, swelling was estimated on the basis of the kind and amount of clay minerals in the soil and on measurements of similar soils. If the shrink-swell potential is rated moderate to very high, shrinking and swelling can cause damage to buildings, roads, and other structures. Special design is often needed. Shrink-swell potential classes are based on the change in length of an unconfined clod as moisture content is increased from air-dry to field capacity. The change is based on the soil fraction less than 2 millimeters in diameter. The classes are "Low," a change of less than 3 percent; "Moderate," 3 to 6 percent; and "High," more than 6 percent. "Very high," greater than 9 percent, is sometimes used.

ORGANIC MATTER is the plant and animal residue in the soil at various stages of decomposition. In report PHYSICAL PROPERTIES OF SOILS, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter. The content of organic matter in a soil can be maintained or increased by returning crop residue to the soil. Organic matter affects the available water capacity, infiltration rate, and tilth. It is a source of nitrogen and other nutrients for crops.

EROSION FACTOR K indicates the susceptibility of the whole soil (including rocks and rock fragments) to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter (up to 4 percent) and on soil structure and permeability. Values of K range from 0.05 to 0.69. The higher the value, the more susceptible the soil is to sheet and rill erosion by water.

EROSION FACTOR Kf is like EROSION FACTOR K but it is for the fine-earth fraction of the soil. Rocks and rock fragments are not considered.

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EROSION FACTOR T is an estimate of the maximum average annual rate of soil erosion by wind or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

WIND ERODIBILITY GROUPS are made up of soils that have similar properties affecting their resistance to wind erosion in cultivated areas. The groups indicate the susceptibility of soil to wind erosion. Soils are grouped according to the following distinctions:

1. Coarse sands, sands, fine sands, and very fine sands. These soils are generally not suitable for crops. They are extremely erodible, and vegetation is difficult to establish.

2. Loamy coarse sands, loamy sands, loamy fine sands, loamy very fine sands, and sapric soil material. These soils are very highly erodible. Crops can be grown if intensive measures to control wind erosion are used.

3. Coarse sandy loams, sandy loams, fine sandy loams, and very fine sandy loams. These soils are highly erodible. Crops can be grown if intensive measures to control wind erosion are used.

4L. Calcareous loams, silt loams, clay loams, and silty clay loams. These soils are erodible. Crops can be grown if intensive measures to control wind erosion are used.

4. Clays, silty clays, noncalcareous clay loams, and silty clay loams that are more than 35 percent clay. These soils are moderately erodible. Crops can be grown if measures to control wind erosion are used.

5. Noncalcareous loams and silt loams that are less than 20 percent clay and sandy clay loams, sandy clays, and hemic soil material. These soils are slightly erodible. Crops can be grown if measures to control wind erosion are used.

6. Noncalcareous loams and silt loams that are more than 20 percent clay and noncalcareous clay loams that are less than 35 percent clay. These soils are very slightly erodible. Crops can be grown if ordinary measures to control wind erosion are used.

7. Silts, noncalcareous silty clay loams that are less than 35 percent clay, and fibric soil material. These soils are very slightly erodible. Crops can be grown if ordinary measures to control wind erosion are used.

8. Soils that are not subject to wind erosion because of coarse fragments on the surface or because of surface wetness.

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The WIND ERODIBILITY INDEX is used in the wind erosion equation (WEQ). The index number indicates the amount of soil lost in tons per acre per year. The range of wind erodibility index numbers is 0 to 300.

Water Features

Map symbol and soil name	Hydrologic group	Flooding: Frequency	Flooding: Duration	Flooding: Months	High water table and ponding: Water table depth (Ft)	High water table and ponding: Kind of water table	High water table and ponding: Months	Maximum Ponding: duration	Maximum Ponding: depth (Ft)
134: Bracken	B	None	–	–	>6.0	–	–	–	–
206: Glencarb	C	Occasional	Very brief	JUL-SEP	3.0-5.0	Apparent	Jul-Jun	–	–
278: Land	C	Rare	–	–	1.5-3.0	Apparent	Jan-Dec	–	–
282: Land	C	Rare	–	–	3.0-3.5	Apparent	Jan-Dec	–	–

Hydrologic soil groups are used to estimate runoff from precipitation. Soils not protected by vegetation are assigned to one of four groups. They are grouped according to the infiltration of water when the soils are thoroughly wet and receive precipitation from long-duration storms. The four hydrologic soil groups are:

- Group " A". Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

- Group "B". Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

- Group "C". Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

- Group "D". Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a permanent high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

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If a soil is assigned to two hydrologic groups in this report, the first letter is for drained areas and the second is for undrained areas. Flooding, the temporary inundation of an area, is caused by overflowing streams, by runoff from adjacent slopes, or by tides. Water standing for short periods after rainfall or snowmelt is not considered flooding, nor is water in swamps and marshes. This report gives the frequency and duration of flooding and the time of year when flooding is most likely. Frequency, duration, and probable dates of occurrence are estimated.

Frequency is expressed as "None", "Rare", "Occasional", and "Frequent". "None" means that flooding is not probable; "Rare" that it is unlikely but possible under unusual weather conditions; "Occasional" that it occurs, on the average, once or less in 2 years; and "Frequent" that it occurs, on the average, more than once in 2 years.

Duration is expressed as "Very brief" if less than 2 days, "Brief" if 2 to 7 days, "Long" if 7 to 30 days, and "Very long" if more than 30 days. The information is based on evidence in the soil profile, namely thin strata of gravel, sand, silt, or clay deposited by floodwater; irregular decrease in organic matter content with increasing depth; and absence of distinctive horizons that form in soils that are not subject to flooding. Also considered are local information about the extent and levels of flooding and the relation of each soil on the landscape to historic floods.

High water table (seasonal) is the highest level of a saturated zone in the soil in most years. The depth to a seasonal high water table applies to undrained soils. The estimates are based mainly on the evidence of a saturated zone, namely grayish colors or mottles in the soil. Indicated in this report are the depth to the seasonal high water table; the kind of water table, that is, "Apparent", "Artesian", or "Perched"; and the months of the year that the water table commonly is high. A water table that is seasonally high for less than 1 month is not indicated in this report.

An "Apparent" water table is a thick zone of free water in the soil. It is indicated by the level at which water stands in an uncased borehole after adequate time is allowed for adjustment in the surrounding soil.

An "Artesian" water table exists under a hydrostatic beneath an impermeable layer. When the impermeable layer has been penetrated by a cased borehole, the water rises. The final level of the water in the cased borehole is characterized as an artesian water table.

A "Perched" water table is water standing above an unsaturated zone. In places an upper, or "Perched", water table is separated from a lower one by a dry zone. Only saturated zones within a depth of about 6 feet are indicated.

Ponding is standing water in a closed depression. The water is removed only by deep percolation,

transpiration, evaporation, or a combination of these processes.

This report gives the depth and duration of ponding and the time of year when ponding is most likely. Depth, duration, and probable dates of occurrence are estimated.

Depth is expressed as the depth of ponded water in feet above the soil surface. Duration is expressed as "Very brief" if less than 2 days, "Brief" if 2 to 7 days, "Long" if 7 to 30 days, and "Very long" if more than 30 days. The information is based on the relation of each soil on the landscape to historic ponding and on local information about the extent and levels of ponding.

Existing Issues

The Las Vegas Valley Soil Survey mapped the physical condition of the Las Vegas Wash as it existed in 1981. Las Vegas Wash is a dynamic stream system which is no longer in equilibrium. Properly functioning equilibrium in a stream system is a balance between sediment erosion and sediment deposition. This imbalance in the Las Vegas Wash occurs when high peak flows remove more sediment than is deposited during low flows. The pressure of urbanization has resulted in reduced area of the floodplain and increased channel flow. Dissection of the existing floodplain concentrates channel flows, reduces retention times, minimizes spreading of water on the floodplain, and drains existing ground water into adjacent channels.

The hydrogeology and available water supply of the Valley have been well documented. Exemplary work includes (Domenico et al., 1964), (Kaufmann 1977), and (Malmberg 1965). Based on numerous geotechnical studies performed in the Valley, and specific research by Kaufmann (1977), groundwater is within 50 feet of the surface over one-half of the Valley. Depth to groundwater is less than 15 feet along Las Vegas Wash and in the center of the Valley. Permanent construction dewatering systems have been installed near Las Vegas Wash, and contribute to the recharge of the shallow ground water system. With a modification of the current shallow ground water table, potential impacts to adjacent commercial and residential sites need to be evaluated.

Hydrocollapsible soils occur along the length of the Las Vegas Wash north of Duck Creek. The majority of the porous fine-grained soils were presumably deposited in a playa environment at a time when portions of the Las Vegas Valley were an enclosed basin. When external drainage developed and erosion in the Valley increased, the saturated, generally under-consolidated, fine-grained soils rapidly dried out. Thus in a short time, the water content decreased several-fold with little change in porosity. Upon inundation these porous soils exhibit markedly reduced strength and hydrocollapse. The mechanism of hydrocollapse is described by Clemence (1981). Briefly, addition of water weakens the binding agent (i.e. silt, clay and/or capillary tension), resulting in collapse of the porous honeycomb structure.

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Gypsiferous deposits occur as evaporite beds within the Las Vegas Wash floodplain. The Bracken soil is significantly high in gypsum. Potential distress to structures within the floodplain caused by rising ground water and dissolving of gypsiferous foundational materials could result in collapse of the soil matrix. As water percolates through gypsiferous soils it leaches soluble gypsum from the soil matrix, thereby increasing its void ratio with an accompanying decrease in strength.

Expansive, water-soluble salts are responsible for over five million dollars worth of property damage in the Valley (DiSanza 1973). Mirabilite $Na_2SO_4.10H_2O$ and its anhydrous form Thenardite (Na_2SO_4) are the primary salts associated with chemical heave. These highly soluble salts are transported in solution to low-lying poorly drained areas. The Land soil has a high potential for these salts in the upper six to twelve inches, where they are deposited as evaporites. Chemical heave research has been limited to work by Blaser(1978). Apparently, the solubility of sodium sulfate in water decreases with decreasing temperatures. Thus, as the temperature drops during the night, sodium sulfate crystallizes out of solution. Concurrently, as temperatures drop below 90.3 degrees Fahrenheit, the anhydrous Thenardite imbibes up to 10 molecular weights of water as it hydrates to Mirabilite. The molecular size of Mirabilite is 400 times its anhydrous form. The combination of crystallization and hydration produces pressures within the soil matrix, and the soil expands. DiSanza (1973) reports swelling pressures as much as 2,300 pounds per square foot, with 300 pounds per square foot common. Any structures within the Las Vegas Wash floodplain should have an on-site evaluation for the presence of expansive water-soluble salts.

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APPENDIX 10.2

RESEARCH PROJECTS RELATING TO LAS VEGAS WASH

Las Vegas Wash Coordination Committee - Environmental Resources Study Team

PROJECT	DETAILS	AGENCY	STATUS	DATA COLLECTED
WATER QUALITY				
Water Quality Monitoring	Monitor various water quality constituents biweekly. Locations include 4 stations in Las Vegas Wash: 1) confluence of WWTP, 2) confluence of City of Henderson and LVW, 3) near Three Kidds mine area, 4) Northshore Road.	City of Las Vegas Cooperators 1) City of Henderson 2) Clark County	On-Going	Constituents Monitored: PO4-P, DisOPO4, NO2-N, NO3-N, NO3-NO2, NH3-N, TSS, TDS, Turbidity, Chloride, Sulfate, TKN, Total Coliform, Fecal Coliform, TN, Chlorophyll-a.
Water Quality Monitoring	In February 1998, SNWA started sampling thirty locations in the Las Vegas Bay and Boulder Basin monthly.	Southern Nevada Water Authority Cooperator 1) Southern Nevada Water System	On-Going	Profile water quality data including EC, temperature, DO, pH, and turbidity.
Water Quality Monitoring	Sampling of Las Vegas Wash (field data and lab data). Conducted every two weeks, at four locations in Wash, 1) at confluence of CCSD and CLV discharges, 2) downstream of COH discharge, 3) prior to Lake Las Vegas, 4) downstream of Lake Las Vegas.	City of Henderson Cooperator 1) Clark County Sanitation District Lab	On-Going	DO, pH, Water Temperature, Air Temperature, Conductivity, Turbidity, TPO4-P, orthoPO4-P, NO2-N, NO3-N, NH3-N, TSS, TDS, Turbidity, Chloride, Sulfate, TKN-N, Total and Fecal Coliform, Total Nitrogen, and Chlorophyll a.
Water Quality Sampling	Selected water quality parameters... Event driven... Las Wash at confluence...	U.S. Geological Survey	On-Going	
	ADDITIONAL INFORMATION NEEDED			
Groundwater Sampling	Groundwater sampling upgradient of the Las Vegas Wash on BMI common areas. Pittman Lateral sampling associated with perchlorate immigration to Wash.	Basic Management, Inc. Cooperators 1) Nevada Division of Env. Protection 2) U.S. Bureau of Reclamation	On-Going	Depth to groundwater and priority pollutants, etc. are sampled.
Shallow Groundwater Monitoring	Piezometers and shallow monitoring wells in the Clark County Wetlands Park...	Natural Resources Conservation Service Cooperator 1) Clark County Parks & Recreation	?	
Sunrise Landfill Groundwater Quality Sampling	Sampled twice in 1998 at 1-2 miles from property line.	Clark County Health District Cooperator 1) Republic Silver State Disposal, Inc.	Complete	
Sunrise Landfill Groundwater Quality Monitoring	Proposed groundwater monitoring upgradient and downgradient of the landfill.	Clark County Health District Cooperator 1) Republic Silver State Disposal, Inc.	Proposed	

PROJECT	DETAILS	AGENCY	STATUS	DATA COLLECTED
Source Water Assessment Program	The program assesses activities that may potentially impact the quality of the drinking water source (Lake Mead). The project will start Fall 1999 and be complete May 2003.	Nevada State Health Division (Bureau of Health Protection Services)	Proposed	
Contaminant Source Identification & Effects on Species	Proposed study to identify potential sources of environmental contaminants entering Lake Mead. Information needs include effects of contaminants on listed species and migratory birds, and the effects of contaminants and water quality conditions to the aquatic invertebrate and fish community structure and habitat quality in the Wash/Bay. Note: Elevated organochlorine compounds found in carp from LV Wash/Bay, and existing water quality standards for Wash may be inadequate for protection of endangered species and migratory birds.	U.S. Fish & Wildlife Service Cooperator 1) U.S. Geological Survey	Proposed	
Evaluation of TDS Plume Interception at Pittman Lateral	INFORMATION NEEDED	Basic Management, Inc. Cooperators 1) Nevada Division of Env. Protection 2) U.S. Bureau of Reclamation	Complete	
Applied Research on Wash Microbiology	Sampling was conducted monthly December 1997 through January 1999 at five locations in the Wash.	University of Nevada, Las Vegas (Department of Civil/Env. Engineering) Cooperators 1) UNR Cooperative Extension 2) UNLV Dept. of Biological Sciences	Complete	
Effects of Wash Nutrients on Las Vegas Bay	Sampling conducted weekly, biweekly, or monthly (depending on location) since 1991, at five locations in the Wash, and ten locations in the Las Vegas Bay.	University of Nevada, Las Vegas Cooperators 1) City of Las Vegas 2) Clark County Sanitation District 3) City of Henderson	On-Going	
CONTAMINANTS				
Contaminant Tissue Analysis & Gill Net Surveys	Contaminants tissue analysis in conjunction with gill net surveys. Conducted in Fall 1998 and Spring 1999 only. Tissue analysis is being done by UNLV-HRC. Sites are lake-wide and include outer Las Vegas Wash.	Nevada Division of Wildlife Cooperator 1) UNLV Harry Reid Center	On-Going	
Endocrine Disruption in Fish	In 1998 SNWA funded a study to collect and screen water samples from the lower Las Vegas Wash and Las Vegas Bay, and Lake Mead for xenobiotic compounds, and use caged fish as a biological indicator of endocrine disruption.	Southern Nevada Water Authority Cooperator 1) Michigan State University	On-Going	
VEGETATION				

PROJECT	DETAILS	AGENCY	STATUS	DATA COLLECTED
Aquatic Plant Sampling	In Spring 1999, the USGS will be selecting aquatic plant samples in the Las Vegas Wash.	U.S. Geological Survey Cooperator 1) Department of Defense	On-Going	
Wildlife Habitat Incentive Program	In the D-14 Dike area... ADDITIONAL INFORMATION NEEDED	Natural Resources Conservation Service Cooperator 1) Clark County Parks & Recreation	?	
Wetlands Reserve Program	From the AWT (?) to the Pabco Road Grade Control Structure... ADDITIONAL INFORMATION NEEDED	Natural Resources Conservation Service Cooperators 1) Clark County Parks & Recreation 2) Ducks Unlimited	?	
SOILS				
Sediment Mapping & Core Collection	In Spring and Summer 1999... In Las Vegas Bay... ADDITIONAL INFORMATION NEEDED	U.S. Geological Survey Cooperators 1) USGS MGP 2) Southern Nevada Water Authority 3) University of Nevada, Las Vegas	?	
Technical Soil Services	INFORMATION NEEDED	Natural Resources Conservation Service Cooperators 1) Clark County Parks & Recreation 2) U.S. Bureau of Reclamation	?	
WILDLIFE				
Yuma Clapper Rail	Starting in February 2000, the USBR and SNWA will survey for Yuma clapper rails in the Las Vegas Wash. To be complete July 2000.	U.S. Bureau of Reclamation Cooperator 1) Southern Nevada Water Authority	Proposed	
Southwestern Willow Flycatcher	Starting in February 2000, the USBR and SNWA will survey for southwestern willow flycatchers in the Las Vegas Wash. To be complete July 2000.	U.S. Bureau of Reclamation Cooperator 1) Southern Nevada Water Authority	Proposed	
Southwestern Willow Flycatcher	In May 1999, SNWA funded SWCA to conduct southwestern willow flycatcher surveys in potential habitat along the Las Vegas Wash.	Southern Nevada Water Authority Cooperator 1) Steve W. Carothers & Associates	Complete	

PROJECT	DETAILS	AGENCY	STATUS	DATA COLLECTED
Southwestern Willow Flycatcher	In Spring 1998, Clark County Parks & Recreation funded Southwest Wetlands Consortium and SWCA to conduct southwestern willow flycatcher surveys along the Las Vegas Wash.	Clark County Parks & Recreation Cooperators 1) Southwest Wetlands Consortium 2) Steve W. Carothers & Assocaites	Complete	
Nevada Breeding Birds Distribution	In 1998 SNWA contributed funds to the Great Basin Bird Observatory via the National Fish & Wildlife Foundation to support field work for the development of the Nevada Breeding Bird Atlas. This project will locate and map the locations of breeding birds across the state (including Las Vegas Wash).	Southern Nevada Water Authority Cooperators 1) Great Basin Bird Observatory 2) National Fish & Wildlife Foundation	On-Going	
Desert Pocket Mouse Distribution & Genetics	In 1999, the District and Clark County jointly funded UNLV to conduct a two-year study of distribution surveys along the Muddy, Virgin, and Colorado Rivers (including Las Vegas Wash), population studies on the North Well Field, and a population level genetic analysis.	Southern Nevada Water Authority Cooperators 1) Clark County DCP I&M Committee 2) University of Nevada, Las Vegas	On-Going	
FISH				
Razorback Sucker Population, Recruitment, & Habitat Localities	In 1996, SNWA continued and expanded the work done by NDOW (during 1990-1996) by contracting Bio/West, Inc. to conduct a telemetry study on Lake Mead population(s) of razorback sucker. The purpose is to determine population status, identify important habitat localities, and investigate possibility of recruitment in Lake Mead population(s) of razorback sucker. Note: In 1998 SNWA/USBR entered into Agreement allowing USBR to augment project (to meet RPA of LCR BO) by contributing funds to SNWA over 3 years.	Southern Nevada Water Authority Cooperators 1) Bio/West, Inc. 2) U.S. Bureau of Reclamation 3) Nevada Division of Wildlife 4) National Park Service 5) Colorado River Commission	On-Going	
Razorback Sucker Presence	In 1990, NDOW started surveys at sites including Blackbird Point (mouth of Las Vegas Wash). Surveys are conducted February through April annually. Trammel nets were used to assess presence of razorback suckers.	Nevada Division of Wildlife	Complete	
Threadfin Shad Production	Trawl surveys to assess production of threadfin shad in Lake Mead, including transects in the Inner Las Vegas Bay. Surveys are conducted weekly / bi-weekly May through August annually.	Nevada Division of Wildlife	On-Going	
Sport Fish Population Sampling	In 1990, NDOW started gill and trammel net surveys which include sites in the Inner Las Vegas Bay and Lower Las Vegas Wash. Sampling is conducted twice annually (Spring and Fall).	Nevada Division of Wildlife	On-Going	
GENERAL				

PROJECT	DETAILS	AGENCY	STATUS	DATA COLLECTED
Regional Environmental Monitoring & Assessment Program	Clark County has contacted the UNR BRRC, asking for assistance in developing a monitoring plan for the Las Vegas area. BRRC is interested in using REMAP to do this. REMAP could be used to help collect baseline information, develop and establish biocriteria, reference conditions, and reference sites. Sampling would occur annually, unless specifically requested and/or funded otherwise.	U.S. Environmental Protection Agency Cooperators 1) UNR BRRC 2) EPA Region 9	Proposed	Data collected would include invertebrate, physical habitat, periphyton and algae, water and soil/sediment chemistry, and fish sampling
Halt Erosion & Improve Riparian/Wetlands Habitat	From below Lake Las Vegas to Lake Mead... Protect Northshore Bridge from further erosion... (1999-2004) ADDITIONAL INFORMATION NEEDED	National Park Service Cooperators 1) U.S. Bureau of Reclamation 2) Lake Las Vegas 3) Federal Highway Administration 4) U.S. Geological Survey 5) Clark Co. Regional Flood Ctrl. Dist.	Proposed	
Geotechnical Surveys, Archaeological Surveys, Aerial Photos	Conducted for each construction project in Las Vegas Wash, including 1) Pabco Road GCS, 2) Las Vegas Wash GCS, 3) development of the D-14 Dike, and 4) Ducks Unlimited Habitat Enhancement Project.	Clark County Parks & Recreation Cooperators 1) Southern Nevada Water Authority 2) U.S. Bureau of Reclamation 3) Natural Resources Conservation Svc. 4) Nevada Division of Env. Protection 5) Ducks Unlimited 6) Urban Resources Partnership	On-Going	
Emergency Watershed Program	Location at Pabco Road GCS... ADDITIONAL INFORMATION NEEDED	Natural Resources Conservation Service Cooperators 1) Clark County Parks & Recreation 2) Southern Nevada Water Authority	?	

APPENDIX 11.1

Current Land Use Plans and Reports Relating to the Las Vegas Wash

Clark County Regional Flood Control District Master Plan

The Clark County Regional Flood Control District (CCRFCD) was formed in 1985 by legislative action, to address increasingly damaging flood flows to Clark County caused by storm events. The CCRFCD Master Plan is updated periodically to accommodate many land use changes that take place. It includes an explanation of each watershed in Clark County, as well as descriptions of land use, facilities, soil, and topographic data. The Master Plan also includes the proposed construction plan for flood control facilites. The implementation element of the Master Plan includes a ten-year plan, a five-year plan, and a current construction plan. Projects are prioritized for construction according to ten ranking criteria ranging from public safety to environmental factors.

Clark County Wetlands Park Master Plan

In 1985, County Commissioners adopted the Clark County Wetlands Park Master Plan. Although adopted, the Master Plan was not implemented at that time due to lack of funding. In 1990, a state bond issue was approved which allowed for the provision of $13.3 million toward implementation of the Master Plan. However, due to the dynamic and ever-changing nature of the Wash, the Master Plan as originally written was not be implemented. A new Master Plan was generated. In 1995, County Commissioners adopted the new plan, and Clark County Parks & Recreation has begun implementation of various components identified in the Master Plan.

Clark County 208 Water Quality Management Plan

The Clark County 208 Water Quality Management Plan was recently amended by County Commissioners in 1997. The document outlines water quality strategies for compliance under the Clean Water Act for a period of twenty years. Elements considered in the plan include population, water resources, air quality relating to assessment of wastewater conditions, non-point source conditions, reuse and reclamation opportunities, etc.

Las Vegas Watershed & Wastewater Needs Assessment Study

In 1997, Valley wastewater discharging agencies conducted the Las Vegas Watershed & Wastewater Needs Assessment Study, to determine future wastewater related needs. The study evaluated existing conditions, projected future conditions, and provided development of alternatives to meet future conditions.

Las Vegas Valley Stormwater Quality Management Committee

The Las Vegas Valley Stormwater Quality Management Committee provides a report each year detailing the findings of monitoring and sampling efforts required under the Las Vegas Valley NPDES Municipal Stormwater Discharge Permit. The 1997-1998 Annual Report outlines program requirements and recommended changes for the following permit year.

APPENDIX 13.1

Las Vegas Wash Coordination Committee

Stakeholder Interview Results

Prepared By:
Alpha Communications
Katz & Associates
February, 1999

Executive Summary

The Process

During the months of December 1998 and January 1999, a comprehensive stakeholder interview process was undertaken to determine perceptions and opinions and identify themes, trends and issues surrounding the Las Vegas Wash. Information was gathered from a total of 80 interviews conducted with representatives of the Las Vegas Wash Coordination Committee and elected and appointed, local and state public officials. During these informal interviews, stakeholders were asked their opinions on the most important issues facing the Las Vegas Wash, benefits of the program, obstacles facing the program, projects that should be accomplished in the Wash and how the success of the program will be measured.

Our Findings

The information gathered from this process will allow the Las Vegas Wash Coordination Committee to understand current knowledge of the Las Vegas Wash and related issues, gather suggestions on the development of a comprehensive management program - which includes a public outreach plan - and develop a common definition of the problem. This research also helps to outline the similarities and differences that exist between the two groups interviewed.

The results of this interview process confirm that stakeholders recognize the need for a comprehensive management program for the Las Vegas Wash. Both groups agreed that four major issues facing the Las Vegas Wash: erosion control, funding, public outreach and water quality are the top priorities. Stakeholders shared the opinion that water quality is a critical concern, but funding remains the biggest potential obstacle Coordination Committee members could face in implementing the program. Both groups agree that public outreach and involvement are key to the success of the efforts of the Las Vegas Wash Coordination Committee.

While stakeholders agreed on the importance of the project and the major issues facing implementation of the program, they did differ on some points. For instance, erosion control ranked much higher with Coordination Committee members than public officials and, while water quality ranked as the highest benefit for the public officials, Committee members felt that the greatest benefit the project will provide is recreational opportunities.

The Results

The results of the research have helped to identify the biggest challenges facing the Las Vegas Wash Coordination Committee including the identification of a common goal and problem statement, the inclusion of the key issues in the comprehensive management program, the identification and involvement of the key publics and the demonstration of progress. The issues raised throughout this report will not only help the Las Vegas Wash Coordination Committee create a comprehensive management program for the Wash, but also develop an effective public outreach and education effort.

APPENDIX 13.2

Public Outreach Program

Las Vegas Wash Coordination Committee

Situation Analysis ~

The Las Vegas Wash, located in the southeastern part of the Las Vegas Valley, channels water into Lake Mead from three wastewater treatment plants, irrigation runoff, storm water channeled through the stormwater system and tributary washes, and the adjacent shallow ground water system. In previous decades, the moderate water flows created a wetlands area in the upper reaches of the wash encompassing approximately 2,000 acres. Some believe these wetlands enhanced water quality.

However, Southern Nevada's rapid growth has caused wastewater flows to increase dramatically in the past decade. Although effluent is treated to Clean Water Act standards, the increased wastewater flows saturate the channel, making the wash more susceptible to significant soil erosion during storm events. This also results in increased Total Suspended Solids (TSS) entering Las Vegas Bay.

Further complicating matters is the presence of perchlorate, a salt used as an oxidizing agent in solid rocket fuel, in the Las Vegas Wash. According to reports submitted to the Nevada Division of Environmental Protection (NDEP) by the two companies that manufactured perchlorate in Southern Nevada, this man-made salt appears to be flowing into the wash from an adjacent industrial site via ground water systems. While perchlorate is not regulated by the EPA, the California Department of Health Services has established an action level for the salt at 18 parts per billion (ppb) due to concerns about its potential to affect the thyroid at high levels. A recent report by the Environmental Protection Agency (EPA) indicated that the 18 ppb figure may be too conservative. As of January 1999, perchlorate levels in water drawn from Lake Mead have been below the detection limit of 4 ppb. However, environmental groups and officials from state and federal agencies consider remediation of this chemical a top priority.

Other pollutants, such as household cleaners and pesticides, also enter the wash via home drains, storm water and runoff flows. Concerns relating to these contaminants stem more from secondary health issues such as consumption of contaminated fish than from direct exposure. Nevertheless, they remain important issues that are likely to be addressed by the Las Vegas Wash Comprehensive Adaptive Management Plan.

In 1997, the Southern Nevada Water Authority (SNWA) formed the Water Quality Citizens Advisory Committee. This panel, which was established to provide a public forum through which residents could voice concerns and suggestions relating to water quality issues, developed nine specific recommendations that were accepted by the SNWA Board of Directors in July 1998. One of those recommendations, which is included verbatim below, specifically addresses the development of a Las Vegas Wash Comprehensive Adaptive Management Plan.

Recommendation:

1. The Southern Nevada Water Authority should take the lead in developing a comprehensive plan for managing the Las Vegas Wash. The plan should address the recommendations of the WQCAC and any related recommendations from the Lake Mead Water Quality Forum.

2. The comprehensive plan should be a consensus-based document prepared jointly with stakeholder groups and agencies, including providing opportunities for substantial public involvement as well as input from the WQCAC. Drafts of the plan should be provided to the Lake Mead Water Quality Forum and WQCAC for input.

3. The plan should address such aspects as implementation, existing institutional mechanisms to perform work, or the need for additional authorities. Where appropriate, the Southern Nevada Water Authority should solicit input (for example, using a request for proposal) to aid in development of the plan. The plan should also address funding considerations. Any responses to requests for proposals should be provided to the Lake Mead Water Quality Forum and WQCAC for input.

4. The Southern Nevada Water Authority should begin assessing the need to approach the 1999 Nevada Legislature for additional authorities or funding to support development and implementation of a comprehensive management plan for the Las Vegas Wash. Where possible, the support and input of the Southern Nevada Strategic Planning Authority should be solicited.

In accepting these recommendations, the SNWA board accepted responsibility for coordinating the development of a management plan for the Las Vegas Wash, a massive effort for which the organizational structure is currently being developed. In so doing, it also accepted the inherent responsibility for coordinating the planning and execution of public outreach activities designed to keep residents apprised of progress and issues and provide a forum for public comment. This document represents the underpinnings of that process. It will be executed with the input and under the direction of the Las Vegas Wash Coordination Committee's public outreach study team.

Issues & Opportunities ~

Although flows from the Las Vegas Wash account for less than 2 percent of the water in Lake Mead, the high-profile nature of environmental and health issues relating to the Wash and occasionally incomplete media accounts of those issues have created the perception of a much stronger link between Las Vegas Wash water quality and the safety of drinking water.

While this misperception presents certain challenges, it also creates an opportunity to dramatically improve public perception about drinking water through the dissemination of information relating to activities directed toward improving water quality in the Wash. That is to say, while it is extremely difficult to significantly improve water quality in the entirety of Lake Mead because of the sheer volume involved (also, Lake Mead is by national standards a clean water source), the natural tendency of the public is to extrapolate conditions in the Las Vegas Wash to Lake Mead. Therefore, although improving water quality in the wash will have only a modest effect on Lake Mead as a whole, it may have an enormous impact on the public perception of Lake Mead's water quality.

It should be noted that, from a perception standpoint, the development of this Las Vegas Wash Comprehensive Adaptive Management Plan is at once a great opportunity and a great threat. In general, the public has relatively little understanding or appreciation for the amount of planning and coordination necessary to undertake a project of this magnitude. While public information efforts aimed at explaining the plan's development process may be marginally effective, nothing will satisfy the public's desire for progress except tangible, measurable results. The importance of implementing visible improvement projects within the most expedient feasible timeline cannot be overstated.

Communications Objectives ~

When dealing with subject matter as complex as addressing environmental issues in a water body affected by multiple sources, it is essential to focus on the major elements rather than risk confusing the audience with the intricacies of individual components. It is also important that people understand that their input is extremely valuable in the development of solutions.

With those two strategic goals in mind, the communications objectives are as follows:

~ Impart a greater understanding of the issues surrounding the Las Vegas Wash and tributaries, placing the environmental significance of the Wash in context to its potential to affect water quality.

~ Apprise the public of progress relating to execution of the management plan

~ Emphasize the value and availability of public participation forums and the SNWA's receptiveness to public input

In other words, we must tell people what needs to be done, keep them informed every step of the way, and give them the opportunity to participate and voice their opinions.

Core Messages ~

Too often, public information efforts become so focused on the process of communicating that they neglect to sufficiently define the message. In addition to being clear and specific, the core messages should also reflect the communication objectives. The core messages for these outreach efforts are:

~ The members of the Las Vegas Wash Coordination Committee are actively addressing environmental issues through the development of a comprehensive management plan.

~ Las Vegas Wash Coordination Committee members encourage the public to provide input about efforts being undertaken on behalf of the Las Vegas Wash.

It is important to recognize that the above messages are intended for the majority, rather than for individuals whose views and objectives may diverge radically from those of the general public. There are a certain number of people who will not be satisfied until the Las Vegas Wash contains only hydrogen and oxygen; this plan is not intended to address their goals as they are both unrealistic and, in many cases, undesirable. This public information program, through the core messages indicated above, is designed to impart to Southern Nevadans an understanding that the agencies involved with the Las Vegas Wash view its protection as important, share their concerns, and are actively working to improve environmental conditions in that area.

Target Audiences ~

The Las Vegas Wash management plan is a rare occurrence in which the public outreach component specifically precludes addressing special interest or sub-groups. It is essential that the program be sufficiently sweeping and general in nature as to avoid creating either the perception or reality of favoring any one group or individual in terms of input or receipt of information. That being said, the depth of information may vary among groups. For instance, a media representative may require information considerably more technical or detailed than would be feasible to convey to the public at large. It should be noted that special consideration is being given to regional stakeholders because of additional measures required to communicate with this group.

Strategies ~

There are two issues driving the communications strategies for this outreach program. First,

the public wants results, and it wants them soon. Second, in general, people want the right to participate, even if they choose not to exercise that right. To support the overall communications objectives, the outreach strategies must:

~ Underscore the activities being undertaken toward the protection of the Las Vegas Wash

~ Provide the public ample opportunities to offer comments and actively participate in the development process

Tactics ~

Because management of the Wash is an ongoing program, a limited number of highly effective tactics will both communicate the core messages and establish a consistent vehicle for those messages. In a long-term program such as this, conducting regular, visible information activities may be more conducive to public acceptance than generating an initial "big splash." Put another way, the pacing and method utilized to communicate the messages are nearly as important as the messages themselves. For that reason, a number of specific tactics have been included below. These tactics have been described in some detail to accurately convey their design; however, the public outreach study team is open to discussing individual components and addressing any expressed concerns with the tactics as outlined.

Project Milestone News Releases - The public, and even to some extent the media, will be patient with the management plan's development as long as they sense progress is being made. While physical construction is the most visible form of progress, there are myriad other milestones both within the overall umbrella and within the sub-projects that can and should be publicized. These releases will also be distributed to published industry newsletters.

Participants: LVWCC Public Outreach Team
Frequency: Based on viable opportunities
Potential near-term topics: lvwash.org Web Site launch

Public meetings/info. fairs begin

Grade control structure construction begins

Las Vegas Wash & Wetlands Clean-Up - This event was very successful in its initial year, drawing hundreds of participants and thousands of passers-by. In addition to creating a positive visual presence, the event raises public awareness of the Las Vegas Wash and what is being done to improve it from a pollution standpoint. In conjunction with the grass-roots Friends of the Desert Wetlands organization, efforts should be made to build upon the success of the 1998 event.

Participants: LVWCC Public Outreach Team
Frequency: Annual
Activities: Promotion
- ~ Media calendar notices
- ~ Media advisory
- ~ Media pitches

Advertising/Public Notice
- ~ Notice in internal/external publications
- ~ Notice in public facilities

Execution
- ~ Media tours
- ~ Collateral materials
- ~ Exhibit booths
- ~ Commemorative items

Post-event publicity
- ~ News release
- ~ Segment for video news program
- ~ Article for internal/ external publications

Water Information Fairs - Public information fairs focusing on all aspects of water are currently being developed. Materials depicting the issues surrounding the wash would help convey a baseline understanding of the management plan's objectives to the public.

Participants: LVWCC Public Outreach Team
Frequency: Variable (based on existing outreach opportunities)
Activities:
Promotion
- ~ Media calendar notices
- ~ Media advisory
- ~ Media pitches
- ~ Notice in internal/external publications
- ~ Notice in public facilities

Execution
- ~ Set/strike
- ~ Video presentations
- ~ Informational materials
- ~ Staff interaction

Post-event publicity
- ~ Segment for video news program
- ~ Article for internal/external publications

Speakers Bureau - In conjunction with the existing speakers bureau program, a special presentation will be developed which will provide audiences an overview of the issues related to the Las Vegas Wash and the scope of the management plan. This affords the project management team an opportunity to hold an open discourse with members of the community so as to determine their concerns and provide timely information.

Participants: LVWCC Public Outreach Team
Frequency: To be determined by interest
Activities:
Promotion
- ~ Solicitation letters (SNWA)
- ~ Notice in internal/external newsletters

Execution
- ~ Set/strike (SNWA only)
- ~ A/V support (SNWA only)
- ~ Presentation development (SNWA only)
- ~ Speaker
- ~ Collateral materials

Post-event publicity
- ~ Article in internal/external publications

Target Audiences:
- ~ Environmental groups
- ~ Civic organizations
- ~ Business organizations
- ~ Large businesses/employee meetings
- ~ Senior citizen organizations

Public Scoping Meetings - It is essential that the public have a voice in matters relating to the Las Vegas Wash. However, incorporating public sessions into work group meetings could unnecessarily slow the development process, which would undermine the project's expediency. For that reason, it is advisable to conduct independent scoping meetings under the direction of the work group coordinator.

Participants: LVWCC Public Outreach Team
Frequency: Variable (TBD by Coordination Committee subgroups)
Activities:
Promotion
- ~ Internal/external publications
- ~ Notice in public facilities
- ~ Paid media announcements
- ~ Media calendar notices
- ~ Printed notices in public buildings
- ~ Media advisory
- ~ Media pitches

Execution
- ~ Set/strike
- ~ Scheduling facilitator
- ~ Collateral materials
- ~ Visual presentations
- ~ Staff support

Post-meeting publicity
- ~ News release

~ Article in internal/external publications
~ Segment in video news program

Las Vegas Wash "Familiarization Trips" - This tactic represents the "depth of information" referenced in the Target Audience section of this document. Key constituents should be led on tours of the Las Vegas Wash early in the process. Their personal observations will help underscore the project's urgency and establish a vivid "before" picture, thereby increasing their perspective on progress. Visiting the wastewater treatment facilities will also increase their understanding of mitigating factors in the wash. These tours should be renewed upon completion of major "milestone" accomplishments.

Participants: Las Vegas Wash Project Team
Frequency: Variable (contingent on mile stones)
Activities:
Promotion
~ Letters of invitation
~ Follow-up calls
Execution
~ Scheduling
~ Transportation arrangements
~ Collateral materials
~ Staff guides
Post-event activities
~ "Thank you" letters to participants
Audiences
~ Media - Environmental reporters (all local outlets)
~ Media - Editorial staff (editors, assignment editors)
~ SNWA Board of Directors
~ Local elected officials
~ SNWA member agencies (administration)
~ SNWA member agencies (PI staff)

Media briefings - Whereas the working media will be inundated with information about the Las Vegas Wash Comprehensive Adaptive Management Plan and associated activities, editorial board representatives are frequently placed in the position of taking a position on an issue without full knowledge of all relevant factors. These briefings would serve to impart an understanding of the issues at stake and a general knowledge of how implementation of the management plan will affect those issues. It will become increasingly important that the member agencies coordinate so as to present a united position on the Wash. The existing public information communication channels should suffice to keep the various entities apprised of media inquiries relating to this topic.

Participants: LVWCC Public Outreach Team
Frequency: Annual
Activities:
Promotion
~ Letters of invitation
~ Follow-up calls
Execution
~ Scheduling
~ Audio-visual presentation
~ Collateral materials
Post-event activities
~ "Thank you" letters to attendees
Audiences
~ Media - Editorial boards (all local outlets)

Stakeholder awareness briefings - Employees are ambassadors, whether on the front lines of customer service or in the engineering bunkers. Friends, neighbors, and even strangers on the street often expect them to be apprised of situations that may in fact have nothing to do with their scope of work. If the LVWCC is to establish a united position on the Las Vegas Wash, it is imperative that employees of participant entities have at least a general understanding of the wash and issues surrounding it. Many of these entities already have a variety of vehicles for disseminating that information; steps will be taken to assist entities with their employees on an as-needed basis.

Participants: LVWCC Public Outreach Team
Frequency: Annual
Activities: Promotion
- ~ Notice in internal newsletters
- ~ Notice in break areas
- ~ Announcement by department managers

Execution
- ~ Scheduling
- ~ Audio-visual presentation
- ~ Collateral materials
- ~ Feedback mechanism

Post-event activities
- ~ Article in internal publications
- ~ Responses to individual questions/concerns

Water Quality Reports - Water purveyors responsible for distributing a Consumer Confidence Report will include information about efforts being undertaken by the Las Vegas Wash Coordination Committee. This text will be included in either the Source Water section or in another area as deemed appropriate by the purveyor.

Participation: All water purveyors
Frequency: Annual
Activities: Promotion
- ~ Article in external newsletters

Execution
- ~ Copy writing
- ~ Graphic design/layout

Lobby Displays - Text/graphic panels can be produced for use at member agencies' public facilities, libraries, etc. They will be updated periodically to reflect the LVWCC's current activities.

Participants: LVWCC Public Outreach Team
Frequency: Ongoing
Activities: Execution
- ~ Copy writing
- ~ Graphic design/layout
- ~ Production
- ~ Distribution

The "Current" Newsletter - Stakeholder interviews have indicated that those people with an interest in the Las Vegas Wash and the comprehensive management plan's development would like to be apprised of the LVWCC's progress.

Therefore, it is recommended that the project coordination team, in conjunction with the public outreach study team, write and distribute a quarterly newsletter to provide community leaders, elected officials, and other interested members of the public current information about LVWCC activities.

Participants: LVWCC Public Outreach Team
Frequency: Quarterly
Activities: Execution
- ~ Copy writing
- ~ Production of graphics
- ~ Printing
- ~ Database development
- ~ Distribution

LVWCC Web site - Increasingly popular Internet technology will allow interested citizens access to the most current information available and provide a forum for feedback and/or discussion of key issues.

Participation: Las Vegas Wash Project Team
Frequency: Ongoing
Activities: Promotion
- ~ Media advisory
- ~ Notices in internal/external publications.
- ~ Hyperlinks in related websites

Execution
- ~ Copy writing
- ~ Graphic design/layout
- ~ Information systems support

Interested Regional Stakeholder Outreach - Because water from the Colorado River is a shared resource, there is considerable interest in

the Las Vegas Wash outside Southern Nevada. Potential additional stakeholder groups include downstream American Indian tribes and officials from Arizona and California. Their lack of proximity to Southern Nevada mandates that additional outreach efforts be used to communicate current information.

Participation: Las Vegas Wash Project Team
Frequency: Ongoing
Activities: Promotion
- ~ Outreach letter
- ~ Notice of meetings

Execution
- ~ Information packet
- ~ Distribution of news releases, bulletins
- ~ Feedback mechanism

Children's Educational Program – An important aspect of public outreach is education. The Children's Educational Program is designed to teach children about the significance of the Las Vegas Wash as a natural resource; water quality and the monitoring process.

Participation: Las Vegas Wash Project Team
Frequency: To be determined by interest

Execution
- ~ Presentation development
- ~ Collateral material
- ~ Staff support

Target audiences
- ~ Schools
- ~ Libraries
- ~ Community centers
- ~ Youth groups

Post Event Publicity
- ~ Article internal/external publications

APPENDIX 13.3

Stakeholder Outreach Activities

AGENCY	PUBLIC OUTREACH EVENTS	CONTACT	ADDRESS	PHONE
Clark County Comprehensive Planning	• Box City - This program goes into schools and teaches students how to design and plan cities. • Earth Fair/County Fair • Open houses for public input. • Clark County has a comprehensive folder which allows them to continually update materials.	Carolyn Boyle	500 Grand Central Pky Las Vegas, Nevada 89155	(702) 455-5190 (fax) 455-5190
Clark County Conservation District	• Pollution Prevention Project • Paint a Drain Campaign • Stormwater Plaque Attack Campaign • Las Vegas EMPACT project • Various videos and handouts on Backyard Conservation, Groundwater and Wells in the Las Vegas Valley, Boulder City Wetlands, Muddy River Habitat Restoration Project.	Heather Gallo	2357 A. Renaissance Dr. Las Vegas, Nevada 89119	(702) 262-9047 x1937 (fax) 736-7415
Clark County Heritage Museum	• Wetlands Park temporary Visitor's Center located at 6800 E. Russell Road, is open 10:00 a.m. to 4:00 p.m., and is staffed by volunteers and free to the public. They have photo, text, and video exhibits.	Chris Leavitt	1830 S. Boulder Hwy Henderson, Nevada 89015	(702) 455-7955
Clark County Parks & Recreation	• C@P&R has made ten three-minute videos which highlight various aspects of the Las Vegas Wash and the Wetlands Park. They are currently developing a thirty-minute video.	Patrick Gaffey	3130 S. McLeod Las Vegas, Nevada 89121	(702) 455-7340 (fax) 455-7344
Clark County Regional Flood Control District	• Safety Advertisements are visible on bus shelters and billboards throughout the valley. • Thirty third-grade classes are visited a year. July through September is when the majority of outreach programs take place. • A seven minute video is show in the classes and rulers, mazes, stickers and flyers in both English and Spanish are passed out.	Judy Orr	301 E. Clark Ave. #301 Las Vegas, Nevada 89101	(702) 455-3139
Clark County Sanitation District	• Various outreach and educational tools are used. They include, maps, crossword puzzles, coloring books, fact sheets and book marks. At school presentations, jars of water are used to show the various stages of the wastewater treatment process.	Hazel Dewey	5857 E. Flamingo Rd. Las Vegas, Nevada	(702) 434-6613 (fax) 434-5435
City of Henderson	• The City of Henderson water treatment facility also contains a bird-viewing preserve. It is used for viewing and learning about various bird species and also provides a habitat and food for the birds.	Sherri Collier	240 Water Street Henderson, Nevada 89015	(702) 566-5659 (fax) 564-2530
City of Las Vegas	• Tours of the water treatment facility are conducted by Bruce Dacko and are for all ages and grades. • Programming is done on the Channel 4 community bulletin. CLV has a website and attends science fairs and distributes a Water Source Book.	Debby Hauth & Bruce Dacko	400 E. Stewart Las Vegas, Nevada	(702) 229-6581

Las Vegas Wash Project Coordination Team	• The LVWPCT has teamed up with Mabel Hoggard Elementary School to teach 5th graders about the wash and water sampling. This program involves three steps. First, the team goes out to do an orientation with the students, second, they take the students out to the wash to take samples and then they visit the SouthernNevada Water Systems facility. Third, the team goes back to the school to show the students the results of their samples and have discussion.	Elizabeth Bickmore	1900 E. Flamingo Suite 255 Las Vegas, Nevada 89119	(702) 892-3885
Nate Mack Elementary School	• Nate Mack is building a 5000 sq. ft. wetlands lab at their school. The goal of this program is to educate students and their parents on the positive role wetlands can play in our environment. They will be starting up a website and will eventually link to the LVWCC site.	Eugene Life	3170 Laurel Avenue Henderson, Nevada 89014	(702) 799-7760
Southern Nevada Water Authority	• Youth Education Program. The goals of this program are linked to the Clark County School District's curriculum. It is comprised of H2O: The Source resource kits, "Water's Edge" newspaper, Youth Advisory Council, Educ. Advisory Council and Deputy Drip. They cover a variety of grade levels.	Hilarie Robison	1001 S. Valley View Las Vegas, Nevada 89153	(702) 258-7149
UNLV Environmental Studies Department	• The GLOBE (Global Learning and Observations to Benefit the Environment) program is set up for students to collect data and then enter it onto the GLOBE web page, so any students in the nation can access the data. There are 35 GLOBE schools in Las Vegas. The program coordinator takes students out to the LV Wash and the Boulder City wetlands.	Darlene Cartier	4505 Maryland Pkwy Box 454030 Las Vegas, Nevada 89154	(702) 734-5395 (fax) 895-4436

Appendix 13.3 Stakeholder Outreach Activities

APPENDIX 14.1

Funding Study Team – Funding Survey
Las Vegas Wash Coordination Committee

Agency	Funding Source	Activities to which Revenues are Dedicated	Policies and Procedures that govern Revenue Expenditure	Benefits to Wash	Activities Impacting the Wash	Contact
Basic Management, Inc.	• Profits from Land • Reserves from Land Sales	Operating funds for planning and development of land, to include environmental characterization and remediation.	Annual budget preparation is conducted under internal policy guidelines, then approved by Board. "Major" expenditures must be approached at periodic Board meetings.	• Erosion control structures • Private sector development, which provides gateway to Wash and Park, benefits from tangible and intangible aspects of Wash management	Building golf courses along Park boundary. One owner, TIMET, discharges cooling water into Wash under a NPDES permit.	Robin Bain 702-565-6485
University of Nevada, Las Vegas	• State of Nevada operating budget • External grants and contracts • Gifts and donations	Post-secondary education, research, and community service.	State and federal law, policies, guidelines, and procedures.	• Educational opportunities and research.	Research and educational field trips.	Stephen Rice
National Park Service (Lake Mead)	• Congressional appropriations	Administration of Lake Mead National Recreation Area for resource management and protection, and public recreation.	NPS-8 budget and programming guidelines.	• Water quality improvement • Recreational opportunities • Erosion control structures	Management activities for enhancement of wetland and/or riparian habitat within Lake Mead NRA.	Kent Turner 702-293-8941
Nevada State Health Division (Bureau of Health Protection Services)	• Federal grant from EPA	Safe Drinking Water Act requires State Health Division to assess all drinking water sources in Nevada. Colorado River and Lake Mead will be assessed and a report, including GIS map, will be submitted to SNWA.	Nevada's Source Water Assessment Program is presently under review by EPA. Approval is expected in November 1999.	• Water quality improvement (drinking water)	None	Jon Palm 775-687-4754 x229
Clark County Conservation District	• Operations – grants from and Clark County • Projects – grants from various sources	Conservation and preservation of natural resources.	Nevada Revised Statue 548 – seven member board of supervisors	• Wetland restoration • Water quality improvement • Recreational opportunities • Environmental enhancements • Erosion control structures • Public outreach	Activities that improve the environmental integrity of the Wash and Lake Mead.	Heather Gallo 702-262-9047 x5
Clark County Comprehensive Planning	• Clark County general fund	Salaries, benefits, and supplies (e.g., water quality projects).	State statutes and Generally Accepted Governmental Accounting Practices (GAGAP).	• Wetland restoration • Water quality improvement • Recreational opportunities • Environmental enhancements • Erosion control structures	Regional environmental planning, land use, and zoning.	Christine Robinson 702-455-4181
Las Vegas Valley Water District	• Rates, fees, and charges in normal operations of municipal water distribution company	Serving Clark County as primary distributor of potable water. Mission is to provide a safe, reliable water supply and serve customers in responsible manner.	LVVWD Service rules and annual budget are governed by Clark County Board of Commissioners and administration by LVVWD staff.	• Indirectly, through additional allocations from Colorado River through return flow credits to supplier, the Southern Nevada Water Authority.	In separate partnerships with City of Las Vegas and Clark County Sanitation District. LVVWD in near future will divert up to 20 mgd of reclaimed water from Wash, and provide to large irrigation customers currently on LVVWD system.	Carey Casey 702-258-3106

Agency	Funding Source	Activities to which Revenues are Dedicated	Policies and Procedures that govern Revenue Expenditure	Benefits to Wash	Activities impacting the Wash	Contact
Southern Nevada Water Authority	• Wholesale delivery charges • Interest Income • Regional connection / commodity charges • Regional reliability surcharge • Quarter cent sales tax • Debt sales • Program fees • Misc. revenues	SNWS power costs, SNWS operation and maintenance costs, and capital expenditures, SNWS debt service, administration operation and maintenance costs and capital expenditures, new expansion debt, PAYG construction payment, construction payments, resource purchases, program expenditures.	**SNWA** - cooperative agreement, facilities and operations agreement, capital improvement plans, Capital Improvement Fund Plan, Water Resource Plan. **LVVWD** - service rules, purchasing guidelines, AB 291 (1997 legislation), AB 436 (1997 legislation), Nevada Revised Statues	• SNWA has critical interest in Wash water quality because SNWS intake in Lake Mead is six miles downstream from Wash.	SNWA has been involved recently with preservation and maintenance of the Las Vegas Wash Grade Control Structure, designed to control erosion.	Matt Thorley 702-259-8169
Clark County Regional Flood Control District	• Sales tax at ¼ percent	Improving the protection of life and property for existing and future residents from hazards of flooding. District revenues are dedicated primarily to design, right-of-way, construction, operation and maintenance of facilities in Master Plan. District operating budget is typically less than 10% of annual revenues.	District Policies and Procedures Manual, Nevada Revised Statue 543.	• Erosion control structures. The Master Plan includes a system of structures taken directly from Park planning. This is a low priority for immediate construction; however, this will relieve District of capital improvement burden. The system would be eligible for District maintenance funding.	By implementation of flood control system in Master Plan, along with urban growth, the natural hydrologic process in Wash watershed is altered. Detention basins should reduce flow, however, no reduction in total storm water will occur. This is a trade-off for flood protection in Valley.	Kevin Eubanks 702-455-3139
Colorado River Commission	• State agency – derives revenues from wholesale of water and electric power resources from Colorado River	Not-for-Profit State Agency. Revenues go toward water and power delivery, and construction of facilities.	State approval by Legislature and Budget Office.	• Water quality improvement • Return flow credits	None	Kurt Fritsch 702-486-2670
Natural Resources Conservation Service	• Congressional appropriations	Erosion and sediment control, natural resource education, wetlands restoration, and agriculture.	Numerous manuals that contain policies and procedures.	• Wetland restoration • Water quality improvement • Environmental enhancements • Erosion control structures	None	Bill O'Donnell 702-262-9047
City of Henderson (Utility Services Division)	• Rates and fees	Operations & Capital Improvement Program	Federal law, State law, city ordinance, City Council policies and generally accepted accounting principles.	• None	Wastewater discharge.	Wayne Robinson 702-565-2111
U.S. Fish & Wildlife Service (Southern Nevada Field Office)	• Congressional appropriations	Conserve, protect, and enhance fish and wildlife and their habitats. Activities include regulatory responsibility for Federal wildlife laws, including ESA, review State permits, conduct field studies.	Certain programs are allocated funding based on estimated cost of operation year to year. Other activities, such as contaminant investigations go through a competitive proposal process to obtain funding.	• Wetland restoration • Water quality improvement • Environmental enhancements • Erosion control structures • Protection of federally threatened and endangered species	ESA Section 7 Consultations, contaminant investigations, NPDES permit review.	Janet Bair, or Erik Orsak 702-647-5230
Clark County Parks & Recreation	• Clark County General Fund • Question 5 Bond • State and Federal grants	Implementation of Clark County Wetlands Park Master Plan, and associated EIS.	State law and grant acceptance requirements.	• Wetland restoration • Water quality improvement • Recreational opportunities • Environmental enhancements • Erosion control structures • Education, outreach, social volunteer, cultural/historical, etc.	Implementation of Clark County Wetlands Park Master Plan.	Bruce Sillitoe 702-455-8287

Agency	Funding Source	Activities to which Revenues are Dedicated	Policies and Procedures that govern Revenue Expenditure	Benefits to Wash	Activities Impacting the Wash	Contact
U.S. Bureau of Reclamation	• Congressional appropriations	Water quality monitoring of Wash and Lake Mead, wildlife enhancement, recreation, cooperation with other agencies.	Congressional authorities, law, OMB regulations. Note: No revenue, only annual appropriations from Congress.	• Water quality improvement • Environmental enhancements	Land use permits.	John Johnson 702-293-8509
U.S. Geological Survey (Water Resources Division)	• Congressional appropriations • Reimbursable customers	Scientific studies, monitoring, and data collection.	Federal laws, regulations, rules, and policies.	• Water resources information	Collection of discharge and water quality samples.	Gary Russell 702-897-4031
City of Las Vegas (Environmental)	• Sewer service fees • Bonds	Wastewater treatment.	Nevada Revised Statutes and City Code.	• Effluent discharge	Wastewater treatment.	Jim Mahoney 702-229-2417
Environmental Protection Agency (San Francisco)	• Federal tax revenue	Implementation of environmental laws, Clean Water Act, Safe Drinking Water Act, Resource Conservation and Recovery Act (RCRA), Comprehensive Emergency Response and Compensation and Liability Act (CERCLA). These are primary EPA statues.	Federal Acquisition Regulation (FAR) and 40 CFR Parts 30 and 31.	• Wetland restoration • Water quality improvement • Environmental enhancements • Benefits pertaining to environmental laws	With NDEP in a lead role, water quality standards for Wash, NPDES permit issuance and administration, and other programs, projects, and actions consistent with and/or pursuant to environmental laws.	Mike Schulz 415-744-1817
Clark County Sanitation District	• Sewer service • Connection charges	Collection, treatment, and reclamation of wastewater.	40 CFR 35, Nevada Revised Statute 318, and CCSD Resolution 96-004.	• Wash is conduit to deliver highly treated effluent to Lake Mead for return flow credit.	Increased flows of treated effluent contribute to erosion. CCSD participates in public education about Wash. Treated effluent dilutes high TDS and other pollutants seeping in from groundwater.	Frank Pearce 702-434-6685
City of North Las Vegas	• General Revenues for local Nevada governments • Approximately 250 sources of revenue	General government functions for Nevada cities.	State law, City Council actions, and Federal regulation	• Call point of contact	Sanitary discharge via City of Las Vegas.	Ken Albright 702-633-1242

APPENDIX 14.2

DRAFT

Las Vegas Wash Coordination Committee Funding Request to the FUNDING STUDY TEAM

Date Submitted: _____

Request Submitted by: _____

Project Name: _____

_____

Project Description: _____

_____

_____

_____

_____

_____

Project Timeline:

Start date: _____

End date: _____

Funding Requirements:

Estimated Total Cost: _____

Estimated Annual Cost: _____

Possible Funding Sources: _____

_____

_____

_____

_____

Comments & Responses

Comments Received on the Draft Las Vegas Wash Comprehensive Adaptive Management Plan

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
		Document Organization		
1	USFWS	Key Actions	Over the life of the program, we suggest emphases on the following key actions outlined in the CAMP: 1) Continued involvement and oversight by a single authority (SNWA or its equivalent), 2) Securing funding as soon as possible to implement those study team priority recommendations not already in progress, 3) Adherence to established timelines for specific goals and 4) Implementation of a comprehensive environmental monitoring plan that includes thorough baseline sampling.	Comment taken under advisement. The key items are identified throughout the document as activities necessary to ensure the success of the Plan. Specific reference to these items can be found in the Executive Summary and Summary of Recommendations sections.
2	EPA	Level of Detail	The voluminous nature of the document doesn't lend itself to easy review, either for the involved agencies or the public. The degree of detail varies throughout the plan, so we suggest including all detailed information in appendices, with references to the appropriate chapters, and striving for a summary level of detail for the key issues and recommendations in each chapter.	The final document will include a separate volume that will contain the appendices.
3	WQCAC	Initial Steps	The plan doesn't explain effectively why initial steps need to be taken as indicated.	An explanation of the importance of the Initial Steps has been incorporated in the Executive Summary and the Summary of Recommendations.
4	EPA	Long-Term Vision	A long-term vision, with some detail, for the Wash needs to be established.	The mission statement developed by the Coordination Committee provided the foundation for the recommendations reflected in the comprehensive plan. It is felt that the long-term "vision" for the management of the Wash will be articulated once the management entity is identified. Additional discussion regarding the purpose of the document can be found in the Executive Summary and Summary of Recommendations sections.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
5	EPA	Architectural Drawings	Architectural drawings or plan diagrams of the area over a period of years would also be helpful in showing what structures will be built first, and where wetlands would be added.	The intent is to incorporate renderings, diagrams, and other visual aids into the Plan as much as possible, time and information permitting. As the comprehensive management process evolves, more material will be develope along these lines, and this material would be included or otherwise referenced in future iterations of the document.
6	EPA	Key Issues	Key issues and questions that require further follow-up should be highlighted, especially those requiring input from the public, elected officials, and agencies.	Comment taken under advisement. Final decisions on formatting will be decided by the publications staff, taking into consideration best practices in this area. The Executive Summary contains discussion of several key issues and recommendations. Many of the individual actions developed by the Study Teams include continuing communication between stakeholders, keeping elected officials informed, and continued public outreach.
7	NDOW	Schedules, Priorities, Feedback, Deadlines	With exception to a draft time-line for siting and construction of the flood control structure, attention to the synthesis of problems, goals and actions cited by the various study teams is lacking. Time certain assignments and schedules, reality checks to attaining priorities which are fiscally dependent and feedback mechanisms to evaluate efficacious progress in coordinating and accomplishing task deadlines are not yet clearly identified in the Draft Plan.	Comment taken under advisement. This information will evolve in the report in concert with the overall progress of the comprehensive management process. Where possible at this stage, text relating to these issues has been included in the Executive Summary and the Summary of Recommendations.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
8	NDOW	Organize, Edit	The Draft Plan has been dubbed an Adaptive Management Plan. Not surprising then is the appearance of the Draft Plan replete with the growing pains it contains. The Draft Plan is a rough draft at best of a lot of valuable information and ideas. Organization and editing of the Draft Plan itself is necessary before it can be considered a complete document ready for careful review. The Draft Plan, rough as it is, has a way to go from evolving from a guidance document to a comprehensive, funded, action plan. This will take additional time to accomplish. The Division also looks forward to reasonable time lines for a finished, quality product.	Comment taken under advisement. The 44 recommendations contained within the Plan are intended to serve as a roadmap for the long-term management of the Wash. The document is intended to be adaptable in nature, thereby allowing for the frequent updates the Coordination Committee feels will be necessary for a successful project. Issues such as timelines and funding will be developed once the Las Vegas Wash Management Entity has been established. Additional discussion regarding the purpose of the document can be found in the Executive Summary and Summary of Recommendations.
9	Clark County	Divide Plan into Two Sections	Use and implementation of the Plan can be simplified by dividing the plan into two sections. The first section should be the recommendations and action steps. The second section should be the finding of facts which will include all the background material and appendices.	The final document will include a separate volume that will contain the appendices. In addition, a separate document containing just the Executive Summary will be developed to provide a detailed summary of the key issues and recommendations.
10	Clark County	Move Chapter 12	Move Chapter 12 (Jurisdictional & Regulatory Study Team) so that it is the first section of the Plan after the Executive Summary.	The chapters are organized with the more "structural" related first and administrative last.
11	Clark County	Correct Nomenclature	When listing members of the LVWCC, Clark County's departments should be listed as Clark County Departments of Comprehensive Planning and Parks and Recreation.	This recommendation has been incorporated throughout the document.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
12	Clark County	Acronym List	Develop an acronym list of agencies, permits, etc., to be incorporated into the beginning of the Plan.	Comment taken under advisement. Acronyms have been incorporated into the text of each chapter in the present version of the document, but future versions may incorporate a separate appendix or other reference tool.
13	Clark County	Alphabetical Order	Entities should be listed in alphabetical order in Section III.	This recommendation has been incorporated into the document.
14	Clark County	Combine Sections	Integrate Executive Summary and Summary of Recommendations section.	The Executive Summary was written to provide anyone reading the document the opportunity to get a synopsis of the plan that includes selected recommended actions. The Executive Summary will also be developed as a separate, stand-alone document. The Summary of Recommendations, on the other hand, discusses each of the 44 recommendations. The two sections will remain separate to preserve this intent.
15	WQCAC	Timeline	Add timeline to provide reader with sense of when things are expected to be implemented and completed. Focus on funding needs and revenue sources. Provide reader with sense of what final product will look like - what the public can expect to see in the Wash once all activities are implemented. Vision is essential to interesting the public and getting them involved.	Issues such as timelines and funding will be developed once the Las Vegas Wash Management Entity has been established. Additional discussion regarding the purpose of the document can be found in the Executive Summary and Summary of Recommendations.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
16	WQCAC	Review & Coordination Processes	Somewhat related to the above [the rights of landowners] are additional draf recommendations regarding a "common environmental review process" and pursuing opportunities for "Interagency coordination efforts". While this would seem a most logical goal for many of us, there are going to be concerns raised, I'm sure quite vocally, that it is a "back door effort" at consolidation. My observations indicate that consolidation is still very much a non-starter politically in this valley, and I would simply caution that we need to be careful that we don't inadvertently allow that issue to become a focal point rather than saving the Wash.	We support and agree with the comment. Any environmental review processes delineated are recommendations only for individual entities tasked with planning and/or zoning decisions.
17	WQCAC	Funding	I want very much to reaffirm the concerns of our original WQCAC regarding financially, and specifically the avoidance of creating a new and costly bureaucracy to administer the Wash. I am somewhat concerned with the volume of resources that SNWA has already committed to this effort, both in a very significant number of personnel and additional office space. Apparently these funds were unused and therefore available within SNWA when this issue came forth; I cannot imagine that costs to continue the effor from an administrative viewpoint, should substantially exceed what is already being funded and expended. Therefore I would hope that the issue of future financing would deal primarily with capital needs for actual hard, on-site improvements to the Wash.	As stated in the Executive Summary and in Chapter 12, the preferred option is to have an existing body with interlocals as needed to provide management. The SNWA budget has a staff dedicated to environmental activities, including water quality issues. Some of those funds are dedicated to Wash activities. The management entity will define future funding.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
18	WQCAC	Watershed Drawdown	Although the plan does not go as far as I would have liked, e.g., it does not address the full watershed issue, but it does recognize the critical role of the wash in the health of the Las Vegas Valley. For instance, floodwaters provide the natural system for recharging Valley aquifers and in shipping them out, we are not only drawing down groundwater systems which has led to subsidence, but eventually this practice will have impact on vegetation in mountains which surround the Valley. In fact we may already be losing trees due to water stress.	We appreciate the comment and reiterate the critical need to address the Wash as soon as possible.
19	WQCAC	Greater Understanding	From my view, the most significant benefit derived from development of the plan is to bring greater understanding to the representatives of the many agencies which have a part to play in the wash and water issues. If nothing else is gained, at least agencies will not move ahead in taking actions without considering to some extent the impacts to the Valley.	We appreciate the comment and concur.
		Executive Summary		
20	CCSD	Three Initial Steps	Under Initial Steps: The document gives the impression that the Management Entity has to happen first, before any other steps can begin. Instead, list all 3 steps (forming an agency, stabilizing the wash, and determining the amount of wetlands) as the first 3 steps, with no particular order between them. These efforts could start concurrently, through the same or different forums. Don't give the idea that some hold-up in forming an agency would stop progress on other fronts.	This recommendation has been incorporated into the document. There is no indication that one should occur before the other.
21	CCSD	Edit	Page 5, under Step 1: Rewrite the first sentence to say "the study team narrowed its focus to two options", then delete the next two sentences.	This recommendation has been incorporated into the document.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
22	LVVWD	Water Quality	Executive Summary. Add "Fecal Coliform Bacteria and Fecal Streptococcus" to the end of the first paragraph on page 4. After monitoring actual dry weather flows for six years, these two parameters are the ones exceeded the most.	Bacteria is mentioned as water quality concern in Chapter 4, Water Quality. It was decided not to include these two parameters in the Executive Summary because of the technical explanation that would need to accompany the inclusion.
23	CCSD	Consult Study Team	Under "Action: Identify Water Resources Needed for the Wetlands Park", There should be some mention of cooperating with the efforts of, or supplying information to the Alternate Discharge Study Team.	This recommendation was incorporated in the Executive Summary as indicated, as well as Chapter 9, Clark County Wetlands Park.
24	Clark County	Management Entity	Another issue that tends to mislead the reader is also found on Page 8. It reads that "Option 1 is to establish a new joint powers authority … " This statement ignores the potential of an Interlocal Agreement or MOA and implies that the development of an Authority is the preferred option. We recommend that the above working be removed from the Executive Summary, especially given that there will be "further discussion at the LVWCC level".	This section has been revised to reflect dialogue and recent comments.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
25	Clark County	Management Entity	Page 8 states that the first step is to "Form an agency to oversee and coordinate management and restoration of the Wash" and "Forming this entity is one of the first steps to be taken if the process of comprehensive adaptive management is to be realized." It is clear from the body of the text that the decision has not been made to form an agency. Rather, in Chapter 12, the study team recommended the use of an Interlocal Agreement, MOA, or Joint Powers Agreement, to "establish the intended relationship". Given that "the teams conclusions will be subject to further discussion at the LVWCC level before a final option is selected" and that the type and content of the Agreement has not been determined, it is premature to imply that the structure for an "oversight body" will be a new agency, district, authority, or entity. We recommend the Executive Summary remain consistent with the body of the text, in that the discussion should be focused on forming and refining the interagency relationships to oversee the Wash as recommended by the Jurisdictional & Regulatory Study Team rather than the formation of	This sentence has been deleted and replaced with, "The following three initial steps provide the foundation for the implementation of the plan and the long-term management of the Wash."
26	WQCAC	Management Entity	It is unclear who would ultimately make the decision to develop or modify interlocal agreements and create the proposed oversight body.	This is clarified within the Executive Summary and Chapter 12, Jurisdictional and Regulatory Study Team.
27	City of Las Vegas	1% of Flow	Page 2. Where does the other 1% of flows into Lake Mead come from?	This has been clarified in the text on page 2.
28	City of Las Vegas	Seepage	Page 2. Also, suggest replacing "shallow groundwater seepage" with "surfacing groundwater" or "rising groundwater". "Seepage" sounds like the flow is down, not up.	This has been clarified.
29	City of Las Vegas	Head-cutting	Page 3. "Head-cutting" should be defined.	Headcutting has been defined in Chapter 3.
30	City of Las Vegas	Largest Reservoir in U.S.	Page 3. Also, may want to mention that Lake Mead is the largest reservoir in the Nation.	This comment has not been incorporated. References have been made throughout the document, specifically in Chapter 4, regarding the importance of Lake Mead along the Colorado River.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
31	City of Las Vegas	Accurate MGD?	Page 4. Is there actually 160 mgd currently? The combined wastewater flows to the Wash average less than 139 mgd (City of Las Vegas less than 55 mgd, CCSD about 75 mgd, and City of Henderson averages less than 9 mgd). Is there another 20 mgd flow in the Wash?	The value has been changed to 150 - 160 million gallons per day.
32	City of Las Vegas	Storm Flows	Page 4. Also, this section indicated that heavy floods can increase this volume to about 4.5 billion gallons per day, equivalent to approximately 7,000 cfs for a 24 hour period. Has there been such a storm?	The 4.5 billion gallons was estimated by the USGS for the July 1999 storm event.
33	City of Las Vegas	Water Quality Improved	Page 4. The introduction should mention that since the 1970s the quality of the wastewater discharged from the treatment plants has greatly improved, and water quality in much of the Wash is probably better than it has ever been.	This recommendation has been incorporated into the document.
34	City of Las Vegas	Wetlands Weren't Natural	Page 4. The introduction should also make clear that the wetlands weren't natural, but were created in the 1950s or 1960s by the discharge from a wastewater treatment plant.	This recommendation has been incorporated into the document.
35	City of Las Vegas	New Water Quality Concerns	Page 4. The references to increasing water quality concerns should be revised to refer to new concerns about such things as perchlorate, and should make clear that the perchlorate has undoubtedly been there for years but has only recently been discovered. The greatest concerns probably in the late 1980s, when DEP was concerned that the ammonia coming out of the wash would cause a big fish kill.	This is addressed in Chapter 4, Water Quality.
36	City of Las Vegas	Change of Verbiage	Page 4. The phrase "reverse the continuing degradation" seems to exaggerate the problem, and should be replaced with "reverse the continuing erosion". Although erosion continues, habitat seems to have remained fairly stable (although of poor quality) during the past 15 years or so. Most of the wetlands were gone after the flood of 1984. Except for Lake Las Vegas, which stabilized (and thereby improved) two miles of the lower wash, there seems to be little evidence that the cattail wetlands acreage has changed very much since then, although there were undoubtedly some increases and decreases in response to dam building and flooding.	This recommendation has been incorporated into the document.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
37	City of Las Vegas	Change of Verbiage	Page 5. The first sentence on the second paragraph reads awkwardly. We suggest changing it to "Because the Las Vegas Wash is surrounded by many complex issues and is not ...".	This recommendation has been incorporated into the document.
38	City of Las Vegas	Edit	Page 5. The last paragraph on the page ends with a colon, but there is no appropriate text following the colon.	This recommendation has been incorporated into the document.
39	City of Las Vegas	Change of Verbiage	Page 6. The report refers from time to time to the "restoration" of Las Vegas Wash, which isn't exactly accurate. It would be better to refer to "improving" the Wash or "establishing" wetlands. The Wash in 1972 seems to have been at a brief but idyllic state, where the constant flow from the treatment plants supported an expansive area of vegetation. By the late 1970s, even before the old Northshore Road was removed, there was significant erosion between the wetlands at Northshore Road and at Pabco and Telephone Line Roads (photographs taken by Vern Bostick and posted on the site show some of the erosion problems from the last 1970s). Even when new wetlands are created in the wash, it is unlikely that the wash will be "restored", because for example, the thick sludge deposits that turned the water black and filled the air with sulfide will be gone. Also, the thick stands of tamarisk that prevented access to the wash will be removed, at least in part.	The word "restoration" has been replaced with "the stabilization and enhancement". Additional changes have been made throughout the document to use words such as "stabilize", "establish", and "enhance" in addition to "restore" in order to reflect the diversity of work required in the Wash.
40	City of Las Vegas	Change of Verbiage	Page 7. The first paragraph under the bulleted list is somewhat misleading since it indicates that the teams met at least monthly and researched issues in depth. While the teams typically met at least monthly, sometimes meetings were cancelled. Also, many times issues were not researched in depth, but were only identified as issues to be resolved. Recommend wording such as "Each team typically met at least monthly, discussed and researched issues, and developed ... ".	This recommendation has been incorporated into the document.
41	City of Las Vegas	Change of Verbiage	Page 7. In the second paragraph, last sentence, recommend changing "The plan is simply a guide ..." to "The plan is intended as a guide ...".	This recommendation has been incorporated into the document.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
42	City of Las Vegas	Jurisdictional Issues	Page 7. We suggest that the discussion on the jurisdictional issues should be made more concise. This section seems more like an attempt to convince th reader of the recommendation than as a summary of what the recommendation is.	This recommendation has been incorporated int the document.
43	City of Las Vegas	Jurisdictional Issues	Page 8. Will the final report contain a recommendation for either Option 1 or Option 2 of the jurisdiction models?	The Executive Summary and the Jurisdictional Regulatory Study Team have been revised to contain text reflecting recent dialogue pertaining to the jurisdictional models.
44	City of Las Vegas	Change of Verbiage	Page 9. The last paragraph on dry weather flows is unclear. Can't tell what is intended here.	The final sentence in this paragraph clarifies the intent.
45	City of Las Vegas	Step 2	Page 10. Fourth paragraph refers to Step 2. There is no Step 2 identified.	This recommendation has been incorporated int the document.
46	City of Las Vegas	Recommended Actions	Page 10. The last paragraph on Page 10 refers to a table which we do not see in the document (version printed off the web site). Does this table list the Key Recommendations that are then discussed in more detail? If not, recommend that all the recommendations be listed firstthen discussed.	No table was intended at this point in the document. The text has been changed to delete this error.
47	City of Las Vegas	Edit	Page 13. Additional line needed after "vegetation and wildlife" if separate paragraph is intended.	This recommendation has been incorporated int the document.
48	City of Las Vegas	Edit	Page 16. Typo on second line - "witht he".	This has been corrected in the document.
49	City of Las Vegas	Funding	Page 16. Accomplishing the work outlined in bullets 2, 3, 5, 6, & 7 will require a significant funding source and perhaps hiring a consulting firm. Has the funding source or lead agency been identified?	The Funding Study Team has developed a list o funding options and selection criteria. In addition, there are several recommended actions that have been developed to provide a basis for the management entity to determine the most equitable funding source(s).

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
50	City of Las Vegas	Acknowledgement	Page 20. The first paragraph does not acknowledge that the Dischargers are already contributing significant funding by allocating monies to the Alterna Discharge Study. There should be some recognition that there are already funds being dedicated to some of these activities by various agencies.	This is clarified in Chapter 8, Alternate Discharge.
51	Clark County	Executive Summary	Regarding the Action: Support the development and implementation of a common Environmental Review Process among Planning Entities (page 20) This item needs to be clarified. Are we saying only zone changes require mitigation or any land action that may impact the environment? Change common to standardized.	Additional discussion regarding this recommendation can be found in Chapter 11. "Common" has been changed to "standardized".
52	Clark County Health District	Recommended Actions	Some of the recommendations presented in Montgomery Watson's study are more specific and detailed than the general recommendations presented in Section V: Summary of Recommendations, or in the Executive Summary.	No action required. This document is intended to serve as a roadmap for the Long-term Management of the Wash. The 44 recommendations included provide for the foundation from which to start. The LVWCC realizes that additional recommendations and tasks will be developed throughout the process.
53	USBR	Executive Summary	Each study team developed a number of recommended actions. In the Executive Summary, "the most important recommendations from the study teams, in order of priority." were presented. However, we found no explanation of how the most important recommendations were selected and how the priorities were established. We suggest such an explanation.	Text states that the action items are listed in general order of priority. They were included to give someone reading just the Executive Summary a sense of the larger activities required for a successful Management Plan.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
		Individual Chapters		
54	City of Las Vegas	Introduction	Page 26. Suggest changing "… that ends at Lake Mead at a place known as Las Vegas Bay.", to "… that ends at Las Vegas Bay, an arm of Lake Mead."	This recommendation has been incorporated into the document.
55	USBR	Introduction	In our copy of the draft, there is apparently some text missing between page 30 and page 31 in the Introduction.	We have reviewed our copies and have not found this.
56	City of Las Vegas	Chapter 1	Page 37. In the 1950s the City of Las Vegas operated a small treatment plant located at the southwest corner of the intersection of Mojave Road and Harris Avenue.	This recommendation has been incorporated into the document.
57	City of Las Vegas	Chapter 1	Page 40. The comment about ero ion between Telephone Line Road and Pabco Road in 1975 appears incorrect, at least if the comment refers to the two crossings of the Wash, which were very close together. (After Pabco Road was washed out, people often called the Telephone Line Road crossing "Pabco Road", because you went down Pabco Road and jogged over to get to it.) Both crossings acted as dams to stabilized the Wash, and there were ponds between the two crossings as of 1978, and no sign of erosion whatsoever.	This has been corrected in the document.
58	City of Las Vegas	Chapter 1	Page 40. According to Appendix 1.1, Power Line Road is not Telephone Line Road, but is instead close to Three Kids Wash.	This has been corrected in the document.
59	City of Las Vegas	Chapter 1	Page 41. Removal of the bridge did not affect how far upstream the erosion went, but did allow the cutting to go much deeper at Northshore Road.	Removal of the bridge caused a dam or hinge point to also be removed, which allowed erosion to move further upstream.
60	City of Las Vegas	Chapter 1	Page 41. In 1978, the City of Las Vegas retained the flood-control consultant John Tettemer, who proposed a series of low dams to stop erosion and expand wetlands as an alternative to advanced wastewater treatment. The State Environmental Commission did not adopt this proposal.	This recommendation was not thought to be stand alone.
61	City of Las Vegas	Chapter 1	Page 42. In the last paragraph we suggest changing "… more than the amount …" to "… more than the equivalent amount of concrete … ."	This recommendation has been incorporated into the document.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
62	City of Las Vegas	Chapter 1	Page 42. There are apparent inconsistencies within the paragraph. For example, marsh habitat decreased 80% from 1975 through 1982, but only 160 of about 1400 acres. Page 33 of Appendix 1.1 indicates that the 80% referred only to the decline in reach 3, not the entire wash. Although we don't want to minimize the loss, we don't want to exaggerate it either. Four hundred acres are much easier to restore than eleven hundred acres. According to page 14 of Appendix 1.1, cattail wetlands, the most important Wash habitat, decreased from 427 acres in 1975 to 138 acres in 1986.	The 80% decrease refers to only "marsh habitat" within the entire Wash, and the 160 acre loss refers to wetland vegetation only between Desert Inn Road and Lake Las Vegas. Thus, these figures are non-comparable.
63	City of Las Vegas	Chapter 1	Recommend including reference to following events in this section: 1) 198 The City of Las Vegas Water Pollution Control Facility (CLVWPCF) began providing chemical treatment to remove phosphorus. 2) 1991 - The CLVWPCF expands capacity to 66 mgd. 3) 1994 - The CLVWPCF filtration complex was added to remove even more phosphorus. 4) 1995 - The CLVWPCF nitrification complex were added to remove ammonia.	Portions of this recommendation were incorporated into Chapter 1. However, the intention of this chapter was to describe the history of the Wash and paint a picture for the reader of how it has changed over time, not so much the treatment practices of each wastewater discharger.
64	Lockheed Martin Env. Services	Chapter 1	The historical context provided for the Wash appears very interesting but incomplete for the early 1950's timeframe, a critical baseline period. It is noted by the USGS that a major change in vegetation has occurred over the last half century, with a continuous flow in the Wash starting in 1955. Samples of 1950 era aerial photography imagery are used in the document; given the availability of this imagery, baseline vegetation mapping for 1950 seems possible and appropriate. Additional imagery is also available for this area on later dates. Reviewing this imagery would significantly expend upon the 1975 to 1986 vegetation study conducted by the USBR.	This recommendation will be presented to the appropriate study team for consideration, and potential recommended action in the implementation phase.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
65	Clark County	Chapter 1	Add the following information to Chapter 1 (derived from the Las Vegas Valley 208 Water Quality Management Plan amendment). In July 1968, the first community-wide effort to solve Las Vegas Bay pollution problems was initiated. The interagency Water Pollution Control Task Force was formed and acted as a Technical Advisory Committee to the Clark County Board of Commissioners.	This has been incorporated under the 1960s header.
66	Clark County	Chapter 1	Add the following information to Chapter 1. In April 1977, the first 208 reports were published for Clark County. Four of the reports dealt with the following Las Vegas Wash issues: Las Vegas Wash Development and coordination with wastewater treatment facilities, salinity control, recreation and flood control aspects of the wash.	This has been incorporated. Since April 1977, there have been numerous amendments to the 208 Plan.
67	Clark County	Chapter 1	In July 1978, the board of County Commissioners transferred water quality planning functions from the Clark County Sanitation District to the Clark County Department of Comprehensive Planning.	This recommendation has been incorporated into the document.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
68	Clark County	Chapter 1	Add the following information to Chapter 1. *In July 1973, the Sewage and Wastewater Advisory Committee (SWAC) was organized as required by NRS 244A. The SWAC is comprised of technical employees from municipalities or districts who are actively engaged in the operation or management of sewer or water facilities within the Clark County.* SWAC membership composition is based, in part, on population of each agency. The SWAC membership is organized as follows: 2 members appointed by Board County Commissioners, 3 members appointed by the City of Las Vegas, 2 members appointed by City of Henderson, 1 member appointed by City of North Las Vegas, 1 member appointed by City of Boulder City, 1 member appointed by the City of Mesquite, 1 member appointed by Las Vegas Valley Water District, 1 member appointed by Clark County Sanitation District. The SWAC is tasked with remaining current with significant laws and other issues that may affect water quality. Furthermore, SWAC is responsible for advising and making recommendations to the Board of conditions that require action by the Board.	Part of this (italicized only) has been incorporated under the 1970's header. Incorporation of this text provides a more complete historical perspective.
69	Clark County	Chapter 1	In 1978, the BCC adopted the Clark County 208 Water Quality Management Plan. The initial 208 Plan presented objectives, policies and programs for managing water quality in the County.	This recommendation has been incorporated into the document.
70	Clark County	Chapter 1	In March 1979, a multi jurisdictional planning board, called the Las Vegas Valley Water Quality program was established. The program established a planning process to address effluent limits for the Las Vegas Wash and Lake Mead.	This recommendation has been incorporated into the document.
71	Clark County	Chapter 1	In 1982, The Las Vegas Wash Environmental Assessment for the Clark County Wetlands Park was published. It addresses the recreational plan development for Las Vegas Wash, a spin off of the 208 planning efforts.	This has been incorporated in Chapter 9.
72	Clark County	Chapter 1	Through the 1980's and 1990's various amendments to the Clark County 208 Water Quality Management Plan were adopted.	Discussion of the 208 Water Quality Management Plan has been incorporated into Chapter 1.

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73	Clark County	Chapter 1	In July 1997, the BCC adopted the Las Vegas Valley 208 Water Quality Management Plan Amendment. Elements of the Plan include wastewater flow projections, wastewater treatment, water reclamation, non-point source Las Vegas Wash Wetlands, integrated planning coordination and water quality planning.	This has been incorporated in reference to numerous 208 Plan Amendments.
74	Clark County	Chapter 1	Please add to the references: Montgomery Watson (1997). Las Vegas Valley 208 Water Quality Management Plan Amendment. Clark County Department Comprehensive Planning.	This recommendation has been incorporated into the document.
75	Clark County	Chapter 1	Please ensure the consistency in the history section of this chapter [Chapter 3] and history of the Las Vegas Wash in Chapter 1. Specifically, wastewater flows in the 1950's were discharged to Las Vegas Creek or primarily discharged into evaporation ponds and cess pools?	This recommendation has been incorporated into the document.
76	WQCAC	Chapter 1	The history omits any reference to the first Master Plan completed by CCP&R and Comp. Planning approved by the Clark County Board of Commissioners on Sep. 3, 1982. There was considerable agency and public involvement in developing the document which largely was the result of efforts of the Las Vegas Wash Development Advisory Committee. This set the stage for the widely held belief which is now being voiced that there is a good deal of lip service to restoring the wash, but no action will be taken. Unless many of the public can be assured that the Wash will be saved, support will be withheld. The Wash cleanups have helped considerably, but seeing the first park building will be much more effective. The grade control structures are seen by some as nothing more than an extension of the flood control project for which people are already paying taxes.	The first part of this recommendation, regarding Clark County's initial 1982 Master Plan, has been incorporated into the document. Installation of grade control structures are necessary for controlling erosion in the Wash, and serve as the foundation for wetlands development along the channel.
77	Clark County	Chapter 2	Figure 2.4, change the name of Clark County wastewater treatment facility to Clark County Sanitation District.	This recommendation has been incorporated into the document.
78	Clark County	Chapter 2	Reconcile the spelling of "gage" and "gauge".	This recommendation has been incorporated into the document.
79	City of Las Vegas	Chapter 2	Throughout this section, in text, tables and figures, "gauge" and "gage" are both used. Recommend using one spelling only ("gauge" recommended).	This recommendation has been incorporated into the document. "Gage" is being used because the USGS uses this spelling.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
80	City of Las Vegas	Chapter 2	Page 56. Second sentence, last paragraph, refers to "these measurements as a basis". Need to clarify which measurements "these" refer to, i.e., metered or gaged?	Text refers to both gaged and estimated measurements, text not changed.
81	City of Las Vegas	Chapter 2	Page 56. First paragraph, add comma between Management and incorporated.	This recommendation has been incorporated into the document.
82	City of Las Vegas	Chapter 2	Page 59. Remove line separating "Basic" and "Management" in the first paragraph.	This recommendation has been incorporated into the document.
83	City of Las Vegas	Chapter 2	Page 60. The City of Las Vegas did not reach a capacity of 66 mgd until 1991 (correctly stated in the text), however the tables show 66 mgd of capacity in 1989.	Corrected 1989 capacity to 41 mgd.
84	City of Las Vegas	Chapter 2	Page 60. Also, the second paragraph refers to the 88 mgd capacity of CCSD and the 90 mgd capacity of the AWT. Recommend clarification that the AWT is not a separate facility, but was an expansion of the CCSD facility.	This recommendation has been incorporated into the document.
85	City of Las Vegas	Chapter 2	Page 61. The distinction between the legend items is not clear in Figure 2.6 of the review copy, i.e., the lines all look the same in the legend, although they are discernible in the graph.	Final copies will be in color.
86	City of Las Vegas	Chapter 2	Page 61. Text directly under Figure 2.6 - Recommend replacing "and" between "irrigation" and "higher" with a comma.	"and" is used to separate two distinct processes, text not changed.
87	City of Las Vegas	Chapter 2	Page 61. Last sentence. In reference to "The remaining wastewater of all three ...", recommend using "treated" wastewater or otherwise indicate the wastewater is treated.	This recommendation has been incorporated into the document.
88	City of Las Vegas	Chapter 2	Page 62. In the second line, move comma before "or" rather than after "or".	This recommendation has been incorporated into the document.
89	City of Las Vegas	Chapter 2	Page 62. In second paragraph, first sentence. Recommend inserting "shallow" between "intercepted" and "groundwater".	This recommendation has been incorporated into the document.
90	City of Las Vegas	Chapter 2	Page 63. In the third paragraph, and throughout this section, Bureau of Reclamation is abbreviated to "Reclamation. Isn't "BOR" or USBR as used in Appendix 1.1 more commonly used? Recommended "Bureau of Reclamation" or USBR.	This recommendation has been incorporated into the document. U.S. Bureau of Reclamation and USBR is used.
91	City of Las Vegas	Chapter 2	Page 64. Second paragraph. Remove "simply" and change "(wastewater)" to "(treated wastewater)" or "(wastewater treatment facility effluents)".	"Simply" emphasizes the point, text not changed.

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92	City of Las Vegas	Chapter 2	Page 64. Third paragraph, last sentence. Insert "data" after "groundwater flow" and after "tributary flow".	The word "data" was not used, but sentence has been clarified.
93	City of Las Vegas	Chapter 2	Page 65. Laughlin is not included in service area for CCRFCD? Needs to be included.	This recommendation has been incorporated into the document.
94	City of Las Vegas	Chapter 2	Page 67. Item 3 in the fourth paragraph is currently prohibited by State law This is further discussed in other section of the document, but it should still be mentioned here.	It is not against State Law if recharge water meets potable standards. Text was clarified.
95	City of Las Vegas	Chapter 2	Page 69. In the summary, the numbered list of (4) reasons to capture stormwater flows is exactly the same numbered list as in the paragraph at the top of the page. Seems duplicative, especially since they are so close together.	Although duplicative --some may only read summary.
96	City of Las Vegas	Chapter 2	Page 70. Introductory paragraph under "Water Resources & Supply" needs to get to the point.	Background information in the first few paragraphs is required.
97	CCRFCD	Chapter 2	Detention basin max drain time criteria is less than 7 days, not 48 hrs.	This has been clarified in the text.
98	City of Las Vegas	Chapter 2	Page 74. Last Paragraph. The City of Las Vegas also has a Primary Permit for their wastewater. Shouldn't this be mentioned as a option also?	This recommendation has been incorporated into the document.
99	Clark County	Chapter 3	Please ensure the consistency in the history section of this chapter and history of the Las Vegas Wash in Chapter 1. Specifically, wastewater flows in the 1950's were discharged to Las Vegas Creek or primarily discharged into evaporation ponds and cess pools?	This recommendation has been incorporated into the document.
100	City of Las Vegas	Chapter 3	Page 82. In the first line ft3 should be ft^3.	This recommendation has been incorporated into the document.
101	City of Las Vegas	Chapter 3	Page 82. In the first sentence of the second paragraph, the wash flows are stated as being 200 cfs. In an earlier chapter they are stated as 160 cfs. Which is correct?	The 160 figure was million gallons per day (mgd), not cubic feet per second (cfs).
102	City of Las Vegas	Chapter 3	Page 82. In the third paragraph, "bed load" should be defined.	The word "bedload" has been replaced with "sediment load".
103	City of Las Vegas	Chapter 3	Page 83. In the second paragraph, is the reference to "Boyle" meant to be Boyle Engineering? If so, it should be stated as such.	This recommendation has been incorporated into the document.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
104	CCRFCD	Chapter 3	Top Page 82. I'm not sure what the Conservation District's site characterization program is, but the NPDES co-permittees added a similar Source ID program on the Flamingo to find where bacteria is coming from. It includes dry weather and wet weather sampling at 8 sites along the Flamingo to try to ID a bacteria gradient, if you will, that might lead us to a source or land use as a culprit. The data was very variable and difficult to verify and did not lead to any definitive conclusions or trends.	Unable to locate the text this comment is referring to.
105	USFWS	Chapter 4	Chapter 4, Water Quality, Water Quality Issues of Concern, Selenium Page 84. The paragraph reads "A concentration at this level (15 parts per billion) raises concerns regarding the potential for bioaccumulation ..." We suggest a statement that more directly conveys the risks that these selenium levels may pose to wildlife, such as "A concentration at this level raises concerns regarding the potential for bioaccumulation within the food chain and appears to be related to adverse effects on some species of fish and wildlife."	This recommendation has been incorporated into the document. The sentence now ends, "... and appears to be related to adverse effects on some species of fish and wildlife found in areas with elevated selenium concentrations (e.g., Kesterson National Wildlife Refuge)."
106	USFWS	Chapter 4	Chapter 4, Water Quality, Water Quality Issues of Concern, Perchlorate Page 85. Studies have shown concentrations of perchlorate in surface water above 100 parts per billion may pose a risk to birds and mammals that consume the water for long-term durations (Fendick, et.al., 1999). The concentration of perchlorate where the plume intercepts the wash (i.e. 1000 parts per billion) is an order of magnitude higher than this threshold toxicity value.	Because Fendick, et.al. (1999) is based on a statistical model, and not in vivo data, this specific study was not referenced. However, in order to incorporate the concern associated with perchlorate, the following sentence has been added to the text, "... promote the further understanding of the potential health effects of perchlorate, and will continue to sample, characterize, and stay informed as to the most recent research regarding perchlorate."
107	Clark County	Chapter 4	The depth of shallow groundwater in Table 4.1 should be consistent at 25 or 30 feet throughout the document.	Unable to identify inconsistency in document.
108	Clark County	Chapter 4	Clark County 208 Water Quality Management Plan. In the third sentence, please add Las Vegas Wash Wetlands. This chapter is a significant chapter addressing Las Vegas Wash issues.	This recommendation has been incorporated into the document.

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109	EPA	Chapter 4	Page 80, the plan should be changed to note that the most recent Safe Drinking Water Act (SDWA) amendments were in 1996, not 1998. Also, the SDWA in Nevada is implemented by the Bureau of Health Protection, not NDEP.	This recommendation has been incorporated into the document.
110	EPA	Chapter 4	Page 81, states that the "CWA mandates that all discharges be permitted and meet certain requirements as to quantity and quality". NPDES permits specify maximum volumes, but don't regulate water quantity per se.	This recommendation has been incorporated into the document.
111	EPA	Chapter 4	Page 81, in the section on wastewater discharges, we suggest separating the last sentence of this paragraph which discusses water quality standards (WQS), as WQS apply to the Wash rather than wastewater discharges, which are governed by NPDES permits that include limits intended to result in meeting the WQS.	This recommendation has been incorporated into the document.
112	LVVWD	Chapter 4	This chapter seems too short for such an important issue.	The intent of this chapter is to provide a general background on the water quality issues surrounding the Las Vegas Wash. It is not intended to provide an exhaustive review. There are numerous publications and databases that provide detailed water quality information.
113	City of Las Vegas	Chapter 4	Throughout this section, there is reference to the Las Vegas Valley Dischargers, but they are not defined. Perhaps, early in the section, the Dischargers should be defined as the Cities of Las Vegas and Henderson and the Clark County Sanitation District, perhaps with some indication that flows from North Las Vegas are treated by the City of Las Vegas?	This recommendation has been incorporated into the document.

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114	City of Las Vegas	Chapter 4	Recommend inserting the following comment into this section: "Existing EPA policies penalize dischargers, such as the Clark County Sanitation District and the Cities of Henderson and Las Vegas, who discharge into effluent-dominated waters such as Las Vegas Wash. These policies can result in unrealistically stringent limits that the treatment plants cannot meet or that can only be met at great expense, which is passed on to local taxpayers. If large expenditures produced large environmental benefits, that would be one thing. Unfortunately, because EPA policies were not designed for conditions in the arid Southwest, even a great expense may not be accompanied by any real environmental benefit."	Because this comment may not reflect the views of the entire LVWCC, it has therefore not been incorporated into the chapter.
115	City of Las Vegas	Chapter 4	Page 79, Table 4-1: The box should say that our wastewater is highly treated. Our first choice is to delete the reference to TMDL's altogether. If it is left in, the comment should be modified to make clear that the concern for the distant future. Selenium is identified on page 84 as an issue of concern, but its source is not mentioned Table 4-1. Perchlorate is identified as an issue of concern on page 85, and perhaps "including perchlorate and various organics" could be added to "compounds from past industrial practices".	The following sentence has been added to Table 4.1, "Specific concerns include selenium, perchlorate, and various organics." The following additional text was added to the 'Past Industrial Practices section, "... perchlorate and various organic compounds are examples ...".
116	City of Las Vegas	Chapter 4	Page 80: This section makes the point that a lot of people use water in the Colorado River, and therefore that what comes in from the Wash "requires attention". Although we do not disagree, the text should say something about the great amount of water into which the Wash mixes and the fact that bodies of water can purify themselves by removing many pollutants. The rest of the chapter might make clear which constituents might affect downstream users, and which (sediment, for example) do not.	Comment taken under advisement. The purpose of this section is to summarize the regional concern regarding water quality. Discussing dilution is not appropriate for this chapter. The percentage of the Wash contribution is discussed in several places in the document.

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117	City of Las Vegas	Chapter 4	Page 81: Bulleted Section on Wastewater discharges - Recommend following wording for entire section to clarify permit requirements as well a the differences between permit limitations and standards. "Wastewater discharges--National Pollutant Discharge Elimination system (NPDES) permits are required for all of the treated wastewater that is discharged into the Wash. Each permit specifies the maximum amount of discharge allowed and sets limits for various constituents which may be in the discharge. The permits limitations are established to insure that water quality standards for the Las Vegas Wash and Lake Mead are met. These standards are set by NDEP, according to Clean Water Act requirements, based on the intended use of the water and to prevent degradation of water quality."	This recommendation has been incorporated into the document.
118	City of Las Vegas	Chapter 4	Last paragraph, under urban runoff, there should be some indication that wet weather monitoring is also part of the permit.	This recommendation has been incorporated into the document.
119	City of Las Vegas	Chapter 4	Page 82: The statement that WQS were first set in 1987 is incorrect. We're not certain of the true date, but it was back in the early 1970's, at least.	This recommendation has been incorporated into the document.
120	City of Las Vegas	Chapter 4	In the first line of the third paragraph, change "who" to "which".	This recommendation has been incorporated into the document.
121	City of Las Vegas	Chapter 4	In the third paragraph, May 1998 is given as the date of the last adoption of the Water Quality Standards. However, on the next page June 17, 1998 is given. We believe the June date is correct.	This recommendation has been incorporated into the document.
122	City of Las Vegas	Chapter 4	Sediment: Since the setup for this chapter is that the Wash can affect drinking water, the text should say that sediment drops out quickly and does not affect drinking water.	This chapter was written to not only present concerns regarding the potential for the Wash to impact our drinking water source, but also to present impacts the water quality of the Wash may have on other established uses in Las Vegas Bay and Lake Mead.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
123	City of Las Vegas	Chapter 4	Page 83: Same comment for phosphorus and ammonia. They affect water quality in the inner bay, and do not increase algae growth or cause toxicity at the water intake.	This chapter was written to not only present concerns regarding the potential for the Wash to impact our drinking water source, but also to present impacts the water quality of the Wash may have on other established uses in Las Vegas Bay and Lake Mead.
124	City of Las Vegas	Chapter 4	Please clarify that NPDES permits do not establish TMDL's. The TMDL's are derived from the water quality standards and the permits convert the TMDL's to a Waste Load Allocation.	The word "establish" has been replaced with "include".
125	City of Las Vegas	Chapter 4	Page 84: Second Paragraph. Conducting Alternate Discharge Study is one of the recommendation of the NAS. It is really not a continuation of the NAS.	This recommendation has been incorporated into the document.
126	City of Las Vegas	Chapter 4	Last Paragraph, last sentence - Insert "is" between "this" and "by".	This recommendation has been incorporated into the document.
127	City of Las Vegas	Chapter 4	First Page 86: The text says that Bevans found that urban activities have been the primary source of chemicals found in the shallow aquifer. Was there ever a shallow aquifer before the valley was settled? Aren't urban activities the reason for the existence of the shallow aquifer, at least in most of the valley, and everything in it?	The shallow aquifer exists in the Valley due to a combination of the upward gradient from the principal aquifer and from urban influences, and existed prior to urbanization. No changes were made.
128	City of Las Vegas	Chapter 4	Second Page 86 - Discussion of Bureau of Reclamation data is extensive. Reference to data collected by other agencies is presented in brief summary with interpretative. Either the summary should be shortened, or other discussions o data collection programs increased proportionally. The Plan should indicate that the studies are conducted by the Bureau of Reclamation rather than by Dr. James LaBounty.	The discussion provided by this section helps support the chapter by explaining the influence of the Wash to Lake Mead. "Bureau of Reclamation Scientists" now replace reference to one individual.
129	City of Las Vegas	Chapter 4	Third Page 85: Second paragraph - Change "20o C " and "28o C" to "20^{o} C" and "28^{o}C". Also "1-20C" should be revised to "1 - 2^{o}C".	This recommendation has been incorporated into the document.
130	City of Las Vegas	Chapter 4	Fourth Page 85: Paragraph under bullet labeled "Water Quality Database", line 11 - Should "second site" read "second section"? Also, there should be credit given to data contributors.	This recommendation has been incorporated into the document.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
131	City of Las Vegas	Chapter 4	Paragraph under bullet labeled "Lake Mead Water Quality Forum" - In the first sentence, capitalize "forum". This section indicates that the purpose of the Forum is to provide a mechanism to keep stakeholders informed. Recommend alternate wording that would indicate the Forum provides a means of communicating and coordinating on Lake Mead water quality issues, perhaps including Forum water quality issues and priorities as a bulleted list. Also, there should be some reference to who the Forum participants are.	The majority of this recommendation has been incorporated into the document. Not included is the rewrite describing the Forum.
132	City of Las Vegas	Chapter 4	Fourth Page 86: First paragraph - recommend first sentence should be replaced with something like" This group meets monthly on issues related to Lake Mead and Las Vegas Wash monitoring activities. Studies are conducted to improve and standardize sampling and analytical procedures and to insure reliability of data generated by all participants". Also, there should be some reference to who the participants are.	This recommendation has been incorporated into the document.
133	City of Las Vegas	Chapter 4	Last page (numbered as 85, but following one of the 86's): The comment that the Wash affects 20 million people downstream should be deleted.	This recommendation has been incorporated into the document.
134	USBR	Chapter 4	In Chapter 4: Water Quality, Understanding the Influence of Las Vegas Wash on Lake Mead, Water Quality Monitoring. Bureau of Reclamation reference is made to the work of a specific individual scientist. This is the only place in the text of the report where an individual researcher is identified by name. In the spirit of consistency, perhaps it would be more appropriate to refer generally to Reclamation scientists or researchers and cite the work in the bibliography.	This recommendation has been incorporated into the document.
135	USBR	Chapter 4	On page 86, the "Salinity Control Program" is mentioned. We suggest you use "Colorado River Basin Salinity Control Act of 1974."	This recommendation has been incorporated into the document.
136	City of Las Vegas	Chapter 5	Page 38 - The third bullet does not make sense grammatically.	This recommendation has been incorporated into the document.
137	LVVWD	Chapter 6	Erosion needs immediate attention "as soon as possible" on page 35. A design-build contract may be a way to expedite construction improvements.	This recommendation will be presented to the appropriate study team for consideration.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
138	EPA	Chapter 6	Regarding Issue 3, Re-Establishment of Wetlands must be Conducted Outside of the Wash Channel. How does this conclusion fit in with the Wetlands Park and their plans to re-establish wetlands within the Wash channel and behind the erosion control structures? Is the goal to establish acres of wetlands beyond what is anticipated by the Wetlands Park, and what would be the function of the off-channel wetlands?	The Clark County Wetlands Park Master Plan seeks to increase the amount of wetlands within the Wash channel. Because the Wash has experienced significant erosion and channelization, it is not possible to develop a very large wetlands in the channel. One method to address the issues facing the Wash (i.e., water quality, habitat loss, increased wastewater flows), is to develop an area of significant wetlands off-stream (but near) the Wash.
139	EPA	Chapter 6	Regarding Action 1, Install Erosion Control Structures. How do the identified sites fit with the sites for erosion control structure identified by the Wetlands Park plan? It is unclear if the recommendation is to change the location of the Wetlands Park recommended erosion control sites or if these sites would be in addition. How many of the sites overlap the Wetlands Park sites?	Some of the sites recommended in this chapter are at the same location or very close to the sites identified in the Wetlands Park Master Plan. Two things that are included in the chapter, that are not included in the Master Plan is the identification of "priority sites" and the fact that less expensive prototype structures can be installed quickly.
140	EPA	Chapter 6	Regarding Action 5, Evaluate Storm Water Detention/Retention Basins. There's been discussion that the Corps of Engineers will be installing storm water basins above the Wash. This is not mentioned in the discussion on this Action, and should be included if appropriate.	These basins are part of Clark County Regional Flood Control District's Master Plan, and have been mentioned in this chapter.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
141	EPA	Chapter 6	Regarding flows in the Wash. It would be helpful to have more discussion provided concerning improvements to the CCRFCD and the expected impac on the Wash. Some discussion was provided on past studies of converting detention basins to retention basins and on discharge requirements for the impoundments; however, more discussion needs to be provided on the effec of modifications and improvements to the upstream system and how this affects the flows and construction of structures and wetlands in the Wash.	A section was added to this chapter that discusses the role of the CCRFCD.
142	Clark County	Chapter 6	Appendix 6.2 (The Process, Table 1). Table 1 has BMI average daily discharge at 15 mgd. Previously in the plan, BMI was listed as having a 10 mgd average daily discharge.	The text in the Las Vegas Wash Engineering Workshop document (Appendix 6.1) should have been written more clearly. Based on 1999 discharge limits (discussed in Chapter 2), BMI is permitted for 10 mgd and City of Henderson is permitted for 20 mgd.
143	Clark County	Chapter 7	Introduction. The second paragraph characterizes the depth of shallow groundwater. Consistency at 20 or 30 feet to shallow groundwater should be met through out the document.	This recommendation has been incorporated int the document.
144	Clark County	Chapter 7	"The hydrology of the shallow groundwater system and proximity to the urban environment makes the aquifer particularly vulnerable to contamination that could result from a variety of land use practices including over-irrigation of landscapes, leaking underground storage tanks and improper surface disposal of contaminants" These pollution sources are not the direct result of land use practices rather an externality of the use of the land. The sentence should be changed to reflect a more accurate assessment of the causes of pollution or reference Best Management Practices to mitigate with issues.	"Human-related activities" has been added to replace "land use practices."
145	Clark County	Chapter 7	Regarding Action 4: Develop a Long-Term Monitoring Program. Add the Las Vegas Valley Municipal Stormwater Quality Management Committee t the entities that will be a part of the long-term monitoring of water quality.	For the purposes of this document only coordination committee members were included as "Entities".

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146	EPA	Chapter 8	EPA supports water conservation/reclamation/reuse as a key component for realizing the objectives of the Plan and for the Wash. Thus, EPA supports maximizing reuse options where water supply considerations of return flow credits aren't compromised.	No action required.
147	CCSD	Chapter 8	1) The table associated with Existing and Projected Flows is misleading/confusing. We should probably add a column, which would be the design capacity of the three plants, and then re-label the "Capacity under Current Conditions 1997" to be something like "Current Flows" or "current utilization of design capacity". 2) Under Reuse: I am not aware of reuse studies done by SNWA, but I know that there were joint studies done with Greeley/Hansen, one done by the City of Las Vegas and LVVWD, and another by the CCSD, LVVWD, and Summerlin.	Both comments have been incorporated into the document.
148	City of Las Vegas	Chapter 8	Page 63. The Discharger partnership was already in place when we started the NAS. The Dischargers have had their informal partnership since the Fall of 1994 when they started work on the Biosolids Study.	This recommendation has been incorporated into the document.
149	City of Las Vegas	Chapter 8	Page 34. Although the Dischargers' starting point for the Study are the alternatives listed in Figure 8.1, consideration is being given to evaluating discharge below Hoover Dam. This alternative was eliminated by the Study Team. The elimination was perhaps premature, and it probably should be added back into the list of possible alternative prior to finalizing the document.	The Alternate Discharge Study Team determined that this option should be removed, but also realized, based on the Alternate Discharge study, that options other than those on their list may be reviewed. Thus, no action has been taken on this recommendation.
150	City of Las Vegas	Chapter 8	Page 36. Suggest changing number 12 to No Action Alternative. Continue discharging to the same location.	This recommendation has been incorporated into the document.
151	City of Las Vegas	Chapter 8	Page 37. The first column in Figure 8.2 is confusing. Our 'capacity" is currently 66 MGD. Our 'flow' in 1997 was 49 MGD.	This correction has been incorporated into the document.
152	City of Las Vegas	Chapter 8	Page 37. We believe the current combined design capacity is 187 (CLV 66, CCSD, 91, COH 30) not 174 MGD.	The 174 mgd figure is the daily average.

Comments Received on the Draft Las Vegas Wash Comprehensive Adaptive Management Plan

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
153	City of Las Vegas	Chapter 8	Page 38. In the first paragraph it is stated that in 1998, 13 millions gallons per day of reclaimed water was used. Is this the maximum day or the average for the whole year?	This is the average daily value. Text has been changed to reflect this.
154	City of Las Vegas	Chapter 8	Page 38. The 1999 Black & Veatch interagency study should be mentioned here.	This recommendation has been incorporated into the document.
155	City of Las Vegas	Chapter 8	Page 39. Did the Study Team recommendation only say 'support' or did it recommend that the Dischargers proceed with the study?	The Study Team recommended that the LVWCC support the efforts of the Dischargers to approve the scope of work developed to investigate alternate discharge options. No changes were made to text.
156	City of Las Vegas	Chapter 8	Page 39. (2 'and' one) - Capitalize the word 'district' in the second to last paragraph.	This recommendation has been incorporated into the document.
157	USFWS	Chapter 9	Chapter 9, Clark County Wetlands Park, Compliance with Section 7 of the Endangered Species Act. The endangered razorback sucker should be included as a federally listed species having the potential to occur within the Wash. Lake Mead is designated as critical habitat for this species up to the high water mark, which extends into Las Vegas Bay and Las Vegas Wash. The Las Vegas Wash (e.g. Blackbird Point) is a known spawning location for the razorback sucker (BIO/WEST, Inc., 1999). Hence, the degraded water quality found in the Wash directly affects the habitat quality and spawning success of this endangered fish. In keeping with the ecosystem approach to management of the Wash, the CAMP should also mention the razorback sucker and its relationship to the Wash.	A discussion of the razorback sucker was not included in Chapter 9 (Wetlands Park), because the razorback sucker does not have the potential to occur within the Park's boundaries (that portion of the Wash above Lake Las Vegas). However, a discussion of the razorback has been incorporated into Chapter 10, as it relates to Federally-listed species that have the potential to be impacted (positively and/or negatively) by activities occurring within the Wash (including that portion below Lake Las Vegas, where razorback suckers have the potential to occur).
158	USFWS	Chapter 9	References to "... Formal Program Section 7 Consultation..." should be changed to "... Formal Programmatic Section 7 Consultation..."	This recommendation has been incorporated into the document.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
159	USFWS	Chapter 9	Chapter 9, Compliance with Section 7 of the Endangered Species Act. Section 7 of the Endangered Species Act and the procedural regulations governing the section 7 process provide a 135-day time frame for completio of a Biological Opinion, following receipt of a Biological Assessment from the action agency. Therefore, completion of the consultation process by April 2000, as indicated in this section, may not be realistic, as timing will be dependent on the completion of the Biological Assessment.	The reference to April 2000, has been changed to incorporate this comment.
160	USFWS	Chapter 9	Chapter 9, Compliance with Section 10 of the Endangered Species Act. Inclusion of the following information would clarify the relationship betwee the Clark County Multiple Species Habitat Conservation Plan process and the Las Vegas Wash: *The Clark County Multiple Species Habitat Conservation Plan (MSHCP) is being developed by Clark County, five cities within the county, and the Nevada Department of Transportation, in cooperation with various Federal and State agencies. One of the goals of the MSHCP is to develop a County-wide conservation strategy for ecosystem conservation and management that will benefit approximately 80 listed and unlisted species in the initial phases, and up to 200 species over the 30-year-term of the program. The Fish and Wildlife Service is currently reviewing the permit application, and a permit may be issued by Spring or Summer, 2000. Issuance of the permit would allow for take of federally listed species on non-Federal property during otherwise lawful activities.*	This recommendation has been incorporated int the document.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
161	EPA	Chapter 9	Changing water tables from the creation of wetlands in, and near, the Wash is not discussed for nearby lands, nor is increased irrigation and developmen of adjacent lands on the Wash discussed in sufficient detail to generate a complete understanding of these potentially complex interrelationships.	This comment has been incorporated into Chapter 10. Several study teams have recommended that we not only need to understand the influence that land use activities have on the Wash, but also understand any affects development of the Wash will have on surrounding land. The Land Use Study chapter addresses the relationship between land use and affects on the Wash.
162	Clark County	Chapter 9	On page 1 of the chapter, change " … was designed to guide development of the Park's recreational facilities and support infrastructure, while at the same time ensuring conservation and enhancement of ecological resources within the Park.", to read; *was designed to protect and enhance wetlands for wildlife habitat, environmental education, and recreation* . This statement was derived from the Master Plan.	This recommendations has been incorporated into the document.
163	Clark County	Chapter 9	On page 2 of the chapter, change the second paragraph to read;*Due to the various agencies with jurisdictional interests and related public responsibilities within the Wash, implementation of the Wetlands Park Master Plan will continue to be coordinated with all affected agencies and interests. A few examples are water quality...*	This recommendation has been incorporated int the document.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
164	Clark County	Chapter 9	On page 3 of the chapter under Overview, change the paragraph to read; *The Clark County Wetlands Park Master Plan (Southwest, 1995) was created as a result of substantial public input by the Southwest Wetlands Consortium, an association of Design Workshop, Montgomery Watson, and SWCA Environmental Consultants. Through the planning process for the Master Plan five goals were established for the Wetlands Park; 1) Develop recreational and tourism opportunities, based on public needs, that are compatible with the conservation/restoration of the Wash, 2) Create social benefits for the Valley by providing opportunities for area residents to gain a sense of community pride and ownership of this park, 3) Create educational opportunities to convey the importance and significance of the Wash through various media, 4) Conserve and restore natural resources by protecting and enhancing the ecological resources of the Wash, and 5) Complete a master plan that will guide the design and development of the Park's recreational facilities and support infrastructure. The Master Plan defines strategies ...*	This recommendation has been incorporated into the document.
165	Clark County	Chapter 9	Regarding Action 4: Ensure Implementation of Mitigation Measures, and Action 6: Ensure Interagency Coordination. Please add Clark County Department of Comprehensive Planning to the "entities" list. The CCDCP water quality and Multiple Species Habitat Conservation programs are interrelated with the implementation of the Clark County Wetlands Park Master Plan.	This recommendation has been incorporated into the document.
166	City of Las Vegas	Chapter 9	Recommend insertion of the following paragraph: "EPA policies are much more reasonable for municipalities that discharge into large bodies of water. As a result, the Las Vegas Valley dischargers would benefit from moving their discharges into the lake. However, we support the creation of wetlands in Las Vegas Wash, and would like to use at least some of the high-quality water from our treatment facilities to sustain new wetlands and the birds and wildlife that will inhabit these wetlands."	This comment does not fit within the nature of Chapter 9, and may not necessarily reflect the view of the entire LVWCC, and has therefore not been incorporated into Chapter 9.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
167	City of Las Vegas	Chapter 9	Recommend insertion of the following paragraph: "Because of these restrictive policies, it is imperative that appropriate water quality standards be developed for the wetlands. The standards must be sufficient to protect wetlands biota, but must also be within the capabilities of the treatment plants. The standards must also allow for the treatment that is to be provided by the wetlands, and otherwise allow the wetlands to be managed as a park."	This comment does not fit within the nature of Chapter 9, and may not necessarily reflect the view of the entire LVWCC, and has therefore not been incorporated into Chapter 9.
168	USFWS	Chapter 10	Chapter 10, Fish and Wildlife. Development of the Las Vegas Wash Wetlands Park will provide opportunities for the incorporation of conservation measures that would complement the MSHCP. During the first two years of the MSHCP, Clark County Department of Parks and Recreation will receive funding specifically for the implementation of conservation activities that provide benefits to listed and other species name in the MSHCP. This grant is specifically contingent upon the Department o Parks and Recreation matching the grant with a contribution from other funding sources.	This recommendation has been incorporated int the document.
169	USFWS	Chapter 10	Chapter 10, Environmental Resources, Fish and Wildlife. The razorback sucker should be included in Table 10.2. Although the bald eagle (Haliaeetus leucocephalus) is currently proposed for delisting, to date, the determination has not been made to delist this species. Therefore Table 10.2 should be changed to show that the bald eagle is proposed for delisting unde the ESA. The document should note that if the bald eagle is delisted, the ESA requires the Service to monitor the status of the species for a minimum of 5 years after removal from the list. If a delisted species is found to be at risk, the Service will review the best available information and if necessary, invoke the emergency listing clause of the ESA, and relist the species.	Table 10.2 is a list of species covered by the CCMSHCP and/or Federally-listed species that could potentially occur in the Wetlands Park Study Area. The razorback sucker falls under neither of these categories, and was therefore no included in Table 10.2. However, a discussion on the razorback sucker (as it relates to Federally-listed species that have the potential t be impacted (positively and/or negatively) by activities occurring within the Wash) has been added to Chapter 10.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
170	USFWS	Chapter 10	Chapter 10, Environmental Resources, Recommended Actions. We agree with the recommendation to develop a long-term environmental monitoring plan and establish a process to gather baseline information, some of which already exists. These actions are essential in assessing the overall health of the Wash and progress of the restoration process.	This recommendation has been incorporated into the document.
171	USFWS	Chapter 10	Chapter 10, Environmental Resources, Recommended Actions, Long-Term Soils Monitoring Plan. We recommend referencing the proposed Sediment Quality Monitoring Program in the Final Program Environmental Impact Statement for the Clark County Wetlands Park (Bureau of Reclamation and Clark County Parks and Recreation, 1998) for use as a template in developing the overall Soils Monitoring Plan mentioned here.	This recommendation has been incorporated into the document.
172	USFWS	Chapter 10	Chapter 10, Environmental Resources, Recommended Actions, Long-Term Water Quality Monitoring Plan, Specific Parameters. Under "General" parameters, we recommend inclusion of dissolved oxygen, ammonia (ionized and unionized), and temperature. Under "Other" parameters we recommend that pesticide analysis include organochlorines and organophosphates.	This recommendation has been incorporated into the document.
173	Clark County	Chapter 10	"Entities" have not been identified under the recommended actions. Clark County (Multiple Species Habitat Conservation Plan) should be listed under the action items as affected entities.	This recommendation has been incorporated into the document. Additionally, the CCMSHCP was not listed as an "entity" because only coordination committee members are included for the initial comprehensive plan.
174	EPA	Chapter 11	Regarding Action 3, Development of Best Management Practices (BMP). The NDEP, Non-point Source Branch, has developed a comprehensive BMP Manual that could be used as a starting point.	This information will be utilized in the continuing process.
175	Clark County	Chapter 11	Regarding City of Las Vegas Planning Process. The General Plan Amendment (GPA) process is a formal p ocess. The GPA's are heard by neighborhood associations, planning commission, and city council four time a year. A change in zoning application can run simultaneously with a GPA.	This recommendation has been incorporated into the document.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
176	Clark County	Chapter 11	Regarding City of Las Vegas Zoning Approval Process. Almost all of the changes in zoning applications are routed to the impacted neighborhood association for meetings, review and recommendations.	This recommendation has been incorporated into the document.
177	Clark County	Chapter 11	Regarding Action 1: Focus Land Use Recommendations on the Priority Zone of Influence (1/2 mile radius of Las Vegas Wash). Staff concurs with this recommendation; however, we have reservations concerning the effectiveness of this action without the active support of the other agencies whose expertise is needed to evaluate projects in Tier 1. In order for this action to be effective, the LVWCC should formally adopt or endorse the map shown in Figure 11.2 and have the agencies that are members agree to support the County and cities in their efforts to evaluate land use applications and provide appropriate recommendations.	This recommendation has been incorporated into the document. The following sentence has been added to the explanation under Action 1, "This recommendation includes recognizing that an interagency effort is necessary for this effort to be effective."
178	Clark County	Chapter 11	Regarding Action 1: Focus Land Use Recommendations on the Priority Zone of Influence (1/2 mile radius of Las Vegas Wash). Upon final action by the Coordination Committee, they should provide the County and other agencies copies of the Map shown in Figure 11.2. Their GIS staff should work with GIS staff from the County and cities to show Tier 1 overlaid on our parcel layer. They should also work with our staff so HTE will flag parcels that fall in Tier 1 similar to the way the Henderson Interlocal Agreement area is flagged.	This recommendation will be presented to the Las Vegas Wash Management Entity, when designated, for action.
179	Clark County	Chapter 11	Regarding Action 1: Focus Land Use Recommendations on the Priority Zone of Influence (1/2 mile radius of Las Vegas Wash). Regulation of applications in Tiers 2 and 3 would call for wide spread changes to other County Codes, not just Title 29. It also may require changes in State and Federal regulations. It may be more appropriate to address these issues under actions 2, 3, and 5 of the Land Use Study Teams recommendations.	This recommendation will be presented to the Las Vegas Wash Management Entity, when designated, for action.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
180	Clark County	Chapter 11	Regarding Action 1: Focus Land Use Recommendations on the Priority Zor of Influence (1/2 mile radius of Las Vegas Wash). As a part of the adoption process for the Map shown in Figure 11.2, the other Study Teams which are reviewing technical issues should evaluate the map to ensure the scientific validity of the 1/2 mile radius for Tier 1 and the boundaries for Tiers 2 and 3. This will be necessary to convince developers of the importance of following the review process and conditions, and in order to stand up to any legal challenges.	Technical validity of this radius is an important consideration. This recommendation will be presented to the appropriate study team and Las Vegas Wash Management Entity, when designated, for consideration.
181	Clark County	Chapter 11	Regarding Action 1: Focus Land Use Recommendations on the Priority Zor of Influence (1/2 mile radius of Las Vegas Wash). Tier 3 zone of influence must reflect the BLM disposal boundary map that was adopted through the Public Lands Management Act adopted October 1997. The BLM disposal boundary map shown is incorrect. The correct boundary map is available through Clark County Department of Comprehensive Planning, map dated April 10, 1997. Access to the map can be found through the Clark county Center for Enterprise Information and Technology GIS Management Office.	The correct boundary has been incorporated into the document.
182	Clark County	Chapter 11	Regarding Action 2: Support the Development and Implementation of a Common Environmental Review Process among Planning Entities. Staff agrees that all entities should have a common review process. The actual environmental review should be conducted by the suggested Las Vegas Wash Management Agency. This will ensure consistency of interpretation and that proper expertise is provided. They should be added to the list of entities affected by this action.	This recommendation has been incorporated into the document.
183	Clark County	Chapter 11	Regarding Action 3: Develop(ment) of Best Management Practices. Although staff agrees with this concept, such BMPs might call for wide spread changes to other County Codes, not just Title 29. It also may require changes in State and Federal regulations. Other concerns are resources and expertise needed to implement/monitor the BMPs after they are adopted.	This recommendation will be presented to the appropriate study team and Las Vegas Wash Management Entity, when designated, for consideration.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
184	Clark County	Chapter 11	Regarding Action 4: Develop educational material for developers. The County already provides this service for the development community. Education concerning BMPs should wait until actions 2 and 3 are completed.	The following sentence has been added to the explanation section of Action 4, "The study team realizes that many entities already provide BMPs to interested parties, but believes additional BMPs could be identified and developed, and that consistency from one entity to another would be beneficial."
185	Clark County	Chapter 11	Regarding Action 5: Identify Opportunities for Interagency Coordination Efforts. This action should be expanded to include other agencies belonging to the Coordination Committee such as US Army Corp of Engineers, Nevada Department of Environmental Protection, etc. Environmental concerns could be discussed and represented by environmental team representatives at the land use plan update level. Representatives could make sure that plans reflect the goals and policies that support the interest and management practices that promote the LV Wash Plans.	This recommendation has been incorporated into the document.
186	Clark County	Chapter 12	Introduction. In the first paragraph, the role and responsibilities of Clark County can be summarized in one or two sentences. An example would be: Clark County is responsible for Area-wide Water Quality Management Planning, implementation of the Wetlands Park Master Plan, flood control and land use planning.	The majority of this recommendation has been incorporated into the document (except "flood control").
187	Clark County	Chapter 12	Background. The second sentence of the background, please add: Furthermore, each city and the county is responsible for planning and zoning,.....	This recommendation has been incorporated into the document.
188	Clark County	Chapter 12	Figure 12.2 should reflect the correct diagram for option 2.	Diagrams have been removed from Chapter 12.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
189	WQCAC	Chapter 12	In Chapter 12 the report deals with jurisdictional and regulatory issues, which probably are the very heart of whether this entire effort will be successful. The concerns set forth above [review and coordination processes] also apply to this issue; I do believe that the suggestions for a new joint powers agreement, or modification of the current SNWA agreement, are logical considerations.	No action required.
190	City of Las Vegas	Chapter 13	Page 63. Change first words to either 'Because of' or 'Due to'	This recommendation has been incorporated into the document.
191	City of Las Vegas	Chapter 13	Page 63. Change 'ofof' to 'of'	This recommendation has been incorporated into the document.
192	City of Las Vegas	Chapter 13	Page 34. Third paragraph, correct 'LVWthe' typo.	This recommendation has been incorporated into the document.
193	City of Las Vegas	Chapter 13	Page 35. Fourth paragraph, first line does not make sense grammatically.	This recommendation has been incorporated into the document.
194	EPA	Chapter 13	EPA urges continued, on-going implementation of a public outreach and involvement program for actions in the Wash, and a public outreach and involvement program specific to the Plan itself.	It is intended that a Public Outreach program will continue to be an important component of long-term management of the Wash.
195	Clark County	Chapter 13	Introduction. The first couple of paragraphs are disjointed and should be reworked.	This recommendation has been incorporated into the document.
196	Clark County	Chapter 13	Appendix 13.2 (Public Outreach Program Overview). In the first paragraph under situation analysis, the first sentence should read "stormwater system" not "storm sewer system".	This recommendation has been incorporated into the document.
197	Clark County	Chapter 13	Recommendation 4 is premature at this time and should be deleted or modified to read: These proposals will be considered in conjunction with the review of this Comprehensive Adaptive Management Plan..	This recommendation has been incorporated into the document.
198	City of Las Vegas	Chapter 14	General: This chapter should include a summary and discussion of the money spent to date or allocated for on-going studies that address issues in and around the Las Vegas Wash (Alternate Discharge Study, Reuse Study, Needs Assessment Study, etc.)	The intent of this chapter is to provide potential funding options for further review by the Las Vegas Wash Management Entity.
		Recommended Actions		

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
199	EPA	How to Accomplish	Information in Chapters 12, 13, and 14 conveys how the recommendations will be accomplished, so it would be helpful to present this information earlier in the document, so readers would have it in mind as they read the balance of the plan.	The Executive Summary has been changed to clarify the key recommendations and action items.
200	WQCAC	Consequences	Place objectives up front in Plan, and highlight negative consequences that may result from recommended actions. Public and elected officials should be forewarned of issues (i.e., expensive bureaucracy proposed, funding needed) and be given opportunity to react.	In Chapter 13, the Public Outreach Study Team recommends developing feedback mechanisms and keeping elected officials involved in the process.
201	EPA	Implementation	Some of the recommendations specify the entities which might implement them. This is very useful, and it would be ideal if all the recommendations included this information.	All the Study Team chapters now contain potential implementation entities.
202	EPA	Summarize in Tables	We suggest including a summary table of the recommended actions, compiling all of them into one place, showing who, what, when, how, etc. Similarly, a summary table of the costs of all the recommended actions would be useful, identifying existing and possible future revenue sources. Yearly estimates of funding needs, related to a timeline, would foster the necessary budget planning required to implement projects. A timeline for accomplishing all the actions would also help identify the magnitude of the overall plan, as well as allow for monitoring of progress.	A summary of all 44 study team actions are included in Section IV, Summary of Recommendations. Timelines and costs will be determined once the management entity is established.
203	EPA	Prioritize	It would be useful to establish relative priorities among the recommended actions, since limited funding and other resources are available. Also, the plan states that certain actions must precede others. This suggests that a critical path would be useful.	This will occur, under direction from the Coordination Committee, once the management entity is established.
		Wetlands		
204	WQCAC	SNWA	The plan doesn't appear to provide a clear commitment on if SNWA desires more wetlands than that envisioned for the Park.	SNWA is working with Clark County to ensure the Master Plan for the Park is successfully implemented. SNWA has no preference for wetland acreage.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
205	FDWP	Sunrise Landfill, Nature Center	Wetlands should be constructed near the Sunrise Landfill to help remedy the contaminated water leaking from the site. Wetlands should be constructed just south of the Nature Center.	Off-stream wetlands are being considered.
206	Public Workshop	Add Organics	Consider adding organics to the sediment where possible, for example at the Nature Center ponds.	This recommendation is not clear.
207	Clark County Health District	Pests	No reference was found relating to mitigation of problems that may be caus by wetlands, such as increased pest populations (especially mosquitoes and mice), and increased risk of diseases vectored by those pests.	No action required. Reference to pest control/nusiance factors is mentioned as selection criteria in Chapter 8.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
		Water Resources		
208	USFWS	Effects of Water Quality to Species	The Las Vegas Wash and Las Vegas Bay provide habitat for a variety of wildlife and species protected under the Endangered Species Act of 1973, as amended (ESA), including the endangered southwestern willow flycatcher (*Empidonax traillii extimus*), endangered yuma clapper rail (*Rallus longirostris yumanensis*), and the endangered razorback sucker (*Xyrauchen texanus*). The Wash and Bay also provide habitat for numerous migratory bird species protected under the Migratory Bird Treaty Act. We continue to be concerned that the degraded water quality found in the Las Vegas Wash and Las Vegas Bay is adversely affecting these wildlife resources. We are particularly concerned with the status of the razorback sucker which has designated critical habitat that extends into the Las Vegas Bay and Las Vegas Wash.	Concern noted, and comment taken under advisement. No action taken at this time.
209	Lockheed Martin Env. Services	Shallow Ground Water	Historical photo analysis of land use for the nearby region could benefit the shallow water monitoring program. These analyses are routinely used to identify probable contamination sources, such as old landfills, and assist the interpretation of well monitoring data.	This recommendation will be added to the list of monitoring considerations in Chapter 7, Shallow Ground Water.
210	WQCAC	Stormwater	LVWCC members should study the benefits of such activities as stormwater harvesting and retention basins, and also consider what is going on upstream and in the watershed as a whole, before solutions are formulated for downstream.	Understanding flood control plans and determining the benefits of stormwater harvesting and the construction of retention/detention basins will be investigated as recommended in Chapter 6, Erosion & Stormwater.
211	LVVWD	Fecal Coliform & Streptococcus	The significant findings of fecal coliform bacteria and fecal streptococcus are not mentioned on page 82, while less important issues are highlighted.	Concerns regarding bacteria as a potential water quality concern is mentioned in Chapter 7, Shallow Ground Water.
212	LVVWD	Public Health Issues	Though this is a Comprehensive Plan, preserving the vegetation in the Wash seems to be the highest priority. The public health issue of a guaranteed pure drinking water supply might be considered a higher priority by many. This issue appears to be under analyzed in the Plan.	Drinking water is one component, but there are many other issues associated with the Wash.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
213	LVVWD	Water Quality	One of the Study Teams should have been, or still could be, dedicated to Water Quality.	It was determined early in the process that water quality should be covered in several individual study teams.
214	Public Workshop	Water Flow	In order to support wetlands in and around the Wash, the flow of water needs to be controlled.	The Wetlands Park and Environmental Resources Study Teams have included this action as a recommendation.
215	Public Workshop	Contaminants	Does the LVWPCT have a list/ranking of leading contaminants in the Wash? There is concern about the cumulative impacts of contaminants on human health.	Water quality data for the wash is included in the water quality database developed by the Las Vegas Wash Project Coordination Team.
216	EPA	Sunrise Landfill, BMI Complex	The Plan needs to clearly set forth how clean up efforts for the Sunrise Landfill and the BMI Complex will be integrated with, and impact, improvements to the Wash.	Any ground water entering the Wash will be addressed; however, clean up and regulatory efforts are outside the scope of this document.
217	EPA	1/2 Mile Zone	The 1/2 mile zone may not be appropriate. A better criteria, but more difficult to establish, might be based on near-surface ground water velocities. For example, activities that potentially could affect the hydrology of the Wash within specific time horizons, such as the next 10, 15, or 20 years, should be reviewed to determine if they will impact the Wash and whether unforeseen, adverse impacts could be mitigated in time to avoid jeopardizing the benefits hoped for from other projects.	The Land Use Study Team set the arbitrary boundaries with the understanding that as more information became available, the boundary could be changed. Additional hydrogeologic studies to determine time of travel, which is recommended by the Shallow Ground Water Study Team in Chapter 7, will need to be conducted.
218	WQCAC	1/2 Mile Zone	One concern that I believe must be carefully addressed is the rights of landowners in the vicinity of the Wash, so that whatever public entity is responsible does not get into a "taking" situation on adjacent properties. I note in Chapter 11 the suggested one half (1/2) mile Zone of Influence from the center line of the Wash. Obviously whatever private holdings are within this corridor would be affected in value, but it could easily, and I would, spill over much further insofar as master planned developments, etc.	We concur with this comment. This will be addressed by the management entity.

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#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
219	UNLV	Stormwater	The plan is lacking information on the long-term bank stabilization in the wash. It seems that a good strategy would be to contain the normal flows (e.g., with a 1-2 year return period) in a well defined bio-engineered channe and then allow larger flows to be conveyed in the overbank areas. This will allow the larger flows to be safely conveyed downstream and also allow for deposition of sediments in the overbank areas.	The plan is a guidance document and these issues will be specifically addressed by the management entity as the plan is implemented.
220	UNLV	Watershed Management	Watershed management is not discussed in plan. There is an increasing awareness that comprehensive plans for rivers, creeks, or washes most have a watershed management component that addresses the quantity and quality of runoff in the watershed. For instance, comprehensive watershed management can be used to identify ways to control the quality of urban runoff at or near the source.	The plan is a guidance document and these issues will be specifically addressed by the management entity as the plan is implemented.
221	UNLV	Endocrine Disruptors	Endocrine disruptors are not mentioned in the water quality portion of the document. Given the close relationship between the Wash and Lake Mead and the possibility of federal regulations to control endocrine disruptors discharge, it would be proactive to monitor the sources and the quantities of these contaminants in the Wash.	The plan is a guidance document and these issues will be specifically addressed by the management entity as the plan is implemented.
222	UNLV	Nitrate	Nitrate levels in the Wash are not mentioned in the water quality portion. The State is currently considering establishing regulations that will limit nitrate discharge to receiving water bodies. When in place, this regulation will require complete removal of nitrogen from the wastewater effluent by denitrification. The levels of nitrate in the Wash would then decrease considerably. This may affect the nutrient load available to establish the Wetlands Park.	The plan is a guidance document and these issues will be specifically addressed by the management entity as the plan is implemented.
223	UNLV	Selenium	The presence of selenium in the wash should be closely studied prior to constructing the Wetlands Park. If selenium were to be found associated with surface sediments in the area, it would be appropriate to remove the contaminated sediments or use in-situ treatment systems to remove selenium prior to establishing the Wetlands Park.	The plan is a guidance document and these issues will be specifically addressed by the management entity as the plan is implemented.

Comments Received on the Draft Las Vegas Wash Comprehensive Adaptive Management Plan

Last Revised: 1/4/2000, @ 4:40 PM

#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
224	UNLV	Perchlorate	Although perchlorate contamination has received much attention, it is necessary to consider the volume and the quality of the flow that will be added to the Wash due to the treatment of the perchlorate-contaminated groundwater. The current estimate suggests it will take about 20 years to treat the perchlorate-contaminated aquifer, treating at 1000 gpm.	Recent clean up activities currently underway have intercepted flows that should result in reductions of perchlorate in the Wash. The plan is a guidance document and these issues will be specifically addressed by the management entity as the plan is implemented.
225	UNLV	Microbial Input	The biological quality of the Wash is not mentioned in the water quality chapter. Monitoring and establishing measures to decrease the microbial input from runoff is critical, since control of this input is very difficult.	Biological concerns are mentioned in Chapter 4, Table 4.1; however, this issue will be monitored and addressed in more detail by the management entity.
226	UNLV	Salinity	The salinity of the Wash was mentioned. However, a more comprehensive approach should be taken to persuade our community to look for alternative discharges for the brine generated by water softening.	Comment taken under advisement.
		Public Considerations		
227	WQCAC	Advance Information	Staff should develop methods to get advance information on the Plan out to the community, before public workshops/meetings.	The LVWPCT will work to ensure information about the Plan is available to the public, prior to future meetings (website, newspaper, newsletter etc).
228	WQCAC	Staff Knowledge	Plan doesn't explain effectively why initial steps need to be taken as indicated. Public might need to know why one step is before the other. Staff should be prepared to answer questions on why no action had been taken before.	Additional information regarding this comment has been included throughout the document.

Comments Received on the Draft Las Vegas Wash Comprehensive Adaptive Management Plan

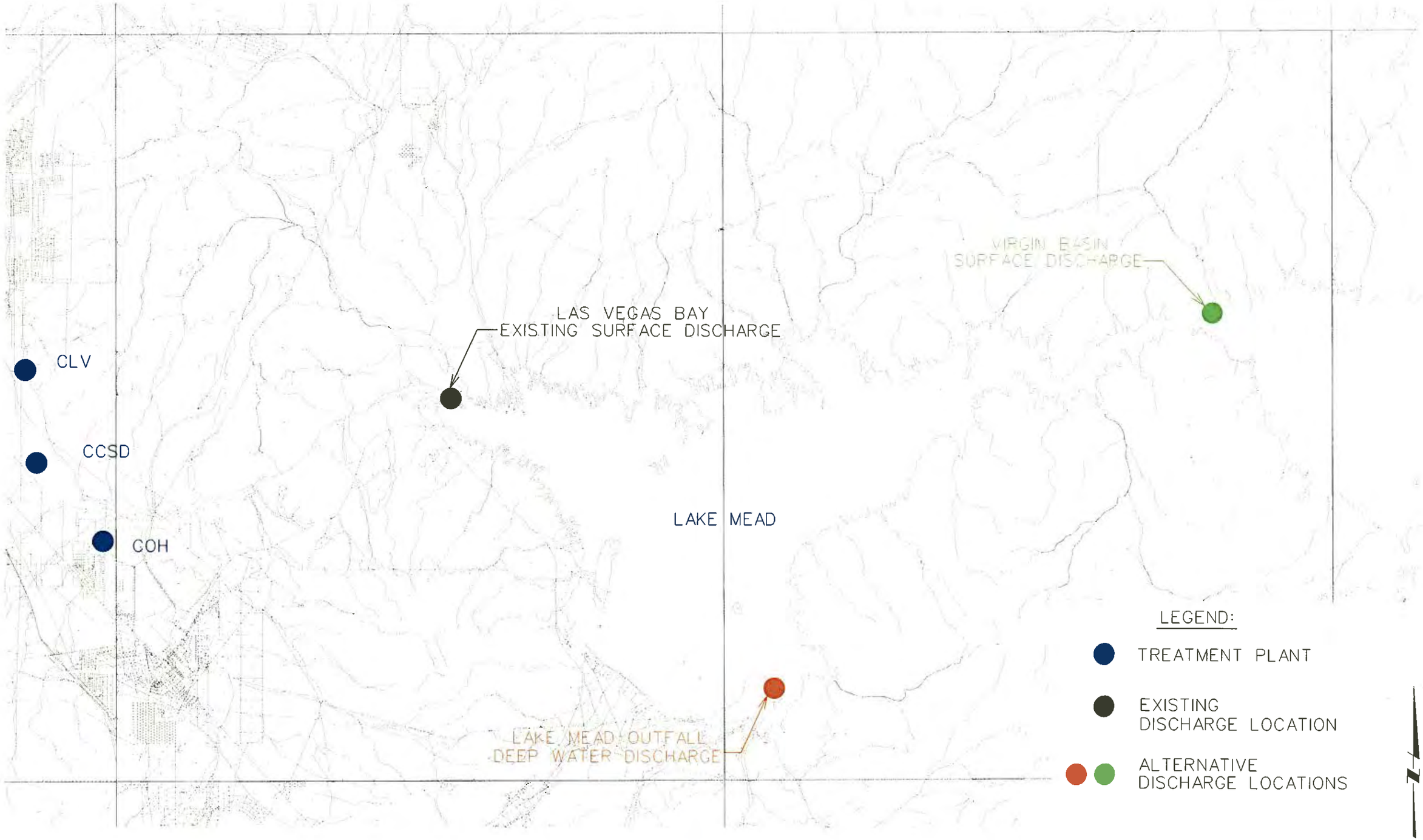
Last Revised: 1/4/2000, @ 4:40 PM

#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
Misc. Suggestions				
229	ACOE	Consult FAA	Check with the FAA regarding developing wetlands where birds may interfere with flight plans. The FAA has rules regarding the impact of wetlands near flight paths.	The LVWPCT will meet with McCarran staff to determine the level of assessment required to address potential conflicts with FAA regulations.
230	ACOE	Conceptual Design Map	Include the map of the proposed conceptual design for the Wash in document.	A variety of conceptual plans have been included in the document.
231	Public Workshop	Annual Clean-Up	Is it possible to use large equipment at the next Annual Wash Clean-Up event, to remove the large debris (e.g., cars). Volunteers were lifting and removing larger items and probably shouldn't have been.	The LVWPCT will work with Clark County to investigate the feasibility of using heavy equipment prior to the next Clean up event.
232	Public Workshop	Bike Trails	Is it possible to connect the bike trails that will be designed/built, to the old Howard Hughes bike trail that runs from Lake Mead to Red Rock?	The LVWPCT will notify Clark County Parks and Recreation of this comment.
233	Public Workshop	Growth	Has the LVWCC included recommendations relating to slowing growth? Resolving issues in the Wash is integrally tied to slowing growth.	This document is not intended to address growth related issues.
234	UNLV	Web Site	It would be nice to add a section to the Wash Web Site named "Ask the Expert". Also, the schools could communicate over the Wash Web Site with each other. Three to four teachers could be trained on the Web Site and used as a "prototype".	The LVWPCT will investigate adding a section to the Wash Web site related to "Ask the Expert", where the public can ask questions on-line. The LVWPCT will also investigate the feasibility of using the Wash Web site for schoo teacher communication in areas relating to educating students about the Wash.
235	Public Workshop	Wetlands Park	Incorporate art into the Nature Center area and/or the rest of the Park. There is a park in Seattle that has incorporated art (e.g., statues, historical items, etc.) into their outdoor park. This may be appropriate for the Wash as well.	The LVWPCT will notify Clark County Parks and Recreation of this comment.

Comments Received on the Draft Las Vegas Wash Comprehensive Adaptive Management Plan

Last Revised: 1/4/2000, @ 4:40 PM

#	ENTITY	SUBJECT	COMMENT(S)	RESPONSE
236	Lockheed Martin Env. Services	Use Remote Sensing Technology	Increased use of aerial photography and other remote sensing products, such as satellite imagery, could benefit numerous analyses (structure siting, flow path mapping, erosion monitoring, etc.) and improve the general communication of important land cover relationships. A good photograph can often help explain complex concepts.	This recommendation will be forwarded to the appropriate study team.
237	Lockheed Martin Env. Services	Use GIS Technology	The various organizations involved are known to make effective use of geographic information system (GIS) technology. Increased support and use of GIS for the Wash program would benefit both analyses and the general communication of program activities. Especially noteworthy are new web-based GIS tools. which can be extremely useful for public outreach.	This recommendation will be forwarded to the appropriate study team.
238	WQCAC	Video Correction	The video covering water quality needs to be brought in line with the history contained in the Plan. Pat Glancy is correct, the wash dates back to million of years ago and the wetlands are historic and not the result of man's settling the Valley.	Every effort will be made to revise the video.
END	**END**	**END**	**END**	**END**

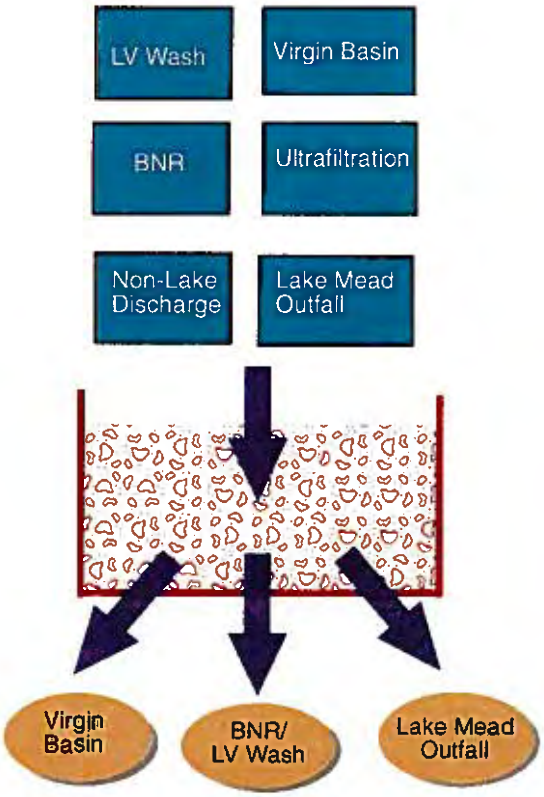


MONTGOMERY WATSON

EXISTING AND ALTERNATIVE DISCHARGE LOCATIONS

FIGURE ES-9

Figure ES-8
Alternatives



FEASIBLE ALTERNATIVES

Each of the three feasible alternatives were further developed and evaluated with respect to each Dischargers' future needs and relative impact.

Discharge Requirements

Discharge requirements applicable to each alternative are presented in Table ES-7.

Capacity Requirements

Capacity phasing requirements were provided by each Discharger. To provide the prescribed level of treatment for each alternative, each of the Dischargers' facilities will require capacity upgrades in three or four phases. The first phase for each Discharger consists of upgrades for treatment level and capacity improvements to the existing facilities necessitated by increases in raw wastewater strength experienced over the last five to ten years. Subsequent phases provide additional capacity to meet or exceed the projected 2027 wastewater flows and discharge criteria.

Project Costs

Capital and operations costs and other considerations were developed for each alternative and for each of the Dischargers. The estimated costs included both treatment and effluent conveyance systems, as applicable, and present worth costs were developed by alternative and discharger to include project phasing through 2027. The estimated treatment, conveyance and present value costs are presented in Table ES-8.

Table ES-7
Future 30-Day Average Discharge Criteria for the Year 2027 (a)

Parameter	Alternative 1 Las Vegas Wash Discharge	Alternative 2 Virgin Basin Discharge	Alternative 3 Lake Mead Outfall
Future Average Annual Flow, mgd	282	282	282
BOD5 (inhibited), mg/L	30	30	30
Total Suspended Solids, mg/L	30	30	30
pH	6 to 9	6 to 9	6 to 9
Coliform Bacteria, #/100mL	2.2 (total)	2.2 (total)	200 (fecal)
Total Phosphorus, mg/L as P (b)	0.14	NA	NA
Total Dissolved Solids,mg/L added (c)	400	400	400
Total Ammonia, mg/L as N (d)	0.5 to 1.0	1.0	NA
Chlorine Residual, mg/L (e)	0.1	0.1	0.1

(a) This table represents possible future discharge scenarios and requirements that may be more stringent than existing requirements.
(b) Equivalent concentration based on total WLA applied to 282 mgd total effluent flow.
c) Goal for increase above background total dissolved solids concentration.
(d) Concentration-based standard for Alternatives 1 and 2.
(e) For Alternatives 2 and 3, the chlorine residual might be achievable at the point of discharge without specific dechlorination processes because of chlorine decay with travel time in the conveyance pipeline.

Table ES-8
Capital, Operations and Present Value Cost Comparison

	Treatment		Conveyance		Total
	Capital Costs ($ mil)	Operations Costs ($ mil)	Capital Costs ($ mil)	Operations Costs ($ mil)	Present Value ($ mil)
Alternative 1 - Las Vegas Wash Discharge					
City of Henderson	238	294	0	0	532
City of Las Vegas	497	738	0	0	1,235
Clark County San. Dist.	469	955	0	0	1,424
Total	**1,204**	**1,987**			**3,191**
Alternative 2 - Virgin Basin Discharge					
City of Henderson	179	298	94	393	964
City of Las Vegas	384	777	260	1,085	2,507
Clark County San. Dist.	362	1,008	306	1,277	2,953
Total	**925**	**2,083**	**661**	**2,755**	**6,424**
Alternative 3 - Lake Mead Outfall					
City of Henderson	149	277	55	190	670
City of Las Vegas	247	725	151	525	1,649
Clark County San. Dist.	201	941	178	618	1,938
Total	**597**	**1,943**	**384**	**1,333**	**4,257**

Executive Summary

RECOMMENDATIONS

Three feasible alternatives for dealing with the growing wastewater needs of the Las Vegas Watershed were evaluated in detail in this Needs Assessment Study. The fundamental difference between the three alternatives is discharge location. Figure ES-9 depicts the discharge locations of the three alternatives.

The least cost alternative is continued treatment and discharge to the Las Vegas Wash. It is recommended that the Dischargers continue their current planning, design, and construction efforts to bring treatment facilities on line as they are needed.

Concurrent with these efforts, there are several issues that warrant additional investigation and study in light of the changing conditions in the Las Vegas Watershed. These items would provide additional information and a base of knowledge from which to make future decisions.

- An ammonia wasteload increase should be pursued immediately.
- A feasibility study of the two alternative discharge locations, Virgin Basin and Lake Mead Outfall, should be initiated.
- The microbiological impacts of treated effluent on Las Vegas Bay and Lake Mead should be quantified.
- The Dischargers should actively participate in the Lake Mead Water Quality Forum and serve as the leaders in technical issues involved with wastewater treatment.
- The Las Vegas Wash plume in Lake Mead should be thoroughly investigated and quantified.
- A study, and perhaps pilot testing, of the effect of alternative pathogen removal technologies on treated effluent should be considered. The goal of this study would be to determine the appropriateness of these technologies for use as effluent pathogen barriers.
- The Las Vegas Watershed Wastewater Needs Assessment Study should be regularly updated as conditions change.

DRY LAKE VALLEY

APEX

I-15

108"

CLV

78"

CCSD

108"

COH

LAKE MEAD

LEGEND:

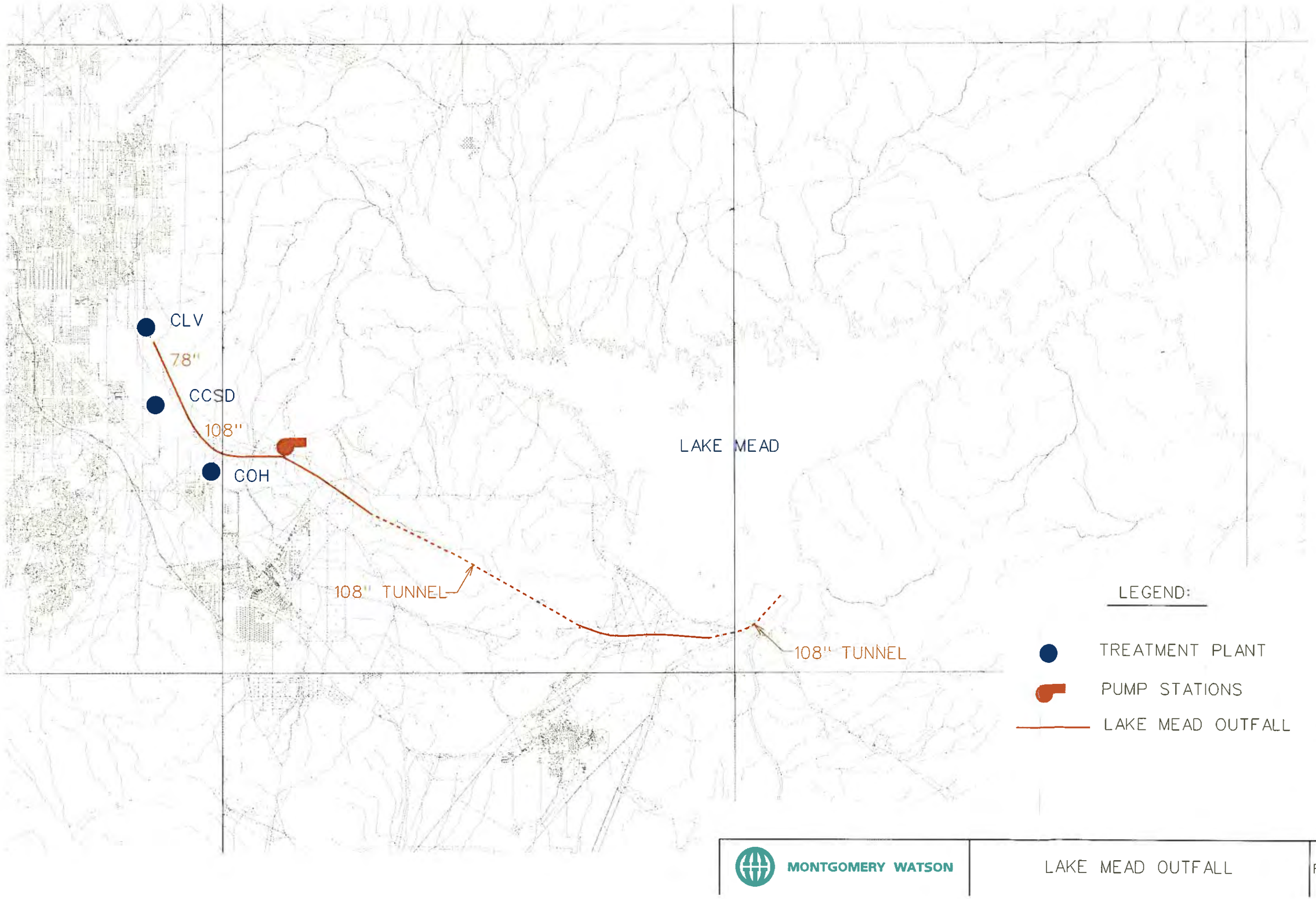
- TREATMENT PLANT
- PUMP STATION
- DRY LAKE DISCHARGE

N

MONTGOMERY WATSON

DRY LAKE DISCHARGE

FIGURE ES-7



MONTGOMERY WATSON	LAKE MEAD OUTFALL	FIGURE ES-6

picts the conceptual alignment of the conveyance system for this alternative.

Tertiary treatment can be achieved by the continued application of the existing treatment processes currently in place and construction of additional tertiary treatment facilities. This includes filtration/disinfection of a nitrified secondary effluent. No phosphorus removal would be required.

Alternative 4. Secondary Treatment with Outfall in Lake Mead

This alternative consists of providing future treatment to meet secondary treatment levels for a submerged and diffused or well-mixed lake discharge. This type of discharge would release effluent deep in the lake, downstream of the water intake for the Las Vegas Valley. The effects of sunlight on effluent nutrients would be mitigated while allowing the nutrients to spread and perhaps increase sport fishing potential in the lower lake. The downstream end of Lake Mead, just upstream of the Hoover Dam, was selected as the outfall diffuser location due to its distance from the water intake, the potentially favorable tunneling conditions in the area, the proximity to the dam and associated currents, and relative accessibility. A common conveyance system from the wastewater treatment plants to the outfall would be sized to pump peak month effluent flows. Figure ES-6 depicts the conceptual alignment of the conveyance system for this alternative.

Secondary treatment can be achieved by the continued application of the existing treatment processes currently in place and construction of new secondary treatment facilities.

Alternative 5. Secondary Treatment with Non-Lake Discharge

This alternative consists of providing future treatment to meet secondary treatment levels for a non-lake discharge. A non-lake discharge would entirely remove the wastewater effluent from Las Vegas Bay and provide a physical separation between the effluent discharge and the water intake for the Las Vegas Valley in Lake Mead. Dry Lake Valley, located north of Apex and west of Interstate Highway 15, was selected as the discharge location due to its internal drainage pattern, absence of development, and proximity to the Las Vegas Valley. A common conveyance system from the wastewater treatment plants to the Dry Lake Valley would be sized to pump peak month effluent flows. Figure ES-7 depicts the conceptual alignment of the conveyance system for this alternative.

Secondary treatment can be achieved by the continued application of the existing treatment processes currently in place and construction of new secondary treatment facilities.

Alternative 6. Ultrafiltration

This alternative consists of providing future treatment through the continued use of existing processes for secondary and tertiary treatment with further treatment by ultrafiltration. This alternative would provide a positive microorganism barrier for the effluent before discharge to the Las Vegas Wash, Las Vegas Bay, and ultimately, Lake Mead.

Alternative Evaluation

Each of these alternatives were evaluated with respect to cost and non-cost criteria and three feasible alternatives were identified for further consideration and evaluation. Seven cost and non-cost evaluation criteria were used to screen the six alternatives down to three feasible alternatives. A list of the criteria follows:

- Lake Mead Water Quality
- Ability to Meet Future Regulations
- Accommodate Growth
- Ease of Permitting
- Impact on Dischargers Relationships
- Community Acceptance
- Cost

Figure ES-8 depicts the six initial alternatives and the results of the screening evaluation.

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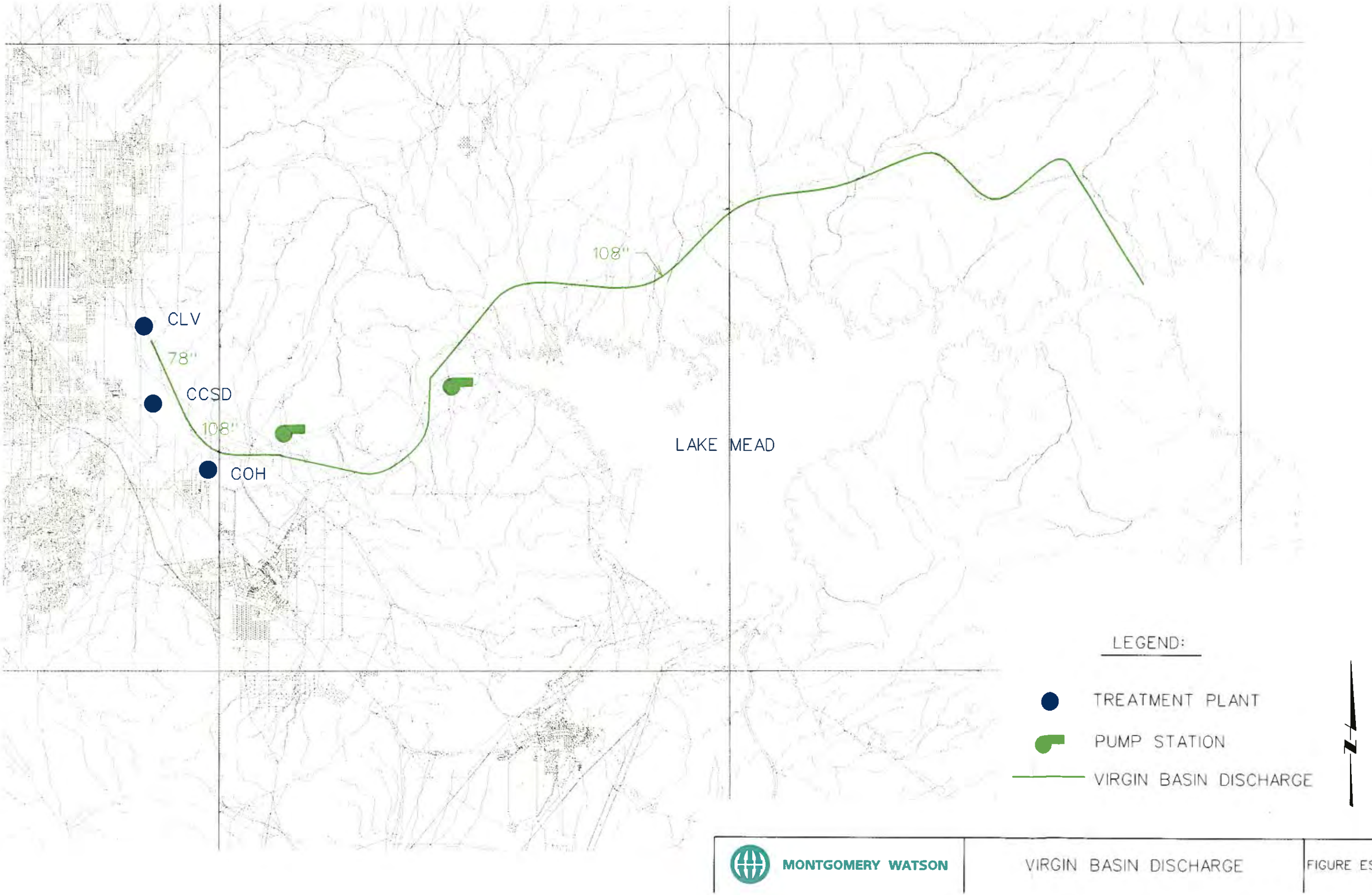

MONTGOMERY WATSON

VIRGIN BASIN DISCHARGE

FIGURE ES-5

Figure ES-2
Las Vegas Valley Average Wastewater Flow and Strength Increases (1991 -1996)

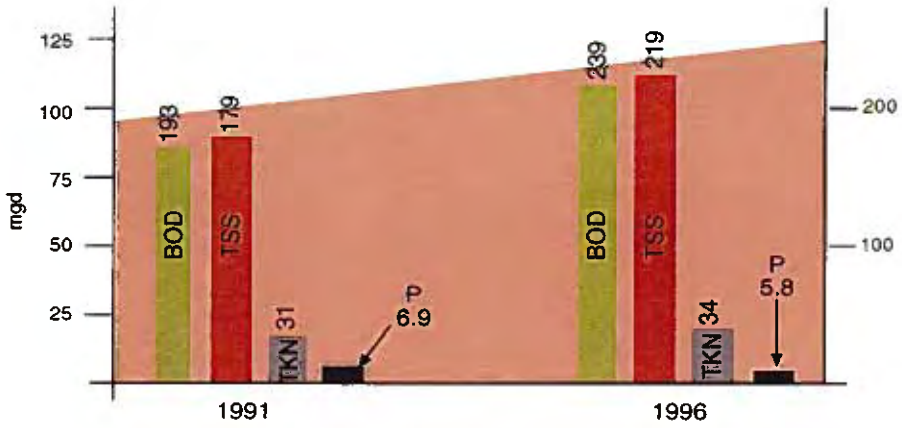

Table ES-1
Influent Wastewater Flow Peaking Factors

Conditions	Peaking Factors CoH	CLV	CCSD
Average Annual	1.0	1.0	1.0
Peak Month			
Recent	1.07	1.1	1.13
Past Studies and Reports	(a)	1.16	1.15
Peak Day	(a)	1.33	1.4
Peak Hour	2	1.5	1.6

(a) No data.

Table ES-2
Las Vegas Dischargers Average Annual Flow
Existing Treatment Plant Capacities

	CoH	CLV	CCSD	Total
As designed	19.5	57	88	173.5
As designed (LV Wash discharge)	10.0	57	88	164
As calculated (LV Wash discharge)	9.3	49	80	138
Limiting Factor	Oxidation ditch	Nitrification facility	Activated sludge-BNR	

provide sewer service to their respective service areas. Interlocal agreements between these agencies allow for sewer service across jurisdictional boundaries which reduces the potential for unsewered areas, increases efficiency, and minimizes cost to rate payers.

Figure ES-3 graphically depicts the institutional arrangements for wastewater in the Las Vegas Valley.

WATER QUALITY AND REGULATIONS

The Las Vegas Wash receives drainage from a 1,600 square mile area and discharges into the western end of Las Vegas Bay. The wash receives treated effluent flows from the Dischargers' wastewater treatment facilities and stormwater, nuisance water, and groundwater non-point discharges from the watershed.

Receiving Waters

In 1987, the Nevada Division of Environmental Protection (NDEP) published recommendations and revisions to the standards for pH, total phosphorus, chlorophyll a, and un-ionized ammonia concentrations for the Las Vegas Wash and Lake Mead. In 1989, the NDEP established Total Maximum Daily Loads (TMDLs) for phosphorus (434 lb/day) and ammonia (970 lb/day). These TMDLs are divided into wasteload allocations (WLAs) among the Dischargers with a portion of the phosphorus TMDL (100 lb/day) allocated to non-point sources. The phosphorus TMDL is in effect from March 1st through October 31st of each year; the ammonia TMDL is in effect from April 1st through September 30th of each year.

In accordance with their respective discharge permits, the Dischargers collect and analyze samples from Las Vegas Wash, Las Vegas Bay, and Lake

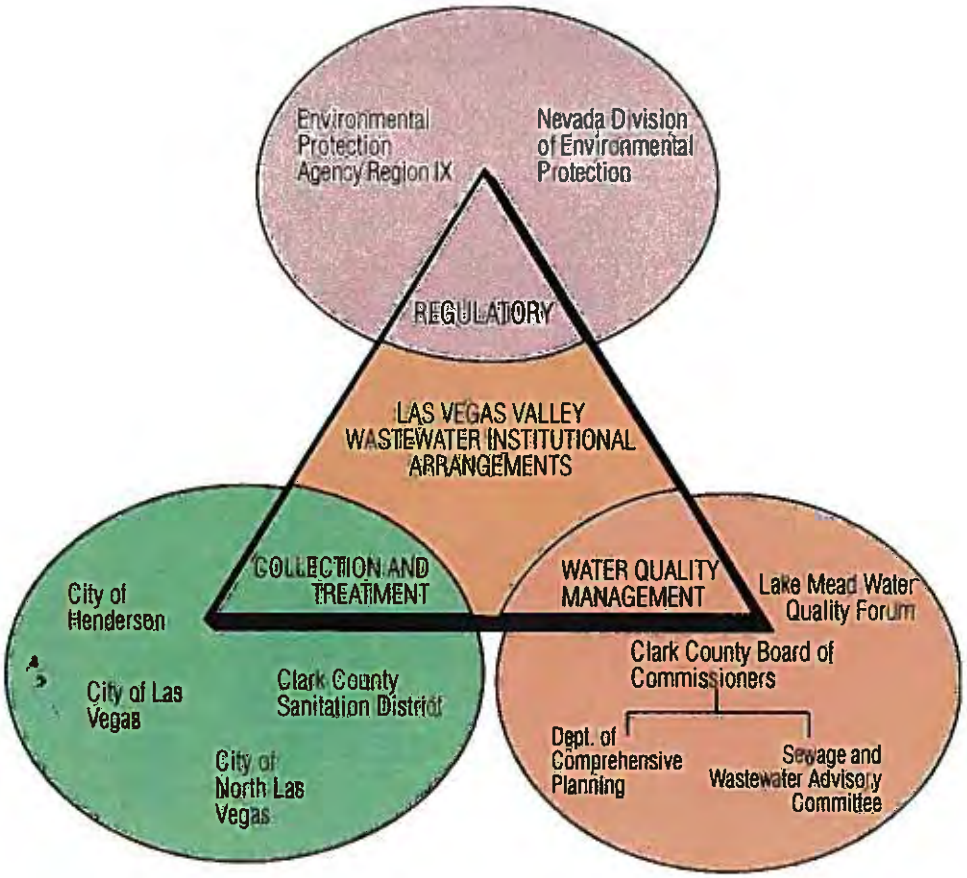

Figure ES-3
Las Vegas Valley Wastewater Institutional Arrangements

Executive Summary

Mead. Actual water quality, when considering chlorophyll a and un-ionized ammonia has significantly improved for both Stations LM2 (Las Vegas Bay) and LM3 (Lake Mead). The causative effect most likely is the construction of new treatment facilities at the CLV and CCSD. This data indicates a trend towards improved water quality. Data show that there is a considerable margin between the water quality standard and actual water quality at both Stations LM2 and LM3.

Water Sources

Wastewater treatment facility discharges account for the majority of flows in Las Vegas Wash, with an average of 125 mgd in 1996. These facilities treat almost all residential, commercial and industrial wastewater generated within the Las Vegas Valley watershed. The Dischargers monitor treated effluent from the facilities in accordance with the requirements of the NPDES permits. In many instances, effluent water quality far exceeds (is of significantly better quality than) the discharge limits.

Non-point sources also contribute nutrients (phosphorus and nitrogen) to the Las Vegas Wash through six major storm drainage outfalls, numerous minor outfalls, and overland flow. Total phosphorus loading from non-point sources discharged through the storm drainage system is computed as the total of the dry and wet weather loadings. A non-point load estimate using stormwater NPDES 1992-1995 data results in an estimated total phosphorus loading of 59 lb/day in an average year. The phosphorus load in a particular year could range from one-half to two to three times this amount based on actual hydrologic conditions affecting the wet weather contribution.

Most of the non-point phosphorus load is contributed to Las Vegas Wash during storm events. In an average year, 12 storms produce significant runoff in the Las Vegas Valley with about one-half of the mean annual rainfall occuring during the March - October TMDL allocation period.

The total phosphorus load of 100 lb/day appears to overestimate the actual load in dry and average years, but is reasonable for wet years. Further study of this issue may be warranted in order to lower the allocated non-point source total phosphorus load and thereby increase the total phosphorus TMDL available to the wastewater treatment plants.

FUTURE FLOWS AND LOADINGS

Wastewater influent and reuse flows are projected to significantly increase during the planning period. Influent wastewater strengths are a significant parameter in the design of future treatment facilities and have steadily increased during the last five years.

Wastewater Influent and Reuse Flows

Wastewater influent flows are expected to increase from the average annual 125 mgd flow of 1996 to 282 mgd in the year 2027. Reuse demand, currently a minor portion of total effluent flows, is also expected to increase as dedicated reclamation facilities are constructed. Figure ES-4 depicts the projected reuse and wastewater flows during the planning period.

Wastewater Influent Concentrations

Wastewater concentrations for BOD, TSS, nitrogen, and TDS have steadily increased over the past 5 years. The phosphorus concentrations, however, have continued to steadily decline over the same period. The concentrations of the various wastewater constituents have been assumed to remain constant over the entire planning period through the year 2027. This assumption could have a significant impact on the selection, sizing and overall cost of future wastewater treatment facilities and actual wastewater characteristics should continue to be monitored and evaluated to ensure that the design criteria used for new treatment facilities are appropriate.

The year 2027 projected influent and reuse flows and influent concentrations are presented in Table ES-3. Peak month values are reported for influent flows and concentrations.

FUTURE REGULATIONS

Future regulations for wastewater treatment may include more stringent requirements for a variety

Table ES-3
Summary of Projected Peak-Month Influent Wastewater Flows and Characteristics

PARAMETER	Units	Annual Average and Peak-Month Value for Year 2027					
		CoH		CLV		CCSD	
		Average	Pk Month	Average	Pk Month	Average	Pk Month
INFLUENT FLOW	mgd	40	43	111	122	131	148
REUSE FLOW	mgd	20	-	33	-	27	-
BOD5	mg/L	222	255	249	298	226	280
TSS	mg/L	230	299	218	247	248	376
TKN	mg/L	35	37	34	41	31	37
NH4-N	mg/L	22	23	21	26	19	22
TP	mg/L	6.3	7.9	5.7	6.3	5.7	6.8
TDS	mg/L	1225	1394	1083	1253	1416	1733

of constituents including phosphorus and bacteria. The current issues with respect to water quality and the location of wastewater discharge in relation to the Southern Nevada Water Authority water intake indicate that alternate discharge locations should be investigated. The potential future regulations that may result from more stringent discharge requirements and alternate discharge locations result in four distinct future scenarios summarized in Table ES-4.

The year 2027 Las Vegas Valley projected influent wastewater flow of 282 mgd is more than double the current flow. The current TMDLs for phosphorus and ammonia result in future effluent concentrations that are quite low and may, in the case of ammonia, be difficult to consistently achieve with conventional, biological treatment processes.

TREATMENT NEEDS

The Dischargers own and operate treatment facilities serving the Las Vegas Valley that have a combined, as-calculated treatment capacity of 138 mgd on an average daily flow basis. The average annual wastewater flow in 1996 was 125 mgd and by the year 2027, the total wastewater flow requiring treatment is estimated to be 282 mgd. Table ES-5 summarizes the existing facility capacities and future capacity needs for the year 2027.

A variety of treatment processes and configurations can be employed to meet future requirements. The alternative processes range from the continued application of the existing processes at each treatment facility to more advanced systems depending on the future scenarios as presented by Table ES-6.

The types of treatment processes that could be employed at each Discharger's facility to meet the requirements of these scenarios are discussed in the paragraphs below.

City of Henderson

The projected 2027 wastewater flows for the CoH are 40 mgd total. With an existing Las Vegas Wash discharge capacity of 9.3 mgd, the capacity deficit is 31 mgd.

Continued application of the existing treatment processes of the WRF can meet the stringent potential discharge requirements for phosphorus. The existing extended aeration process of the WRF is the most efficient biological process for ammonia reduction with the potential of achieving the lowest effluent ammonia concentrations. However, with the current ammonia TMDL applied in the future, the effluent ammonia concentrations that will be required may be difficult to achieve even with the extended aeration process.

Secondary level treatment only could be achieved by continued application of the extended aeration activated sludge process.

Figure ES-4
Total Las Vegas Valley Projected Reuse Water Demands and Wastewater Flows

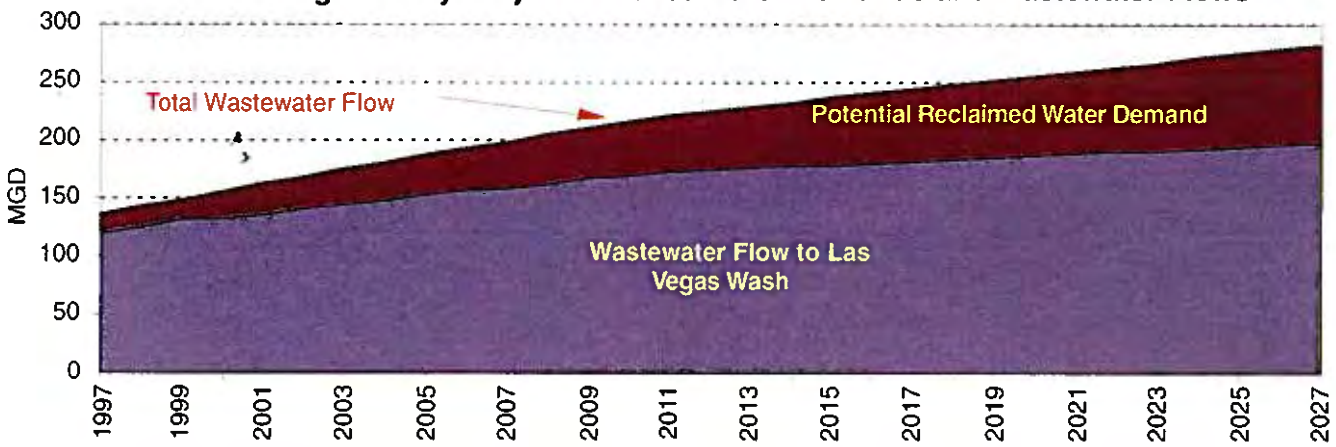

Table ES-4
Current and Potential Future Discharge Conditions

Scenario	Description	Current Conditions (at 282 mgd)	Future Conditions (at 282 mgd)
1. Existing	Current Requirements	-	-
2. Phosphorus restriction	50 percent reduction in WLA	WLA = 334 lb/day	WLA = 167 lb/day
3. Coliform level	Reduction to unrestricted use levels	200 mpn/100 ml Fecal	2.2 mpn/100 ml Total
4. Discharge location	Eliminate/reduce potential impact on water supply	Las Vegas Bay	Deep water outfall Alternate lake surface discharge Non-lake discharge

Table ES-5
Future Wastewater Facility Needs

Discharger	Nominal Average Annual Capacity, mgd	Capacity Under Current Conditions for Discharge to Las Vegas Wash, mgd	Projected Capacity Needs in 2027 for Discharge to Las Vegas Wash, mgd	Capacity Deficit, mgd
City of Henderson	19.5	9.3	40	31
City of Las Vegas	57	49	111	62
Clark County Sanitation District	88	80	131	51
Total	**165**	**138**	**282**	**144**

Table ES-6
Treatment Process Alternatives

Treatment Requirement	Treatment Alternative
Scenario 1 - Current Standards. Application of the current effluent discharge requirements.	• Biological nitrification and chemical phosphorus precipitation • Biological nitrification and enhanced biological phosphorus removal with chemical phosphorus precipitation • Biological treatment for BOD removal with membrane (reverse osmosis) processes for ammonia and phosphorus removal
Scenario 2 - Future Standards. Application of current regulations with a 50 percent reduction in the phosphorus waste load allocation and a more stringent disinfection criteria.	• Biological nitrification and chemical phosphorus precipitation • Biological nitrification and enhanced biological phosphorus removal with chemical phosphorus precipitation • Biological treatment for BOD removal with membrane (reverse osmosis) processes for ammonia and phosphorus removal
Scenario 3 - Tertiary Treatment Standards. Production of a filtered, disinfected effluent following secondary treatment, for non-bay, surface lake discharge.	• Conventional activated sludge process • Trickling filter process • Extended aeration activated sludge process • Any of the above secondary treatment systems followed by filtration
Scenario 4 - Secondary -Treatment Standards. Treatment to secondary level standards only for fully-diffused lake discharge or alternate discharge location.	• Conventional activated sludge process • Trickling filter process • Extended aeration activated sludge process
Pathogen Barrier. Current discharge standards with added requirement for inclusion of a pathogen barrier.	• Biological and chemical treatment for ammonia and phosphorus removal with ultrafiltration as a barrier to the passage of microorganisms

City of Las Vegas

The CLV's projected average annual wastewater flow rate is 111 mgd by the year 2027. With an existing capacity of 49 mgd, the capacity deficit is 62 mgd. To meet future capacity needs, the following facilities will be required:

- Upgrade the existing secondary treatment nitrification process to 57 mgd average annual capacity.
- Construct new primary, secondary and tertiary treatment facilities for 54 mgd of additional average annual capacity.

With the current ammonia TMDL, the future effluent ammonia concentrations that will be required will be difficult to achieve on a reliable basis. New facilities, and upgrades to the existing nitrification process, will require special consideration for improved performance. Alternatively, a higher degree of ammonia removal can be achieved through the implementation of break-point chlorination or the addition of reverse osmosis or ion exchange processes.

Clark County Sanitation District

The CCSD's projected average annual wastewater flow rate is 131 mgd by the year 2027. With an existing capacity of 80 mgd, the capacity deficit is 51 mgd. Facilities needed to satisfy this capacity deficit are:

- Upgrade the existing secondary treatment activated sludge process to 88 mgd.
- Construct new primary, secondary and tertiary treatment facilities for 43 mgd of additional capacity.

With the current ammonia TMDL, the future effluent ammonia concentrations that will be required will be difficult to achieve on a reliable basis. New facilities and upgrades to the existing activated sludge phosphorus and nitrogen removal process will require special consideration for improved performance. Alternatively, a higher degree of ammonia removal can be achieved through the addition of reverse osmosis or ion exchange processes. Given the CCSD's plans to utilize ultraviolet disinfection, breakpoint chlorination for the further reduction of ammonia may not be a viable option.

ALTERNATIVE DEVELOPMENT

Six alternatives were developed from the future discharge scenarios discussed previously. These alternatives are summarized in the paragraphs below.

Alternative 1. Las Vegas Wash

This alternative consists of providing future treatment through the continued application of treatment processes currently in use by the Dischargers.

Alternative 2. Full Biological Nutrient Removal (BNR)

This alternative consists of providing future treatment through the implementation of biological phosphorus removal (BPR) activated sludge processes that optimize phosphorus removal and nitrification performance. Key process requirements include anaerobic zones, anoxic zones for denitrification, and primary sludge fermentation. Tertiary treatment for chemical phosphorus polishing by precipitation with filtration and disinfection are also necessary.

Alternative 3. Tertiary Treatment with Discharge to Virgin Basin

This alternative consists of providing future treatment to meet tertiary treatment levels for an alternate location for surface discharge of effluent in Lake Mead. A non-Las Vegas Bay discharge point would remove the effluent disposal impacts on Las Vegas Bay and increase the separation between the effluent discharge and the water intake for the Las Vegas Valley. The downstream end of Lake Mead's Virgin Basin, just upstream of the Narrows region, was selected as the alternate surface discharge location due to its distance from the water intake, its proximity to a narrow and relatively active reach of the Lake, and the availability of roadway access along the majority of the conveyance route. A common conveyance system from the wastewater treatment plants to the Virgin Basin would be sized to pump peak month effluent flows. Figure ES-5 de-

Las Vegas Wash

Comprehensive Adaptive Management Plan

Las Vegas Wash Project Coordination Team

www.lvwash.org

January 20, 2000

APPENDICES

1.1	Las Vegas Wash Vegetation Study, May 1987
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APPENDIX 1.1

Colorado River Basin Salinity Control Project

Las Vegas Wash Unit

LAS VEGAS WASH VEGETATION STUDY

May 5, 1987

Department of the Interior
Bureau of Reclamation
Denver, Colorado

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FINAL REPORT

LAS VEGAS WASH VEGETATION STUDY

1.0 INTRODUCTION

The Las Vegas Hash Vegetation study was performed in accordance with the objectives of the proposed Whitney Verification Program (WVP) vegetation studies. The objective of this study was to inventory the areal extent and detect changes in quantities of vegetation types along an eleven mile stretch of the Las Vegas Wash. The analysis specifically examined changes in vegetation types for the years 1975, 1982, 1984, 1985, and 1986.

Advanced Sciences, Incorporated (ASI) was contracted to document detailed vegetation mapping of Las Vegas Wash for the five years listed above. Services provided included visual interpretation of 1:6000 color infrared photography, base map transformation, digitization, plotting, and raster polygon overlay analysis. All components of the project were completed at the U. S. Bureau of Reclamation (U.S.B.R.) Remote Sensing Section, E & R Center.

2.0 BACKGROUND

2.1 GENERAL SETTING

Las Vegas Wash, located southeast of Las Vegas, Nevada, is the major drainage for the state's largest population center (Figure 2.1). The wash drains approximately 1,600 square miles and once supported a large mesquite forest and occasional springs (U.S.B.R., 1986). Urban expansion has impacted the wash by reducing the ground water table, harvesting much of the mesquite forest, and introducing wastewater into the surface drainage system. The introduction of wastewater has created an environment that supports a lush, artificially created marsh. These nutrient-rich waters have produced a wetland with greater standing crop and higher productivity than the naturally occurring xerophytic vegetation.

Although a different environmental setting was created, changes have occurred in recent years. Major storms in the summers of 1983 and 1984 produced widespread flooding. During the storm of August 1983, headcutting nearly advanced to Telephone Line Road, draining and sloughing away portions of wetlands. The wash suffered extensive damage in July 1984 as peak flows reached some of the highest levels on record. As a result, wetlands above and below Pabco Road were uprooted or drained. In addition, the headcut advanced approximately 2,000 feet west of Pabco Road (U.S.B.R., 1986). The lower wash also experienced considerable widening of the stream channel in some areas due to severe

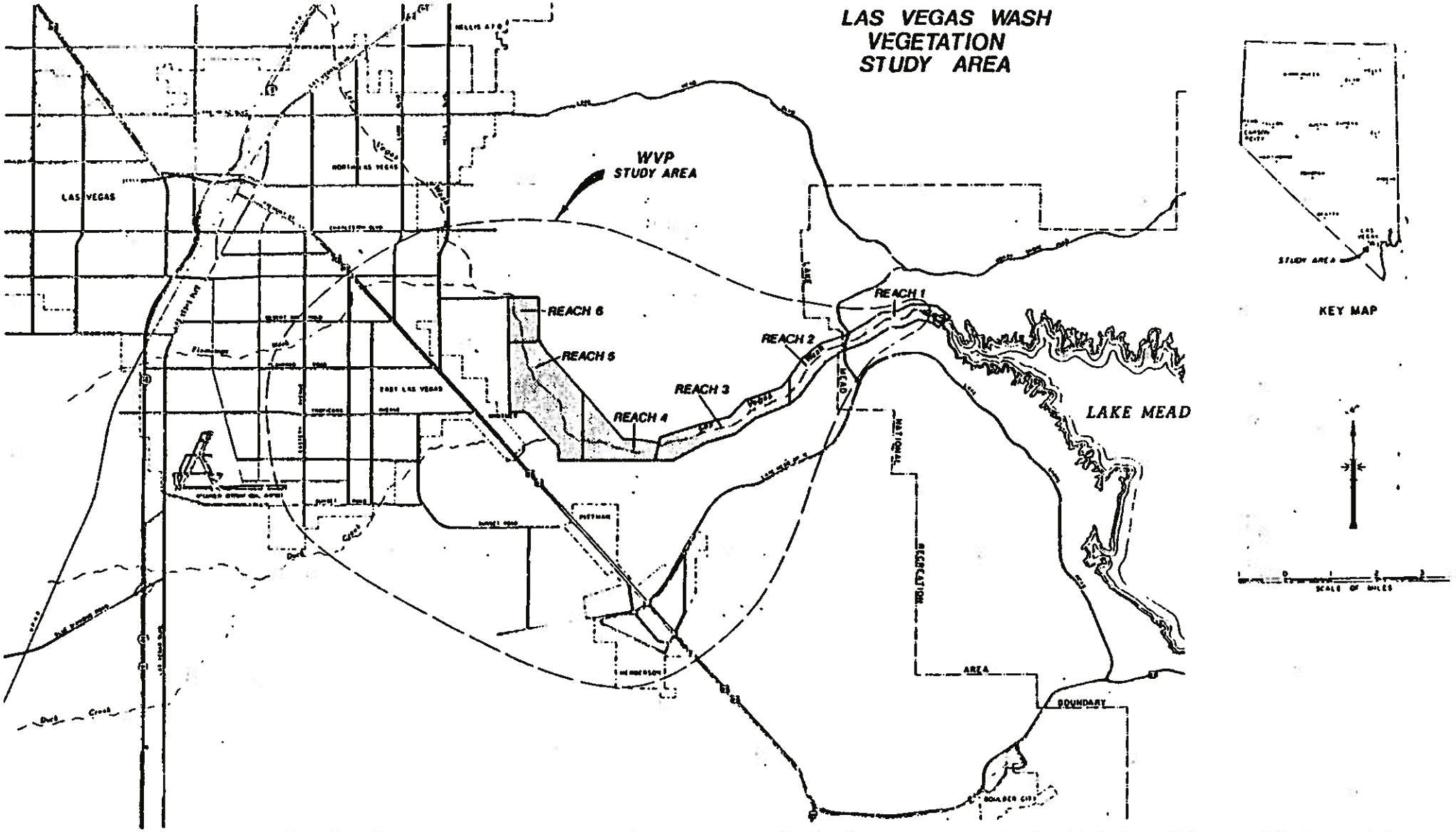

Figure 2.1 Location Map of the Las Vegas Wash Study Area and Whitney Verification Program Groundwater Detention Basin.

bank erosion: however, streambed degradation was minimal. Currently, the wash is in danger of continued erosion and wetland destruction unless appropriate measures are taken.

2.2 SPECIFIC SITE LOCATION

The study area is primarily limited to the Las Vegas Wash floodplain begining at Vegas Valley Drive and continuing to the confluence of the wash and Lake Head at Las Vegas Bay (Figure 2.1). Reaches were defined to extract data from specific areas of the wash. Reach boundaries are identified in Table 2.1.

Table 2.1. .Las Vegas Hash Reach Boundaries.

Reach Boundaries

1 Las Vegas Bay to Northshore Road.
2 Northshore Road to Powerline Crossing in Sec. 28, T.21S., R.63E.
3 Powerline Crossing to Pabco Road.
4 Pabco Road to Transect 5 (Section line along Sec. 25 and 26, T.21S., R.62E.
5 Transect 5 to A.W.T. Plant.
6 A.W.T. Plant to Vegas Valley Drive.

2.3 VEGETATION TYPES

Several vegetation/landcover types are present in the Las Vegas Wash area. The Wash has a highly diverse ecosystem, with a great degree of overlap between biotic communities. The vegetation communities discussed in this report have been examined previously in the Whitney Verification Program Environmental Assessment (U.S.B.R., 1986) and are referred to throughout this section. The vegetation/landcover types are:

Salt Cedar - The salt cedar (Tamarix chinensis) habitat present along the Las Vegas Wash corresponds with the riparian community classification category "Palustrine Scrub-Shrub Wetland" (Cowardin, et.al., 1979). It is dominated by woody vegetation less than 20 feet tall, and is found near permanent water, or where the water table is near the surface. In the Las Vegas Wash, salt cedar is the dominant woody plant, although mesquite (Prosopis sp.) does occur. Shrub species found with salt cedar include saltbush (Atriplex spp.), inkweed (Suaeda torreyana), and pickleweed (Allenrolfea occidentalis). Vegetative ground cover can vary from 15 to 100 percent, with the thicker growth being nearly impenetrable. Eighty percent relative cover of salt cedar is the mapping unit size used for the Wash. In areas where concentrations of juvenile salt cedar were observed, mapped data represents the most reasonable interpretation at the eighty percent cover level.

Mixed Shrub - The mixed shrub community occupies lower desert wash areas in close proximity to the Las Vegas Wash and on subirrigated sites. This community occurs predominantly on the western side of the Wash, although small pockets are scattered throughout the system. It is

typically found in wet, somewhat saline soils, often in relation to the drainage patterns in the area. The ground-water table is generally high in these areas, and there is an accumulation of salts in the soil. The key shrubs in this community are saltbush species. In more saline soils, saltgrass (Distichlis spicata), pickleweed, and inkweed proliferate while in less saline areas, mesquite often occurs. Salt cedar and smotherweed (Bassia hyssopifolia) regularly invade disturbed areas. Ground cover typically ranges from 6 to 20 percent, excluding grasses.

Desert - Desert is defined as the creosote bush and desert wash communities that occur adjacent to the Las Vegas Wash. Limits of the desert habitat are arbitrarily mapped relative to the study boundary. Bradley and Miller (1976) listed 210 plant species existing in the creosote bush community. These areas are characterized by two dominant species : creosote bush (Larrea divaricata) and burrobush (Ambrosia dumosa). This association is found thoughout the desert surrounding the Las Vegas Hash, in both flat and mountainous terrain, except in extremely rocky areas and well-developed washes. Creosote bush and burrobush tend to grow evenly spaced, and vegetative ground cover is usually sparse. Desert washes are an integral part of the cresote bush community. Ground cover ranges from 5 to 40 percent, due to the more vigorous growth associated with the increased moisture potential of these washes. Species often found in desert washes include cheesebush (Hymenoclea salsola), catclaw (Acacia greggii), mesquite, and salt cedar. Due to the wide distribution of desert habitat regionally, it is impractical to further characterize this type.

Barren/Disturbed - Areas devoid of vegetation are common throughout the Wash. A majority of the barren and disturbed areas are roads and trails established for everyday vehicular travel, maintenance, or off-road vehicle activity. Many trails are also established to provide access for trash dumping activities. Additional barren/disturbed areas have resulted from past attempts to develop a golf course, facility development, and pipeline/transmission line installation.

Eroded/Scoured - Floodplain areas that have been cleared of vegetation are included in this category. Flooding is the cause of erosion/scouring, leaving slightly elevated sand bars along the stream course. Periodic flooding occurs during summer thunderstorms and monsoon-type rains. Moist areas along the eroded/scoured bars are rapidly invaded by salt cedar, resulting in dense even-aged growth. Higher, drier areas remain mostly barren.

Dead - Many areas along the marsh have been subjected to fire or draining. Draining occurs as the wash cuts a deeper channel, leaving marsh and riparian vegetation to dry. Often this dry, dead vegetation burns, leaving relatively barren areas exposed. Burns appear to be relatively common within stands of salt cedar along the Wash. It is not known if the primary cause of these burns is arson, escaped rubbish fire, or lighting strikes. Often mature salt cedar trees are not killed in these fires and exhibit some growth.

Thistle/Smotherweed - Some areas that have been subjected to past disturbance, e.g., draining, scouring, and burning, have been invaded by weedy, annual species. Dense stands of thistle (Salsola iberica) and

smotherweed occur to the south of Pabco Road following burning of drained cattail marsh. These weedy species are also commonly observed along road edges, fence lines forming agricultural land boundaries, and in fallow agricultural fields. Continued disturbance is probably necessary for the establishment of annual weeds on a year-to-year basis. This disturbance could be in the form of fire or mechanical activities.

Reed Harsh - Marshy uplands are generally dominated by stands of common reed (Phragmites communis) and occur adjacent to, or within, the cattail marsh habitat. Common reed habitat occurs on the drier marsh sites and is often infiltrated with salt cedar, mesquite, or saltbush along the driest margins. A transition zone, which supports a wetland annual habitat, often occurs between common reed and cattail habitats. Stands of common reed are monotypic, dense, and often exceed 12 to 15 feet in height. This habitat persists much longer on sites dried due to channel erosion than does the cattail habitat. However, a portion of the area mapped as dead formerly supported common reed.

Cattail Marsh - The cattail (Typha domingensis) habitat occurs on saturated soils and mucks within the Las Vegas Wash and along sewage outfalls. . Nutrient-rich effluent contributes to lush growth downstream from effluent outfalls, where cattails often reach heights of 12 to 15 feet. Cattail habitat is nearly monotypic with other species occurring along the fringe in more marginal habitat. Much of the area mapped in the dead category was once cattail habitat. As erosion deepened the Las Vegas Wash channel, this habitat was no longer sub-irrigated, becoming a dry upland. Subsequent fires eliminated the dry vegetative cover, exposing barren soil, some of which has been invaded by thistle and smotherweed.

Mixed Marsh - Habitat that supports a varying mixture of cattail, common reed, wetland annuals, and salt cedar is classified as mixed marsh. Occasionally, relatively dense clumps of alkali bulrush (Scirpus robustus) also occur. Mixed marsh is not generally abundant within the Las Vegas Wash, except in 1975. Generally this habitat occurs where sediments have accumulated deeply enough to support common reed on slightly drier sites and adjacent submerged areas that support cattail. An area where this occurs lies at the mouth of the Las Vegas Wash, at Las Vegas Bay on Lake Mead.

Wetland Annuals - Wetland annual habitat is asociated with both cattail and common reed habitat, occupying the mesic area between the two major habitats. Often the wetland annual zone represents.the transition between common reed and cattail. Subirrigated sites on sandbars and along the Las Vegas Wash channel also support wetland annual species. Species included in wetland annual habitat are dock (Rumex spp.), smartweed (Polygonum sp.) , rabbit's-foot grass (Polypogon monspeliensis) , and species of composites. This habitat is often invaded by cattail along the more mesic interface and by common reed, saltgrass, or salt cedar along the drier interface.

Open Water - Flowing and ponded water are included in this category, where surrounding vegetation does not provide aerial cover. The most significant body of open water is Las Vegas Bay on Lake Head, at the mouth of Las Vegas Wash. Las Vegas Wash flows commonly appear as open water at various locations along the length of the wash. Open

water is also mapped where effluent outfalls from sewage treatment facilities occur. Areas of ponded water were more common on earlier photography. The largest ponded area noted occurs where Telephone Line Road crosses the Las Vegas Wash.

Facilities - Facilities located in the study area are principally in the upper portion of the Hash. The two facilities worth noting here consist of a football stadium and a baseball field complex. The majority of land area contained in this class is located at these two facilities.

3.0 METHODS

3.1 PHOTOINTERPRETATION

The U.S.B.R. supplied AS1 with 1:6000 scale color-infrared aerial photography of the Las Vegas Wash project area. This photography provided the base for identifying and defining the spatial distribution of vegetation/landcover types within the wash. Photography missions were flown during the summer months in 1984 (June 18), 1985 (July 2), and 1986 (July 7). Missions flown at the same relative time period ensured similar signatures on the photography. Aerial photographs in 1975 and 1982 were flown in October (October 15, 1975 and October 1, 1982) and did not correspond to this time period.

To complement the photointerpretation process, a team of AS1 remote sensing specialists spent time in the field to ensure accurate matching of ground cover conditions with photographic signatures. An experienced biologist from the U.S.B.R. Boulder City office accompanied the team. Vegetation and land cover features were observed and identified relative to the photographs.

Following the summer field reconnaissance, the photography was interpreted onto mylar overlays. Features were transferred to the overlays on a light table, using a direct-transfer technique. An Old Delft Scanning Stereoscope II and an Abrams 2-4 Stereoscope Model CB-1 were used to study photographs stereoscopically when features could not be fully identified with a 10X Keyan magnifier.

Only the center portion of each photograph was interpreted, since photographic distortion is increased near the edges of a photograph as opposed to the image center. Thus, less distortion is encountered during interpretation if the area included on successive photographs has sufficient stereoscopic overlap. Proper coverage will typically contain 55 to 65 percent overlap on successive photographs to ensure at least 50 percent endlap over varying terrain (Lillessand and Kiefer, 1979). Some of the Las Vegas Wash coverage did not have sufficient overlap, therefore, the edges of some photographs had to be interpreted. This problem was encountered somewhat on all five missions, especially in the upper and lower portions of the wash on the 1986 and 1975 photography, respectively.

3.2 SIGNATURE DETERMINATION

A number of basic characteristics or features on the photography were used to systematically study the aerial photography. Seven basic characteristics, or variations of them, were typically considered: shape, size, pattern, shadow, tone, texture, and site or association (Whiteford, 1978; Lillesand and Kiefer, 1979). Of these characteristics, tone provided the most information since the color signatures of vegetation types differed. This was due to the differences in reflectivity among the various types of vegetation found in the Wash. Texture was also important because the relative coarseness of stands of vegetation varied. In addition, the association of features provided insight since some vegetation types were found near the center of the alluvial floodplain while others were located most often along the edges. The other characteristics were also used during the interpretation process, but to a lesser extent. A combination of two or more characteristics was used in the identification of most features on the landscape.

3.3 BASE MAP DEVELOPMENT

3.3.1 MAP SETUP

The GES software was used to design a 1:6000 scale map base for the project area. This base was generated by using 7.5 minute quadrangle sheets and surveyed coordinates in the Nevada State plane coordinate system. For the lower wash, Pabco Road to Las Vegas' Bay, sections and major roads from the 7.5 minute quadrangle sheets at a scale of 1:24,000 were transformed into 1:6000 scale map bases. Control points were then selected on the photography and corresponding quadrangle sheets so that data could be accurately transfered onto the map base. A total of 33 features were used as control points in the lower Wash. The most common features were peaks along ridges near the Wash that were depicted as closed contours on the quadrangle maps. Other features delineated as control points were transmission line towers, road intersections, and bridges. From Pabco Road to Vegas Valley Drive, the Nevada State plane coordinates and corresponding markers on the photography were used for base map creation. These coordinates consisted of 19 surveyed, paneled, markers that were identified on the photography as white crosses. Specific coordinate locations were provided by the U.S.B.R. Boulder City office. Electrical poles and sewage disposal tanks were also identified on the photography and corresponding quadrangles as additional control points in Reach 6. Both of the above geographic data sets were combined to make one map base.

3.3.2 DATA TRANSFER

The aerial photography was transferred onto computer generated map bases using a Saltzman projector. Although the scale was nearly equivalent between the photos and map bases, scale adjustment on the projector was necessary when an individual photo was not at 1:6000 scale.

The first year of data transfered was from the 1982 photography. The 1982 photointerpreted landcover data was transferred directly to the map bases in the upper wash area. Photo data were nosaiced together in a best fit situation based on state plane coordinates and corresponding ground control points visible on the photography. The photo data covering the lower wash was transfered to the map bases using the Saltzman projector. After digitizing, computer drawn map bases were generated from the 1982 photointerpreted landcover data and used for the transfer of the 1984 data. This process was repeated for the transfer of all data sets, except 1975, with the previous years data becoming the base for the next year. Because the 1975 photography was an add on to the project, it was received after the data transfer process had already been completed far 1982. Therefore, 1982 served as the map base far 1975.

The generated landcover map bases included all the polygons from the previous year's interpretation, insuring an accurate transfer of the current year's information where there had been no change in polygon boundaries. Where landcover classes had changed, new lines were drawn on the map bases in red to delineate change.

3.4 DIGITIZATION

3.4.1 GEOBLOCR DEVELOPMENT

The Las Vegas Wash area is contained on four 7.5 minute quadrangles. Five geoblocks, each the exact same size and covering the exact same 15 minute by 15 minute geographic area, were created to contain the photointerpreted data as it was digitized - one geoblock per year of photography. A geoblock of this size has an internal unit resolution of 1.4 feet.

Each geoblock was subdivided into overlays, one for each reach plus one each for control points and line data. Polygon overlays were named for the reach number and date (i.e., R1VEG75 - reach 1, vegetation, 1975). Polygon overlays contained only vegetation/landcover classes. Sections were digitized once and stored in the Section overlay in the 1982 geoblock. Line overlays contained digitized roads, trails, and other cultural line information. Where covertypes (i.e., open water) were identified as lines, they were included in the line overlay. Each line and polygon type was given a unique class number (See Appendix L for a listing of all geoblocks, overlays, and class values.).

3.4.2 DIGITIZATION

A numbering scheme was set up to identify each class delineated during the phatointerpretatian effort. As an example, polygons labeled SC (salt cedar) were identified as class 10 in the digitizing process. There were thirteen classes identified.

Section lines were digitized as part of the base map preparation phase (as detailed above). Line data, except landcover, was digitized only once. Landcover line data was digitized in the line overlay using the same numbering scheme developed for polygon data.

As originally planned, after a given reach for a given year was

digitized, the data would be automatically copied into the overlay for the same reach but the next year. The data was then to be edited according to which lines and polygons changed between years. The only new digitizing would then be for boundaries between covertypes that changed. However, this process was found to be too time consuming. Therefore, it was decided to completely digitize each reach for each year, without trying to use the GIS software to automatically copy and manually edit previously digitized lines. The accuracy of line placement did not appear to be affected enough to justify automatic copying between overlays (see Section 4.2, Accuracy Assessment).

The outside boundary for the Wash was copied between years, since this was a very minor copying effort. The boundary, also, did not change between years and needed to be kept constant. Reach boundaries were also copied between reach overlays and years, since these boundaries did not change either.

After each reach was digitized, a hard copy print was made that displayed all polygons. This hardcopy was compared with the information delineated on the map bases and the photo overlays. As an additional check, another digitizer would then check the map base with the hard copy. Any corrections were noted on the hard copy and corrected. The digitizer also checked the map bases against the photo overlays while digitizing to insure that no transfer errors were made or polygons missed.

All hard copy documentation was filed in a notebook by geoblock. The copies were organized by reach. At regular intervals during the digitizing process, once used line segments were displayed to insure that no holes were missed or lines double digitized.

3.4.3 PLOTS

Black and white plots on frosted mylar were created at a scale of 1:6000 on the U.S.B.R. pen plotter. At this scale it was possible to plot a complete reach on one sheet of mylar. A plot was made for each reach for each year. The plots were titled with reach number and year of photography. Legends were plotted on each reach map plot showing vegetation classes plotted, date of aerial photography used, plot scale, and date plotted. Sections were plotted and labeled.

3.5 RASTER POLYGON OVERLAY

3.5.1 RASTERIZATION

The data, as digitized, existed in a vector format. The digitizing software used at the E & R Center for this project did not have vector analysis capability, so it was necessary to convert the data to a raster, or cell, format. All of the vegetation and line overlay files were converted to raster files.

A cell size of 3 meters was chosen for the conversion. Three meters was chosen as the optimum size after considering the minimum mapping size used in the photointerpretation process (.5 acre) and the relative error in the digitizing and map transfer process (<3 meters).

3.5.2 OVERLAY ANALYSIS

Images were created from the raster files. Vegetation and line images for a given reach-year were combined into a single image when line vegetation had been delineated. In order to create images showing vegetational changes between years, it was necessary to compare, or "over lay", the reach-year images with each other. Reach-year images from 1975 were compared to the corresponding reach-year images for 1982, 1982 was compared to 1984, 1984 was compared to 1985, and 1985 was compared to 1986. The resulting change images showed areas of change without defining what the change was.

The raster files were used to define actual acres of between-class vegetational change from one reach-year to the next. The raster files were compared in the same manner as the images had been. The output file for each comparison listed acres of new vegetation type for each original vegetation type as well as acres of original vegetation type that remained the same.

3.5.3 CHANGE PLOTS

The images which were created in the raster image overlay process were plotted in black and white on an electrostatic plotter. Areas of change were delineated in black and areas of no change were delineated in grey. Areas outside the Wash boundary were left blank. Each plot was annotated to show the reach number, the years compared, the plot legend, and the scale of the plot. All plots were done at 1:6000, to match the scale of the vector pen plots done for each reach-year.

3.6 ACREAGE TABULATIONS

Acreage tables were generated at two stages in the project. Tables were created from the vector data to show acreages by reach, by year, and for the entire Hash by year (Tables 3.1 - 3.7). Comparisons were made between the reach-years to generate tables showing net changes by reaches and for the whole Wash (Tables 3.8 - 3.14). As a result of the raster overlay process, tables were generated to show specific vegetational changes by reach between years (Tables 3.15 - 3.37) and between years for the whole Wash (Tables 3.38 - 3.41). Vegetation type abbreviations as supplied by BOR and used in the tables are:

SC - Salt cedar
MS - Mixed shrub
TS - Thistle/smotherweed
RM - Reed marsh
CM - Cattail marsh
WA - Wetland annuals
MM - Mixed marsh
DS - Desert
BD - Barren/disturbed
ES - Eroded/scoured
Dd - Dead
ow - Open water
FAC - Facilities

Table 3.1 - LAS VEGAS WASH ACREAGE STATISTICS FOR REACH 1.

CLASS	1975	1982	1984	1985	1986
SC 10	28.2	30.5	12.9	9.2	18.1
ns 11	20.8	24.6	21.8	14.9	17.8
TS 12	0.0	0.0	0.0	0.0	0.0
RM 13	0.0	2.5	0.0	0.0	3.2
cn 14	0.5	1.0	0.0	3.1	3.0
WA 15	0.0	0.5	0.0	0.4	0.0
MM 16	6.1	4.8	0.0	12.2	41.3
DS 20	325.7	307.8	306.3	300.9	291.6
BD 21	1.0	0.4	0.4	0.5	0.4
ES 22	4.0	0.0	14.8	25.7	3.6
Dd 23	0.0	0.0	0.0	0.0	0.0
OW 30	15.8	29.9	45.9	35.2	23.1
FAC 40	0.0	0.0	0.0	0.0	0.0
TOTAL	402.0	402.0	402.0	402.0	402.0

Table 3.2 - LAS VEGAS WASH ACREAGE STATISTICS FOR REACH 2.

CLASS	1975	1982	1984	1985	1986.
SC 10	55.8	62.0	50.7	31.1	51.0
ns 11	32.3	44.5	40.1	40.6	32.5
TS 12	0.0	0.0	0.0	0.0	0.0
RM 13	4.5	0.0	0.0	0.0	0.0
cn 14	0.0	0.2	0.0	0.0	0.1
WA 15	0.5	0.0	0.0	0.1	0.0
MM 16	9.5	0.2	0.0	0.1	0.4
DS 20	455.7	455.5	457.0	454.0	453.6
BD 21	a.7	1.1	3.2	2.3	6.2
ES 22	1.2	0.0	9.4	30.4	16.7
Dd 23	1.8	2.0	2.6	3.3	3.9
OW 30	2.1	6.6	a.4	10.1	7.6
FAC 40	0.0	0.0	0.0	0.0	0.0
TOTAL	572.0	572.0	572.0	572.0	572.0

Table 3.3 - LAS VEGAS XASH ACREAGE STATISTICS FOR REACH 3.

CLASS	1975	1982	1984	1985	1986
SC 10	181.5	192.2	160.5	141.8	173.7
MS 11	88.4	86.3	119.2	102.5	98.1
TS 12	0.0	0.0	0.0	38.1	0.0
RM 13	9.0	9.4	5.8	1.1	0.4
CM 14	144.2	38.2	29.6	0.6	4.0
WA 15	0.4	0.0	3.6	0.2	0.1
MM 16	42.0	1.3	3.1	2.1	11.7
DS 20	270.7	244.3	241.0	242.1	237.4
BD 21	32.8	48.6	63.2	59.6	69.4
ES 22	5.0	0.0	8.3	84.6	43.3
Dd 23	8.8	160.1	141.8	107.4	147.2
OW 30	13.7	16.0	20.3	16.4	11.1
FAC 40	0.0	0.0	0.0	0.0	0.0
TOTAL	796.5	796.5	796.5	796.5	796.5

Table 3.4 - LAS VEGAS WASH ACREAGE STATISTICS FOR REACH 4.

CLASS	1975	1982	1984	1985	1986
SC 10	84.0	95.8	74.7	84.2	96.8
MS 11	104.8	98.7	96.2	95.5	90.3
TS 12	0.0	8.4	5.7	0.4	0.0
RM 13	1.8	26.7	31.5	37.2	42.2
CM 14	187.9	198.2	186.8	102.9	67.3
WA 15	0.9	0.1	0.3	9.8	7.1
MM 16	26.3	0.8	13.0	12.5	5.8
DS 20	196.9	154.6	153.9	157.7	156.8
BD 21	27.3	46.7	55.1	53.9	58.9
ES 22	0.0	0.0	0.0	2.6	0.3
Dd 23	7.9	0.7	10.6	68.4	101.7
ow 30	6.6	0.2	3.2	5.6	3.4
FAC 40	0.0	13.6	13.6	13.9	13.9
TOTAL	644.5	644.5	644.5	644.5	644.5

Table 3.5 - LAS VEGAS XASH ACREAGE STATISTICS FOR REACH 5.

CLASS		1975	1982	1984	1985	1986
SC	10	65.7	100.7	113.8	112.8	125.3
MS	11	562.6	489.6	479.8	460.6	455.7
TS	12	64.3	9.2	1.0	6.0	0.0
RM	13	41.3	110.5	106.4	122.9	131.8
CM	14	94.5	65.2	55.9	61.6	56.7
WA	15	0.9	21.7	17.2	12.5	15.0
MM	16	29.0	4.8	4.6	5.0	6.3
DS	20	113.2	73.9	70.5	77.4	76.5
BD	21	83.3	154.5	171.5	175.0	163.3
ES	22	0.0	0.0	0.0	0.7	0.2
Dd	23	6.6	5.8	13.9	0.9	4.6
ow	30	1.6	0.7	1.5	1.0	1.2
FAC	40	36.4	62.9	63.2	63.2	63.1
TOTAL		1099.5	1099.5	1099.5	1099.5	1099.5

Table 3.6 - LAS VEGAS WASH ACREAGE STATISTICS FOR REACH 6.

CLASS		1975*	1982	1984	1985	1986
SC	10		243.4	224.7	224.9	254.4
MS	11		98.2	120.2	129.7	83.5
TS	12		46.9	18.1	19.3	31.5
RM	13		1.2	1.6	2.0	4.0
CM	14		5.6	5.8	8.4	7.3
WA	15		1.0	5.5	8.2	5.3
MM	16		0.0	0.3	1.4	5.2
DS	20		29.1	28.5	29.3	29.5
BD	21		151.7	156.0	150.2	144.4
ES	22		0.0	0.0	0.0	2.2
Dd	23		0.0	11.5	3.7	8.6
OW	30		0.0	4.8	2.5	3.8
FAC	40		35.1	35.4	32.9	32.8
TOTAL			612.3	612.3	612.3	612.3

* No data exists for Reach 6 in 1975, therefore Acreage Totals could not be calculated.

Table 3.7 - LAS VEGAS WASH ACREAGE STATISTICS FOR THE ENTIRE WASH.

CLASS	1975*	1982	1984	1985	1986
SC 10	415.2	724.6	637.3	603.9	719.3
MS 11	808.8	841.9	877.9	843.8	777.9
TS 12	64.3	64.6	24.8	63.8	31.5
RM 13	56.6	150.3	145.3	163.1	181.6
CM 14	427.2	308.4	278.0	176.7	138.4
WA 15	2.7	23.3	26.6	31.2	27.4
MM 16	112.9	11.9	21.0	33.3	70.6
DS 20	1362.2	1265.1	1257.4	1261.4	1245.4
BD 21	153.2	403.0	449.4	441.5	442.7
ES 22	10.1	0.0	32.4	144.0	66.2
Dd 23	25.1	168.6	180.5	183.6	266.1
ox 30	39.9	53.5	84.0	70.6	50.1
FAC 40	36.4	111.6	112.1	110.0	109.7
TOTAL	3514.2	4126.8	4126.8	4126.8	4126.8

* No data exists for Reach 6 in 1975, therefore Acreage Totals are reduced by 612.3 acres.

Table 3.8 - LAS VEGAS WASH NET ACREAGE CHANGE STATISTICS FOR REACH 1.

CLASS	1975-1982	1982-1984	1984-1985	1985-1986
SC 10	2.4	-17.6	-3.7	8.9
MS 11	3.8	-2.8	-6.9	2.8
TS 12	0.0	0.0	0.0	0.0
RM 13	2.5	-2.5	0.0	3.2
CM 14	0.5	-1.0	3.1	-0.1
WA 15	0.5	-0.5	0.4	-0.4
MM 16	-1.3	-4.8	12.2	29.1
DS 20	-17.9	-1.4	-5.5	-9.3
BD 21	-0.6	0.0	0.1	0.0
ES 22	-4.0	14.8	11.0	-22.2
Dd 23	0.0	0.0	0.0	0.0
OW 30	14.2	15.9	-10.7	-12.1
FAC 40	0.0	0.0	0.0	0.0
TOTAL	0.0	0.0	0.0	0.0

Table 3.9 - LAS VEGAS WASH NET ACREAGE CHANGE STATISTICS FOR REACH 2.

CLASS	1975-1982	1982-1984	1984-1985	1985-1986
SC 10	6.2	-11.3	-19.6	19.9
MS 11	12.2	-3.8	-0.1	-8.1
TS 12	0.0	0.0	0.0	0.0
RM 13	-4.5	0.0	0.0	0.0
CM 14	0.2	-0.2	0.0	0.1
WA 15	-0.5	0.0	0.1	-0.1
MM 16	-9.3	-0.2	0.1	0.3
DS 20	-0.2	1.5	-3.0	-0.4
BD 21	-7.6	2.1	-0.9	4.0
ES 22	-1.2	9.4	21.1	-13.7
Dd 23	0.2	0.7	0.7	0.6
OW 30	4.4	1.8	1.7	-2.5
FAC 40	0.0	0.0	0.0	0.0
TOTAL	0.0	0.0	0.0	0.0

Table 3.10 - LAS VEGAS WASH NET ACREAGE CHANGE STATISTICS FOR REACH 3.

CLASS	1975-1982	1982-1984	1984-1985	1985-1986
SC 10	10.7	-31.7	-18.7	31.9
MS 11	-2.0	32.9	-16.7	-4.4
TS 12	0.0	0.0	38.1	-38.1
RM 13	0.4	-3.6	-4.7	-0.6
CM 14	-106.0	-8.6	-29.0	3.4
WA 15	-0.4	3.6	-3.4	-0.1
MM 16	-40.6	1.8	-1.0	9.6
DS 20	-26.5	-3.3	1.1	-4.7
BD 21	15.8	14.6	-3.6	9.8
ES 22	-5.0	8.3	76.3	-41.4
Dd 23	151.3	-18.3	-34.5	39.9
OW 30	2.3	4.3	-4.0	-5.3
FAC 40	0.0	0.0	0.0	0.0
TOTAL	0.0	0.0	0.0	0.0

Table 3.11 - LAS VEGAS WASH NET ACREAGE CHANGE STATISTICS FOR REACH 4.

CLASS	1975-1982	1982-1984	1984-1985	1985-1986
SC 10	11.8	-21.1	9.5	12.6
MS 11	-6.1	-2.5	-0.7	-5.2
TS 12	8.4	-2.7	-5.3	-0.4
RM 13	24.9	4.8	5.7	5.0
CM 14	10.3	-11.4	-83.9	-35.6
WA 15	-0.8	0.2	9.5	-2.7
MM 16	-25.5	12.2	-0.5	-6.7
DS 20	-42.3	-0.7	3.8	-0.9
BD 21	19.3	8.4	-1.2	5.1
ES 22	0.0	0.0	2.6	-2.2
Dd 23	-7.2	9.9	57.8	33.3
ow 30	-6.4	3.0	2.4	-2.2
FAC 40	13.6	0.0	0.3	0.0
TOTAL	0.0	0.0	0.0	0.0

Table 3.12 - LAS VEGAS WASH NET ACREAGE CHANGE STATISTICS FOR REACH 5.

CLASS	1975-1982	1982-1984	1984-1985	1985-1986
SC 10	35.0	13.1	-1.0	12.5
MS 11	-73.0	-9.8	-19.2	-4.9
TS 12	-55.1	-8.2	5.0	-6.0
RM 13	69.2	-4.1	16.4	8.9
CM 14	-29.4	-9.3	5.7	-4.9
WA 15	20.8	-4.5	-4.7	2.5
MM 16	-24.2	-0.2	0.4	1.3
DS 20	-39.3	-3.4	6.9	-0.9
BD 21	71.2	17.0	3.5	-11.7
ES 22	0.0	0.0	0.7	-0.5
Dd 23	-0.8	8.1	-13.1	3.7
OW 30	-0.9	0.8	-0.6	0.2
FAC 40	26.6	0.3	0.0	-0.1
TOTAL	0.0	0.0	0.0	0.0

Table 3.13 - LAS VEGAS WASH NET ACREAGE CHANGE STATISTICS FOR REACH 6.

CLASS	**1975-1982***	1982-1984	198471985	1985-1986
SC 10		-18.7	0.2	29.5
MS 11		22.0	9.5	-46.2
TS 12		-28.8	1.2	12.2
RM 13		0.4	0.4	2.0
CM 14		0.1	2.6'	-1.1
WA 15		4.5	2.7	-2.9
MM 16		0.3	1.1	3.8
DS 20		-0.5	0.8	-0.2
BD 21		4.2	-5.7	-5.8
ES 22		0.0	0.0	2.2
Dd 23		11.5	-7.8	4.9
ow 30		4.8	-2.3	1.3
FAC 40		0.3	-2.5	-0.1
TOTAL		0.0	0.0	0.0

* No data exists for Reach 6 in 1975, therefore Net Change could not be calculated.

Table 3.14 - LAS VEGAS WASH NET ACREAGE CHANGE STATISTICS FOR THE ENTIRE WASH.

CLASS	1975-1982*	1982-1984	1984-1985	1985-1986
SC 10	66.0	-87.3	-33.3	115.4
MS 11	-65.1	36.1	-34.1	-66.0
TS 12	-46.6	-39.7	39.0	-32.3
RM 13	92.5	-5.0	17.7	18.5
cn 14	-124.4	-30.4	-101.4	-38.2
WA 15	19.6	3.3	4.6	-3.8
MM 16	-101.0	9.0	12.3	37.3
DS 20	-126.2	-7.8	4.0	-16.0
BD 21	98.1	46.4	-7.9	1.3
ES 22	-10.1	32.4	111.6	-77.8
Dd 23	143.5	11.9	3.1	82.5
OW 30	13.6	30.6	-13.4	-20.5
FAC 40	40.1	0.5	-2.2	-0.3
TOTAL	0.0	0.0	0.0	0.0

*Net Change values are for reaches 1 through 5 only.

Tables 3.15 - 3.41 show the specific vegetation changes between years, by reach, by species. In Table 3.15 acres and types of vegetation present in 1975 are compared with the acres and types of vegetation present in 1982. **For** a given vegetation type, going across a row in the table gives acres of the specific vegetation type that stayed the same or **changed** to another vegetation type in 1982. Table 3.15 shows that 15.8 acres remained salt cedar (SC) in 1982, while 1.6 acres changed to mixed shrub **(MS)** , **.8** acres changed to reed marsh **(RM)**, and so on. Reading down the columns shows the number of acres of salt cedar that stayed the same **or** were a different vegetation type in 1975. Table 3.15 shows that 15.8 acres of salt cedar in 1982 had been salt cedar in 1975, also, and that 3.1 acres had been mixed shrub, that **.6** acres had been mixed marsh, and so on. The total column on the right is for the first year, i.e. 1975, and the total row across the bottom is for the second year, i.e. 1982. The bottom right number is the total acres for the reach. (See Section 4.3.2 - Rasterization Effects - for a discussion of the differences in acreages reported between Tables 3.1 - 3.14 and Tables 3.15 - 3.41.)

Table 3.15

REACH 1

CHANGE IN ACREAGES BETWEEN 1975 AND 1962

1975 \ 1962	SC	MS	TS	RM	CM	WA	MM	DS	BD	ES	Cd	OW	FAC	TOTAL
SC	15.5	1.6	0.0	0.6	0.3	0.1	1.3	1.5	0.0	0.0	0.0	5.9	0.0	27.6
MS	3.1	14.5	0.0	0.2	0.0	0.0	0.3	1.7	0.0	0.0	0.0	0.9	0.0	20.9
TS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CM	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.5
WA	0.0	0.0	a.a	0.0	0.0	0.0	0.0	0.0	a.0	0.0	a.0	0.0	0.0	0.0
MM	0.6	0.0	0.0	0.0	0.1	0.2	1.1	0.1	0.0	0.0	0.0	3.7	0.0	5.6
DS	7.3	4.5	0.0	0.6	0.7	0.0	0.5	303.0	0.1	0.0	0.0	6.3	0.0	323.2
BD	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.6	0.3	0.0	0.0	0.1	0.0	1.0
ES	1.0	1.7	0.0	0.3	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.2	0.0	3.5
Dd	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OW	1.7	0.3	0.0	0.3	0.0	0.1	0.9	0.0	0.0	0.0	0.0	13.6	0.0	16.9
FAC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	29.5	23.4	0.0	2.3	1.1	0.4	4.6	307.4	0.6	0.0	0.0	30.7	0.0	399.7*

*See Section 4.3.2 for a discussion of the effect of rasterization on acreage calculations.

Table 3.16

REACH 1

CHANGE IN ACREAGES BETWEEN 196; AND 1954

1962 \ 1984	SC	MS	TS	RM	CM	WA	MM	DS	BD	ES	Dd	OW	FAC	TOTAL
SC	6.9	3.2	0.0	0.0	0.0	0.0	0.0	1.1	0.0	6.6	0.0	7.7	0.0	29.5
MS	2.1	16.9	0.0	0.0	0.0	a.0	0.0	0.0	0.0	1.1	0.0	3.3	0.0	23.1
TS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RM	C.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.7	0.0	2.3
CM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	a.0	1.0	0.0	1.1
WA	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	0.0	0.4
MM	C.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0	1.6
DS	6.2	P.3	0.0	0.0	0.0	0.0	0.0	304.4	0.0	a.2	0.0	2.3	0.0	307.4
BD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.4
ES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dd	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OW	0.9	6.3	0.0	0.0	0.0	0.0	0.0	0.1)	0.0	2.5	0.0	27.P	0.0	30.7
FAC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	12.5	26.9	0.0	0.0	0.0	0.0	0.0	305.6	0.4	13.7	0.0	16.6	0.0	399.7

Table 3.17

REACH1

CHANGE IN ACREAGES BETUEEN 1986 AND 1985

1985

1986	SC	MS	TS	RM	CM	WA	MM	DS	BD	ES	Dd	OW	FAC	TOTAL
SC	3.2	0.1	0.0	0.0	0.2	0.0	1.7	0.6	0.0	5.2	0.0	1.5	0.0	12.5
MS	1.6	11.9	0.0	0.0	0.0	0.2	0.0	0.2	0.0	5. 3	0.0	1.8	0.0	20.9
TS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0
DS	2.7	2.1	0.0	0.0	0.6	0.0	0.7	296.6	0.1	1.1	0.0	1.5	0.0	305.6
BD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.6
ES	0.6	0.0	0.0	0.0	0.2	0.1	1.3	0.2	0.0	t.2	0.0	3.2	0.0	13.7
Dd	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OW	1.8	0.6	0.0	0.0	2.3	0.1	8.6	0.6	0.0	5.6	0.0	27.3	0.0	16.6
FAC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	9.6	14.9	0.0	0.0	3.1	0.6	12.6	298.2	0.5	25.2	0.0	35.3	0.0	399.7

Table 3.18

REACH 1

CHANGE IN ACREAGES BETWEEN 1985 AND 1986

1986

1965	SC	MS	TS	RM	CM	WA	MM	DS	BD	ES	Dd	OW	FAC	TOTAL
SC	5.6	1.3	0.0	0.0	0.3	0.0	1.7	0.3	0.0	0.0	0.0	0.5	0.0	9.6
MS	1.6	11.1	0.0	0.0	0.0	0.0	0.8	1.3	0.0	0.1	0.0	0.2	0.0	16.9
TS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CM	c.7	C.2	0.0	0.0	0.6	0.0	0.9	0.3	0.0	0.0	0.0	0.3	0.0	3.1
WA	0.2	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.6
MM	1.5	0.3	0.0	2.1	0.6	0.0	7.5	0.2	0.0	0.1	0.0	0.5	0.0	12.6
DS	2.6	6.2	0.0	0.0	0.6	0.0	2.8	287.3	0.0	0.2	0.0	0.7	0.0	296.2
BD	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	3.0	0.5
ES	6.6	0.5	0.0	0.0	0.3	0.0	11.8	0.8	0.0	1.9	0.0	5.6	0.0	25.2
Dd	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OW	1.9	0.6	0.0	0.9	1.0	0.0	13.0	0.2	0.1	1.3	0.0	16.2	0.0	35.3
FAC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	1a.2	17.9	0.0	3.0	3.4	0.0	35.8	290.6	0.5	3.7	0.0	23.9	0.0	399.7

Table 3.19

REACH 2

CHANGE IN ACREAGES BETWEEN 1975 AND 1982

1975	1982 SC	MS	TS	RM	CM	WA	MM	DS	BD	Es	Dd	OW	FAC	TOTAL
SC	37.3	6.2	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	2.2	5.3	0.0	53.9
MS	9.5	20.6	0.0	0.0	0.0	0.0	0.0	2.1	0.6	0.0	0.0	0.8	0.0	33.h
TS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RM	1.6	2.3	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	6.5
cn	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WA	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.6
nn	4.1	3.1	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.7	0.0	8.8
DS	3.3	6.3	0.0	0.0	0.0	0.0	0.0	444.3	0.0	0.0	0.0	0.3	0.0	156.3
BD	1.3	1.7	0.0	0.0	0.0	0.0	0.0	4.5	0.6	0.0	0.0	0.2	0.0	8.3
ES	0.7	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2
Dd	1.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	1.8
ow	1.7	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.6	0.0	2.1
FAC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	61.2	13.8	0.0	0.0	0.2	0.0	0.2	152.2	1.0	0.0	2.2	8.6	0.0	569.1

Table 3.20

REACH 2

CHANGE IN ACREAGES BETWEEN 1982 AN3 1986

1982	1984 SC	MS	TS	RM	CM	WA	MM	DS	BD	ES	Dd	OW	FAC	TOTAL
SC	43.6	7.6	0.0	0.0	0.0	0.0	0.0	0.6	0.2	4.8	0.2	4.6	0.0	61.2
ns	r.2	32.7	0.0	0.0	0.0	0.0	0.0	1.5	0.0	1.9	2.6	1.1	0.0	63.9
TS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rn	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cn	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	a.0	0.0	0.0	0.0	a.0	0.2
WA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
nn	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.2
DS	0.1	0.3	0.0	0.0	0.0	0.0	0.0	451.6	0.0	0.2	0.0	0.1	0.0	452.3
BD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	1.0
ES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dd	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.0	2.2
OW	1.7	1.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	1.8	0.0	3.7	0.0	8.b
FAC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	r9.5	41.7	0.0	0.0	0.0	0.0	0.0	153.8	3.3	8.7	2.6	9.5	0.0	569.1

Table 3.21

REACH 2

CHANGE IN ACREAGES BETWEEN 1984 AND 1985

1985

1984	SC	MS	TS	RN	CH	WA	MH	DS	BD	ES	Dd	OW	FAC	TOTAL
SC	25.7	7.5	0.0	0.0	0.0	0.1	0.0	0.9	0.1	10.6	1.1	3.1	0.0	49.5
MS	1.1	27.3	0.0	0.0	0.0	0.0	0.0	1.5	0.7	8.1	1.3	1.7	0.0	b1.7
TS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DS	0.5	1.2	0.0	0.0	0.0	0.0	0.0	u7.5	0.2	0.7	0.6	0.2	0.0	653.8
BD	2.1	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	3.3
ES	0.2	0.6	0.0	0.0	0.0	0.0	0.0	0.6	0.0	5.6	0.1	1.7	0.0	8.7
Dd	0.2	1.9	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.0	0.0	0.0	0.0	2.6
OW	0.6	0.6	0.0	0.0	0.0	0.0	0.1	0.4	0.0	5.8	0.3	2.1	0.0	9.5
FAC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	30.3	k2.2	0.0	0.0	0.0	0.1	0.1	451.1	2.0	30.7	3.4	9.1	0.0	569.1

Table 3.22

REACH2

CHANGE IN ACREAGES BETWEEN 1985 ANO 1986

1986

1985	SC	MS	TS	RN	CH	WA	MH	DS	BD	ES	Dd	OW	FAC	TOTAL
SC	25.7	1.8	0.0	0.0	0.0	0.0	0.0	0.5	0.6	0.6	0.9	0.4	0.0	30.3
MS	6.4	27.1	0.0	0.0	0.0	0.0	0.0	4.3	0.8	1.8	1.2	0.3	0.0	62.2
TS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WA	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
MH	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
DS	1.3	1.6	0.0	0.0	0.0	0.0	0.0	444.2	2.8	0.5	0.3	0.3	0.0	451.1
BD	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0	2.0
ES	13.3	1.2	0.0	0.0	0.1	0.0	0.2	1.3	0.0	12.L	0.1	2.1	0.0	30.7
Dd	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.9	1.5	0.0	0.0	3.5
OW	6.5	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.7	0.0	3.5	0.0.	9.1
FAC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	52.0	32.6	0.0	0.0	0.1	0.0	0.4	150.7	5.7	17.0	4.0	6.7	0.0	569.1

Table 3.23

REACH 3

CHANGE IN ACREAGES BETWEEN 1975 AND 1982

1982

1975	SC	MS	TS	RM	CM	WA	MM	DS	BD	ES	Dd	OW	FAC	TOTAL
SC	104.5	16.9	0.0	6.6	7.1	0.0	1.3	6.0	2.9	a.0	32.3	7.0	0.0	182.6
MS	13.0	46.0	0.0	0.0	0.0	0.0	0.0	12.5	4.2	0.0	12.0	0.7	0.0	88.6
TS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rtl	3.3	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	5.3	0.1	0.0	8.9
CM	27.2	1.6	0.0	1.8	17.6	0.0	0.0	0.2	0.0	0.0	91.1	1.9	0.0	141.1
WA	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
MM	12.9	1.5	0.0	2.7	7.9	0.0	0.1	0.3	0.0	0.0	16.L	0.5	0.0	*b2.b*
DS	5.6	18.6	0.0	0.0	0.0	0.0	0.0	215.6	26.1	0.0	2.6	0.3	0.0	267.1
BD	6.3	2.7	0.0	0.1	0.1	0.0	0.0	8.5	15.0	0.0	0.0	0.8	0.0	33.5
ES	3.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	a.1	0.0	0.2	0.8	0.0	6.6
Dd	5.9	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.6	0.0	0.0	8.5
au	2.1	0.0	0.0	0.1	6.6	0.0	0.0	0.0	0.1	0.0	0.2	6.5	0.0	13.1
FAC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	184.6	89.3	0.0	9.2	37.1	0.0	1.6	243.1	67.0	0.0	160.5	18.7	0.0	791.0

Table3.24

REACH 3

CHANGE IN ACREAGES BETWEEN 1982 AND 1986

1984

1982	SC	MS	TS	RM	CM	WA	MM	DS	BD	ES	Dd	OW	FAC	TOTAL
SC	132.5	13.5	0.0	0.7	0.5	2.1	0.6	2.0	6.2	6.0	15.5	7.0	0.0	184.6
MS	3.7	69.8	0.0	0.1	0.0	0.0	0.0	7.9	4.8	0.1	2.7	0.1	0.0	89.3
TS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rn	0.5	0.1	0.0	3.8	1.6	0.0	1.0	0.0	0.2	0.0	1.9	0.1	0.0	9.2
CM	0.2	0.8	0.0	0.9	26.5	0.7	0.2	0.0	0.0	0.1	6.6	0.9	0.0	37.1
WA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MM	0.6	0.3	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.2	0.1	0.0	*1.1*
DS	1.8	8.0	0.0	0.0	0.0	0.0	0.0	226.2	6.8	0.0	0.1	0.2	0.0	213.1
BD	3.5	0.7	0.0	0.0	0.0	0.0	0.0	0.5	62.0	0.0	0.0	0.3	0.0	*b7.1*
ES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dd	15.9	*27.1*	0.0	0.1	0.0	C.1	0.6	1.5	0.8	2.2	110.2	1.8	0.0	160.5
OW	b.2	0.2	0.0	0.0	0.3	0.0	0.2	0.0	0.1	1.3	0.2	11.5	0.0	18.7
FAC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	162.7	120.9	0.0	5.6	28.9	3.6	2.9	238.1	61.0	7.8	131.5	22.0	0.0	791.0

Table 3.25

REACH 3

CHANGE IN ACREAGE5 BETWEEN 1981 AND 1985

1985

1984	SC	MS	TS	RM	CM	MA	MM	DS	BD	ES	Cd	OW	FAC	TOTAL
SC	101.0	5.6	0.2	0.0	0.3	0.1	1.2	3.0	3.6	34.0	7.5	6.5	0.0	162.7
MS	11.4	82.0	1.3	0.0	0.0	0.0	0.0	10.6	1.6	4.2	9.2	0.8	0.0	120.9
TS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rn	0.6	0.1	0.0	0.8	0.2	0.0	0.0	0.0	0.2	0.0	3.7	0.0	0.0	5.6
CM	7.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.7	18.9	0.9	0.0	28.9
MA	0.9	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.1	0.0	3.6
ntl	0.8	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.1	1.1	0.3	0.0	2.9
DS	2.6	9.9	0.1	0.0	0.1	0.0	0.0	219.0	5.9	0.1	0.5	0.0	0.0	238.1
BD	3.2	1.5	0.0	0.0	0.0	0.0	0.1	6.8	16.1	5.8	0.7	0.8	0.0	61.0
ES	1.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5	0.1	0.7	0.0	7.8
Dd	9.3	2.7	35.3	c	.	3.3	0.0	0.4	1.5	0.3	18.5	63.8	2.6	0.0	137.5
OW	1.9	0.0	0.0	0.0	0.0	0.0	0.2	0.1	1.8	10.7	2.4	1.9	0.0	22.0
FAC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	142.1	106.1	36.9	1.1	0.6	0.2	1.9	238.7	57.5	83.2	108.3	14.5	0.0	791.0

Table 3.26

REACH3

CHANGE IN ACREAGES BETWEEN 1985 AND 1986

1986

1985	SC	MS	TS	RI	CM	MA	MM	DS	BD	ES	Dd	OW	FAC	TOTAL
SC	117.1	8.9	0.0	0.0	0.7	0.0	1.9	1.9	3.6	1.8	5.2	0.8	0.0	112.1
MS	6.0	77.8	0.0	0.0	0.0	0.0	0.0	11.9	2.2	0.0	8.1	0.0	0.0	106.1
TS	0.2	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	34.8	0.0	0.0	36.9
RM	0.1	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.5	0.1	0.0	1.1
CM	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.6
MA	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
MM	0.1	0.0	0.0	0.0	1.0	0.0	0.3	0.0	0.0	0.1	0.1	0.1	0.0	1.9
Ds	2.5	5.E	0.0	0.0	0.0	0.0	0.0	217.1	12.0	0.1	1.2	0.0	0.0	238.7
BD	4.4	0.6	0.0	0.1	0.1	0.0	0.0	2.7	16.7	0.9	1.6	0.8	0.0	57.6
ES	32.1	0.3	0.0	0.0	0.7	0.0	5.2	0.1	1.7	37.8	1.7	3.3	0.0	83.2
Dd	12.7	L.6	0.0	0.1	0.0	0.0	0.1	0.8	0.7	0.5	85.6	0.1	0.0	102.3
OW	2.2	0.0	0.0	0.0	1.7	0.0	3.0	0.0	0.3	1.3	0.3	5.7	0.3	14.5
FAC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	i77.b	99.5	0.0	0.4	4.4	0.0	10.5	234.4	67.3	L2.8	113.0	11.c	0.0	791.0

Table 3.27

REACH 6

CHANGE IN ACREAGES BETWEEN 1975 AND 1982

1982

1975	SC	SC	TS	Rn	CM	WA	MM	DS	BD	ES	Dd	OW	FAC	TOTAL
SC	59.5	0.6	0.0	a.7	19.7	0.0	0.6	0.0	1.7	0.0	0.0	0.0	0.0	82.7
MS	18.3	56.9	0.0	1.8	5.0	0.0	0.2	4.0	9.0	0.0	0.0	0.0	9.1	104.3
TS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
RM	0.0	0.0	0.0	1.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9
CM	6.0	14.0	7.9	19.7	133.0	0.1	0.0	0.0	0.0	0.0	0.6	0.1	0.0	181.3
WA	0.0	a.2	0.0	a.3	a.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9
MM	3.5	a.5	0.0	2.2	19.6	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	26.0
DS	1.6	23.7	0.0	0.3	2.9	0.0	0.0	145.3	20.9	0.0	0.0	0.0	0.2	197.9
BD	1.2	6.5	0.0	0.0	a.3	0.0	0.0	3.0	16.5	0.0	0.0	0.0	4.4	28.0
ES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dd	0.5	a.1	0.0	0.7	7.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.7
OW	0.0	0.0	a.1	0.0	6.6	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	6.8
FAC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	93.7	100.6	8.0	27.h	194.8	0.1	0.8	152.3	66.2	0.0	0.7	0.6	13.7	638.6

Table 3.28

REACH 6

CHANGE IN ACREAGES BETWEEN 1982 AND 1984

1984

1982	SC	MS	TS	RM	CM	WA	MM	DS	BD	ES	Dd	OW	FAC	TOTAL
SC	69.7	11.5	0.0	1.2	1.7	0.0	3.4	0.2	2.2	0.0	0.9	0.0	0.0	93.7
MS	3.5	78.1	0.0	1.8	2.2	0.1	0.1	3.4	7.2	0.0	4.0	0.1	0.0	100.6
TS	0.0	a.9	5.1	1.3	0.3	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	8.0
RM	a.3	a.9	0.0	21.8	2.1	0.0	0.2	0.0	0.2	0.0	1.9	0.0	0.0	27.k
CM	0.8	1.8	0.3	4.4	172.2	0.2	8.3	0.0	0.3	0.0	3.9	2.6	0.0	194.8
WA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
MM	0.6	a.1	0.0	0.0	0.0	0.0	a.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
DS	a.2	3.6	0.0	0.0	0.0	0.1	0.0	167.7	1.1	0.0	0.0	0.0	0.0	152. *b*
BD	a.3	a.3	0.0	0.0	1.2	0.0	a.1	0.0	43.4	0.0	0.0	a.7	0.0	66.1
ES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dd	c.2	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	a.7
au	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	a.4
FAC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.7	13.7
TOTAL	75.6	97.1	5.4	30.6	183.1	0.1	12.1	151.3	56.8	0.0	10.9	3.7	13.7	638.6

Table 3.29

REACH 6

CHANGE IN ACREAGES BETWEEN 1984 AND 1985

1585

1984	SC	MS	TS	RM	CM	WA	MM	DS	BD	ES	Dd	OW	F A C	TOTAL
SC	55.8	8.5	0.0	0.5	1.5	0.0	2.0	0.3	2.6	0.0	4.4	3.0	0.1	75.6
MS	5.3	73.6	0.0	2.6	4.2	0.1	0.1	7.2	2.2	0.0	1.8	0.0	0.0	97.1
TS	0.0	0.3	0.0	1.0	3.2	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	5.6
Rn	0.3	1.5	0.0	26.9	1.7	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	30.6
cn	18.2	2.9	0.3	3.2	83.8	9.8	1.8	0.1	0.5	1.8	56.6	6.2	0.1	183.2
WA	0.0	0.0	0.0	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
MM	0.6	1.0	0.0	0.6	0.8	0.0	8.1	0.0	0.9	0.0	0.5	0.0	0.0	12.1
DS	0.0	3.6	0.0	0.0	0.1	0.0	0.0	167.3	0.6	0.0	0.0	0.0	0.0	151.3
BD	2.7	6.0	0.0	0.1	0.1	0.0	0.0	1.0	65.8	0.6	0.3	0.1	0.2	56.8
ES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dd	0.9	2.0	0.0	1.2	3.9	0.3	0.0	0.0	0.1	0.1	2.3	0.1	0.0	10.9
OW	1.2	0.1	0.0	0.0	0.7	0.0	0.0	0.0	0.1	0.3	0.7	0.6	0.0	3.7
FAC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.7	13.7
TOTAL	84.8	97.6	0.4	36.1	100.3	10.3	12.1	155.9	52.6	2.6	67.3	5.1	16.0	638.6

Table 3.30

REACH6

CHANGE IN ACREAGES BETWEEN 1985 AND 1986

1986

1985	SC	MS	TS	RM	CR	WA	MM	DS	BD	ES	Dd	OW	FAC	TOTAL
SC	72.7	6.6	0.0	0.5	0.5	0.3	0.6	0.0	3.0	0.1	2.2	0.3	0.0	86.8
MS	6.2	69.6	0.0	2.5	1.2	0.6	0.1	3.2	8.1	0.0	6.4	0.0	0.0	97.6
TS	0.0	0.0	0.0	0.1	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
RM	1.1	1.3	0.0	31.1	0.7	0.5	0.3	0.0	0.0	0.0	1.1	0.0	0.0	36.1
cn	2.3	3.6	0.0	5.0	60.2	3.2	0.5	0.0	0.1	0.0	25.6	0.1	0.0	190.3
WA	0.7	1.3	0.0	0.2	0.3	0.9	1.5	0.0	0.0	0.0	6.5	0.8	0.0	10.3
MM	4.7	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	6.2	0.0	0.0	12.1
Ds	0.1	2.9	0.0	0.0	0.1	0.0	0.1	150.3	2.1	0.0	0.1	0.0	0.0	156.0
BD	1.7	1.3	0.0	0.0	0.0	0.0	0.0	0.6	47.5	0.0	1.1	0.0	0.1	52.2
ES	1.1	0.0	0.0	0.0	0.0	0.1	0.9	0.0	0.0	0.2	0.0	0.2	0.0	2.6
Dd	5.2	2.6	0.0	1.6	1.9	1.3	0.3	0.0	0.6	0.0	53.7	0.2	0.0	67.3
OW	0.6	0.2	0.0	0.1	0.6	0.1	1.2	0.0	0.0	0.0	0.3	1.9	0.0	5.1
FAC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	13.8	14.0
TOTAL	96.3	88.2	0.0	60.9	65.6	7.1	5.4	156.1	62.1	0.3	101.0	3.7	13.9	638.6

Table 3.31

REACH 5

CHANGE IN ACREAGES BETWEEN 1975 AND 1982

1982

1975	SC	ns	TS	RM	CM	MA	MM	OS	BD	ES	Dd	OW	FAC	TOTAL
SC	69.1	9.7	0.2	1.5	0.3	0.0	0.0	0.0	1.9	0.0	2.6	0.0	1.2	66.5
MS	32.1	403.9	1.0	11.9	a.6	0.1	0.1	4.1	79.1	0.0	0.2	0.1	23.1	556.8
TS	8.6	4.5	1.1	16.5	27.5	6.1	0.0	0.0	0.3	'0.0	0.0	0.0	0.0	62.7
RM	0.6	2.4	0.0	37.9	0.3	a.2	0.0	0.0	0.1	0.0	0.0	0.0	0.0	Cl.2
cn	3.1	10.6	6.1	23.5	30.2	12.8	3.5	0.0	0.0	0.0	2.5	0.0	0.0	92.6
MA	0.3	0.0	a.0	0.8	0.2	0.0	0.0	0.0	0.0	0.0	a.0	0.0	0.0	1.0
nn	2.0	6.9	a.0	18.7	0.2	0.0	0.1	0.0	0.3	0.0	0.0	0.0	0.0	20.2
OS	1.6	21.6	0.1	0.0	a.0	0.0	0.0	68.7	18.5	0.0	a.0	0.5	0.0	110.8
BD	3.3	22.0	0.2	0.0	1.8	0.0	0.0	1.6	56.6	0.0	0.0	0.0	1.5	85.1
ES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dd	a.3	2.1	0.0	1.2	0.9	2.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	6.7
OW	0.7	0.6	0.1	0.0	1.1	0.0	0.6	0.0	0.1	0.0	a.0	0.0	0.0	3.3
FAC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.0	36.0
TOTAL	101.5	484.1	8.8	110.0	63.1	21.3	6.6	76.6	155.0	0.0	5.3	0.6	62.1	1090.8

Table 3.32

REACH 5

CHANGE INACREAGES BETWEEN 1982 AND 1984

1984

1982	SC	MS	TS	Rn	CM	MA	MM	DS	BD	ES	Dd	OW	FAC	TOTAL
SC	82.0	12.2	0.0	2.0	1.6	0.1	0.2	0.0	1.8	0.0	1.2	0.5	0.0	101.7
ns	16.3	437.3	0.0	3.7	1.8	a.6	0.4	0.1	19.8	a.a	3.1	1.2	0.0	606.5
TS	0.1	5.7	0.6	0.5	0.8	0.1	0.0	0.0	0.1	0.0	1.1	0.0	0.0	6.8
Rn	5.9	7.8	0.0	89.5	2.1	a.8	0.1	0.0	a.2	0.0	3.7	0.0	a.0	110.2
cn	1.7	5.9	0.0	7.9	63.8	0.7	1.9	0.0	0.3	0.0	1.1	0.2	0.0	63.5
MA	0.6	1.0	0.0	1.6	3.9	16.2	0.0	0.0	0.0	a.0	a.2	0.0	0.0	21.3
MM	0.6	1.9	0.0	a.1	0.1	0.0	1.3	0.0	0.0	0.0	0.0	0.6	0.0	1.6
OS	1.2	0.6	0.0	0.0	0.0	a.0	a.0	70.9	0.1	0.0	0.0	0.0	0.0	72.8
BD	0.3	2.6	0.6	0.0	0.2	a.0	0.1	0.1	150.2	0.0	0.6	0.1	0.9	155.3
ES	0.0	a.0	0.0	0.0	0.0	0.0	a.0	0.0	a.0	0.0	0.0	0.0	0.0	0.0
Dd	2.0	0.6	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	5.6
OW	0.0	a.2	0.0	0.0	0.0	a.0	0.0	0.0	0.2	0.0	a.0	0.3	a.0	0.6
FAC	0.0	0.0	0.0	3.0	0.0	a.0	0.0	0.0	0.1	a.0	0.0	0.0	62.1	62.1
TOTAL	110.5	175.6	1.0	106.1	54.2	16.3	1.1	71.1	172.7	0.0	13.3	2.9	63.0	1090.6

Table 3.33

REACH 5

CHANGE IN ACREAGES BETWEEN 1984 AND 1985

1985

1984	SC	MS	TS	RM	CH	WA	MM	DS	BD	ES	Dd	OU	FAC	TOTAL
SC	85.6	11.6	0.3	7.4	2.0	0.1	0.5	1.3	1.2	0.0	0.0	0.3	0.0	110.5
MS	15.2	126.2	0.9	9.8	4.7	1.6	0.5	4.4	11.6	0.2	0.1	0.8	0.0	675.6
TS	0.0	0.2	0.3	0.2	0.1	0.2	0.0	0.0	0.1	0.0	0.0	0.0	0.0	1.0
RM	6.3	2.6	0.0	96.6	3.5	0.4	0.5	0.0	0.1	0.0	0.0	0.0	0.0	106.1
al	1.5	1.5	0.0	5.1	43.8	1.6	0.6	0.0	0.1	0.0	0.0	0.0	0.0	54.2
WA	0.3	0.1	0.0	2.3	L.2	8.6	0.5	0.0	0.0	0.4	0.0	0.0	0.0	16.3
MM	0.0	1.5	0.0	0.1	0.3	0.0	1.8	0.0	0.4	0.0	0.0	0.1	0.0	4.1
DS	0.1	1.3	0.0	0.0	0.0	0.0	0.0	69.6	0.1	0.0	0.0	0.0	0.0	70.8
BD	1.9	11.5	1.8	0.1	0.6	0.0	0.3	1.1	155.5	0.0	0.0	0.1	0.2	173.0
ES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dd	3.9	4.4	3.0	2.2	0.6	0.0	0.0	0.0	1.1	0.0	0.7	0.0	0.0	13.3
OU	0.4	1.2	0.0	0.0	0.2	0.0	0.0	0.0	0.2	0.0	0.0	0.9	0.0	2.9
FAC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	62.8	63.0
TOTAL	110.6	462.0	6.3	121.9	59.8	12.3	4.6	76.3	170.4	0.6	0.8	2.2	63.1	1090.8

Table 3.36

REACH5

CHANGE IN ACREAGES BETWEEN 1985 AND 1986

1986

1985	SC	MS	TS	RM	CI	UA	MM	DS	BD	ES	Dd	OU	FAC	TOTAL
SC	89.3	9.6	0.0	5.1	1.8	0.1	2.3	0.1	1.2	0.0	0.4	0.8	0.0	110.6
ns	21.2	b13.9	0.0	8.3	1.1	3.0	0.5	1.7	11.2	0.0	0.3	0.5	0.0	662.0
TS	1.2	0.9	0.1	0.2	0.0	0.0	0.0	0.0	0.8	0.0	3.0	0.0	0.0	6.3
RM	7.0	6.2	0.0	106.3	2.2	0.6	1.6	0.0	0.1	0.0	0.1	0.0	0.0	121.9
CH	1.8	0.9	0.0	6.8	45.6	3.8	0.0	0.0	C.b	0.0	0.1	0.2	0.0	59.8
WA	0.2	0.7	0.0	1.6	2.8	6.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.3
MM	0.2	0.5	0.0	1.5	0.4	0.1	1.3	0.0	0.6	0.0	0.0	0.1	0.0	L.6
DS	0.3	2.8	0.0	0.0	0.0	0.0	0.0	73.2	0.3	0.0	0.0	0.0	0.0	76.5
BD	3.6	19.9	0.1	0.3	0.4	0.0	0.1	0.5	144.3	0.0	0.5	0.1	0.1	170.2
ES	0.0	0.2	0.0	0.0	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
Dd	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.8
OU	0.4	0.8	0.0	0.0	0.2	0.0	0.0	0.0	0.1	0.0	0.0	0.6	0.0	2.2
FAC	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	62.3	63.1
TOTAL	125.0	b5L.9	0.2	130.3	55.1	14.8	5.8	75.6	159.6	0.0	4.8	2.1	62.3	1090.8

Table 3.35

REACH6

CHANGEINACREAGESBETWEEN1982AND1981

1984

1932	SC	MS	TS	Rtl	CH	WA	MH	DS	BD	ES	Dd	OW	FAC	TOTAL
SC	203.3	18.6	2.8	0.4	1.8	1.1	0.0	0.1	6.1	0.0	2.7	2.5	0.4	240.0
MS	3.9	81.1	1.7	0.3	0.3	0.5	0.2	0.1	8.9	0.0	6.7	0.5	0.0	101.9
TS	6.6	13.8	13.0	0.2	0.1	2.9	0.0	0.0	7.3	0.0	1.7	0.5	0.0	45.9
RM	0.2	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2
CH	0.8	0.8	0.1	0.0	3.0	0.2	0.1	0.0	0.2	0.0	0.3	0.6	0.0	6.0
WA	0.0	0.1	0.0	0.0	0.1	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
MH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DS	0.1	0.2	0.0	0.0	0.0	0.0	0.0	27.9	2.0	0.0	0.0	0.0	0.0	30.1
ED	6.7	10.2	0.2	0.0	0.2	0.0	0.0	0.1	129.1	0.0	1.5	0.7	0.1	146.7
ES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dd	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FAC	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	36.2	35.0
TOTAL	219.6	121.6	17.7	1.7	5.5	5.6	0.2	28.2	154.2	0.0	11.0	4.7	31.8	607.8

Table 3.36

REACH 6

CHANGE IN ACREAGES BETWEEN 1981 AND 1985

1985

1984	SC	MS	TS	RM	CH	WA	MH	DS	BD	ES	Dd	OW	FAC	TOTAL
SC	194.4	15.1	1.4	0.3	1.3	1.3	0.2	0.1	3.0	0.0	1.2	0.9	0.1	219.6
MS	16.2	90.5	6.1	0.1	3.2	1.7	0.0	1.6	5.9	0.0	0.3	0.9	0.2	124.6
TS	3.6	6.C	5.5	0.0	0.0	3.6	0.0	0.0	0.5	0.0	0.1	0.0	0.0	17.7
RM	0.2	0.1	0.0	1.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7
CH	0.9	0.9	0.0	0.1	3.4	0.1	0.1	0.0	0.0	0.0	0.0	0.2	0.0	5.5
WA	1.2	0.6	1.1	0.1	0.2	1.4	0.8	0.0	0.0	0.0	0.3	0.0	0.0	5.6
MH	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.0	0.0	0.0	0.0	0.2
DS	0.0	0.2	0.0	0.0	0.0	0.0	0.0	27.0	1.0	0.0	0.0	0.0	0.0	28.2
BD	2.6	10.1	3.6	0.1	0.2	0.0	0.3	1.0	13L.5	0.0	0.0	0.7	1.0	156.1
ES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dd	1.7	1.7	2.1	0.0	0.3	0.0	0.1	0.0	0.3	0.0	1.8	0.0	0.0	11.0
OW	1.0	0.6	0.0	0.0	0.0	0.1	0.0	0.0	1.8	0.0	0.0	1.3	0.0	6.8
FAC	0.4	0.2	1.5	0.0	0.0	0.0	0.1	0.0	1.2	0.0	0.0	0.0	31.3	36.8
TOTAL	222.5	127.6	19.2	2.1	8.7	8.0	1.6	29.5	168.1	0.0	3.8	6.0	32.6	607.8

Table 3.37

REACH 6

CHANGE IN ACREAGES BETWEEN 1985 AND 1986

1986

1935	SC	MS	TS	RR	CH	MA	MH	OS	BD	ES	Dd	CW	FAC	TOTAL
SC	198.7	5.2	3.6	1.5	1.9	1.7	0.5	0.1	7.2	0.4	0.4	1.4	0.0	222.5
MS	38.3	66.2	10.5	0.3	1.2	0.9	1.0	0.5	7.1	0.0	0.1	0.8	0.0	127.1
TS	2.7	1.6	12.1	0.1	0.1	0.2	0.6	0.0	0.9	0.0	0.0	0.0	0.7	19.3
RH	0.2	0.1	0.0	1.6	0.0	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.0	2.1
CH	1.2	0.3	0.0	0.1	3.2	0.1	2.2	0.0	0.7	0.0	0.0	1.0	0.0	8.7
MA	2.1	2.4	0.2	0.2	0.2	2.1	0.3	0.0	0.0	0.0	0.2	0.0	0.0	8.0
MH	0.2	0.0	0.1	0.9	0.1	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	1.6
Ds	0.1	0.3	0.0	0.0	0.0	0.0	0.0	27.5	1.5	0.0	0.0	0.0	0.0	29.5
BD	5.6	6.9	2.8	0.0	0.0	0.0	0.0	1.0	123.2	0.9	7.5	0.3	0.3	148.4
ES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
Dd	1.6	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.9	0.0	0.0	3.8
CW	1.0	0.4	0.0	0.0	0.1	0.0	0.1	0.0	0.8	0.8	0.0	0.7	0.0	4.0
FAC	0.0	0.2	0.3	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	31.1	32.6
TOTAL	251.6	83.9	30.6	6.5	7.0	5.3	5.0	29.2	143.1	2.0	9.1	6.3	32.2	607.8

Table 3.38

REACHES 1-5

CHANGE IN ACREAGES BETWEEN 197: AND 1982

	1982													
1975	SC	MS	TS	RI	CM	WA	MM	DS	BD	ES	Dd	OW	FAC	TOTAL
SC	266.2	37.0	0.2	7.6	27.6	0.1	3.2	8.6	6.5	0.0	37.1	18.2	1.2	413.3
MS	76.6	562.2	1.0	13.9	5.6	0.1	0.5	26.6	92.7	0.0	12.2	2.6	32.5	803.9
TS	8.6	6.5	1.1	16.5	27.5	6.1	0.0	0.0	0.3	0.0	0.0	0.0	0.0	62.7
RM	5.2	6.7	0.0	39.7	0.7	0.2	0.0	0.0	0.1	0.0	5.3	0.5	0.0	56.5
ul	36.3	25.9	16.0	66.9	180.8	12.9	3.9	0.2	0.0	0.0	96.2	2.0	0.0	615.3
WA	0.8	0.2	0.0	1.1	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	3.0
MM	23.1	12.7	0.0	23.6	27.8	0.2	1.6	0.6	0.6	0.0	lb.6	6.9	0.0	111.1
DS	22.6	76.9	0.1	0.9	3.6	0.0	0.5	1177.0	63.9	0.0	2.6	7.6	0.2	1353.4
BD	12.1	31.1	0.2	0.1	2.3	0.0	0.0	18.1	85.0	0.0	0.0	1.1	6.0	156.0
ES	5.1	2.3	0.0	0.3	0.0	0.0	0.0	0.6	0.1	0.0	0.2	1.1	0.0	9.7
Dd	8.1	6.5	0.0	1.9	8.2	2.0	0.2	0.0	0.3	0.0	0.6	0.1	0.0	25.7
OW	6.1	1.0	0.2	0.6	11.9	0.1	1.7	0.1	0.2	0.0	0.2	20.8	0.0	42.8
FAC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.0	36.0
TOTAL	670.6	761.2	16.8	168.9	296.4	21.8	11.6	1229.8	269.5	0.0	168.6	55.7	75.8	3689.2

Table 3.39

REACHES 1-b

CHANGE IN ACREAGES BETWEEN 1982 AND 1986

	1986													
1992	SC	MS	TS	Rn	CM	WA	MM	DS	BD	ES	Dd	OW	FAC	TOTAL
SC	539.7	66.3	2.8	6.3	8.6	3.7	6.2	6.0	16.5	17.6	20.5	22.3	0.6	710.6
MS	33.a	715.9	1.7	5.6	6.3	1.0	0.7	13.1	40.2	3.0	17.3	6.3	0.0	843.5
TS	6.7	20.3	18.7	2.0	1.2	2.9	0.0	0.0	7.7	0.0	2.7	0.5	0.0	62.7
RM	7.3	8.8	0.0	116.1	5.8	0.8	1.3	0.0	0.7	1.3	7.5	0.8	0.0	150.6
cn	3.6	9.5	0.6	13.3	265.6	1.8	10.6	0.0	0.8	0.1	11.9	5.6	0.0	332.7
WA	0.6	1.1	0.0	1.7	6.0	16.9	0.0	0.0	0.0	0.2	0.2	0.2	0.0	22.9
MM	1.6	2.4	0.0	0.2	0.1	0.0	1.8	0.0	0.0	0.0	0.3	5.1	0.0	11.6
DS	3.6	12.8	0.0	0.0	0.0	0.1	0.0	1228.7	9.9	0.3	0.1	2.6	0.0	1258.2
BD	8.9	13.9	0.5	0.0	1.5	0.0	0.3	0.7	366.0	0.0	1.9	1.6	1.1	396.5
ES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dd	16.1	28.0	0.0	0.8	0.2	0.1	0.4	1.5	2.9	2.2	112.6	1.8	0.0	168.7
OW	6.8	1.8	0.0	0.0	0.6	0.8	C.2	0.1	0.2	5.5	0.2	62.6	0.0	5B.8
FAC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0,8	0.0	0.0	0.0	110.0	110.8
TOTAL	630.4	880.9	26.1	166.C	271.8	26.0	19.3	1248.1	666.3	30.2	175.2	89.6	111.5	6.D97.t

Table 3.40

REACHES 1-6

CHANGE IN ACREAGES BETWEEN 1984 AND 1985

1985

1986	SC	MS	TS	RM	CM	MA	MM	DS	BD	ES	Dd	OW	FAC	TOTN
SC	465.6	18.8	1.9	8.3	5.4	1.6	5.7	6.2	10.3	49.8	14.2	12.5	0.2	630.4
MS	50.6	711.5	6.3	12.5	12.1	3.6	0.6	25.1	21.9	17.1	12.8	5.9	0.2	880.9
TS	3.6	6.9	5.7	1.2	3.3	3.8	0.0	0.0	0.6	0.0	0.9	0.0	0.0	26.1
RM	5.3	6.3	0.0	123.7	5.5	0.5	0.5	0.0	0.6	0.0	3.7	0.0	0.0	UC.0
CM	27.7	5.4	0.3	8.3	130.9	11.6	2.5	0.1	0.8	3.1	75.5	5.3	0.1	271.8
MA	2.5	0.6	1.1	2.5	4.7	9.0	1.3	0.0	0.0	3.0	0.3	0.1	0.0	26.0
MM	1.2	2.5	0.0	0.5	1.1	0.1	9.9	0.0	1.6	0.1	1.9	0.5	0.0	19.3
DS	5.9	21.4	0.1	0.0	0.6	0.0	0.7	1206.8	7.6	1.9	1.1	1.7	0.0	1247.8
BD	12.7	27.6	5.b	0.3	0.7	0.0	0.8	7.9	380.9	6.3	1.0	1.7	1.4	446.6
ES	2.2	0.5	0.0	0.0	0.2	0.1	1.3	0.8	0.0	19.3	0.2	5.6	0.0	30.2
Dd	12.3	19.6	40.4	3.6	1.8	0.3	0. 5	...	2.1	10.6	68.6	2.7	0.0	.75.2
OW	9.8	2.7	0.0	0.1	3.2	5.2	a.9	1.1	3.8	22.2	3.3	34.1	0.0	89.4
FAC	0.4	0.2	1.5	0.0	0.0	0.0	0.1	0.0	1.6	0.0	0.0	0.0	107.8	111.5
TOTAL	599.9	850.0	62.8	161.1	172.6	31.3	32.8	1269.6	431.2	162.3	183.7	70.1	109.7	4097.0

Table3.41

- REACHES 1-6

CHANGE INACREAGES BETWEEN 1985 AND 1936

1986

1985	SC	MS	TS	RI!	CM	MA	MM	DS	BD	ES	Dd	OW	FAC	TOTAL
SC	508.9	31.5	3.b	7.1	5.1	2.2	7.0	2.9	15.5	2.9	9.1	1.3	0.6	599.9
MS	79.4	665.9	10.5	11.1	3.8	4.4	2.4	22.9	x.8	1.9	16.1	1.8	0.0	850.0
TS	6.1	4.3	12.3	0.6	0.1	0.4	0.6	0.0	1.7	0.2	37.8	0.0	0.7	62.6
RM	8.4	5.6	0.0	139.0	3.1	1.:	1.9	0.0	0.2	0.0	1.7	0.1	0.0	16i.1
cn	6.0	6.8	0.0	12.0	109.9	7.0	3.6	0.3	1.3	0.0	26.0	1.7	0.0	172.6
MA	3.2	4.5	0.2	2.0	3.5	10.2	2.2	0.0	0.0	0.0	1.7	0.8	0.0	31.3
MM	6.S	1.7	0.1	i.5	2.1	0.1	5.0	0.2	0.8	0.2	6.6	0.5	0.0	32.5
DS	6.8	17.6	0.0	0.0	0.4	0.0	2.9	1199.5	19.1	0.8	1.6	1.0	0.0	1249.8
BD	15.3	28.8	2.9	0.1	0.5	0.0	0.4	L.9	363.8	1.7	10.7	1.2	0.5	133.9
ES	51.6	2.2	0.0	0.3	1.3	3.3	x.1	2.1	1.7	52.5	1.8	10.9	0.0	x.3
Dd	20.0	7.7	1.2	1.5	1.9	1.3	0.4	1.2	1.3	1.5	145.2	0.4	0.0	183.7
OW	10.6	2.0	0.0	1.1	3.7	0.1	17.3	0.3	1.1	1.1	3.6	26.7	0.0	72.1
FAC	0.0	0.4	6.3	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0	107.2	109.7
TOTAL	721.0	776.9	30.8	179.1	135.0	27.2	65.8	1234.2	438.4	65.8	262.0	51.6	106.5	1P9i.0

4.0 RESULTS/DISCUSSION

4.1 OBSERVED VEGETATIONAL CHANGES

The most noteworthy change in the Las Vegas Wash has been the reduction of marsh habitat, primarily seen as a decline in cattail marsh; however, reed marsh has also been impacted. Changes are most evident near Pabco Road. Scouring and draining have drastically changed the complexion of the two mentioned communities in this area. Upstream of Pabco Road, a large portion of the marsh has been drained, while a combination of draining and scouring has reduced marsh habitat downstream.

The above factors have also been impacting the Wash farther downstream, thoughout the study period. For instance, in 1975 the headcutting was evident downstream in Reach 3. By that time the marsh was already declining, and by 1982, the total acreage had been reduced 80 percent.

Other vegetation types have also changed in various portions of the Wash. Salt cedar is present throughout the study area, although its distribution has been fluctuating. The salt cedar community increased over the entire Wash between 1975 and 1982. Subsequent years had declines until 1986, when an increase in distribution was observed. The 1986 increase appears to be the result of the salt cedar's ability to quickly establish itself in areas that have been eroded or scoured.

Thistle and smotherweed have invaded disturbed areas, most notably during 1975 and 1985, in Reaches 5 and 3, respectively. This vegetation generally appeared to be dead in following years. Vegetation along the margins of the Wash, such as mixed shrub, remained generally constant throughout the study period. Exceptions occurred in areas that were disturbed by burning or mechanical activities or when salt cedar cover reached 80 percent.

4.2 ACCURACY ASSESSMENT

A certain amount of positional error was probably introduced at each stage - photointerpretation, transfer, and digitization - of the project. During photointerpretation, the interpreter had to make a best judgement decision as to where a boundary between two covertypes occurred. Sometimes this was a very distinct line, often it was very indistinct due to intergrading of species and communities. Since the focus of this project was year to year change, the photointerpreter had to be much more aware of where boundaries were drawn between covertypes from one year to the next. This concern promoted more consistency in drawing boundaries and identifing covertypes.

Relative positional error during the photointerpretation phase of the project was probably in the range of .5mm or less (approximately 10 feet), at 1:6000 scale. This assumed a distinct boundary between covertypes. Uhere there was an intergrading of covertypes, the relative error was very difficult to define because there was no absolute boundary.

In the transfer process, the placement of lines to denote vegetation polygons had to be very precise. By projecting the current year's interpretation on plots of the previous year's interpretation, it was possible to exactly match polygons that were the same from year to year. Only vegetation polygons that actually changed shape or size needed to be drawn in, minimizing, if not eliminating, the problem of slightly different line placement between years that would normally be expected.

Due to the software problems associated with the overlay copying routine and the cumbersome editing process, it was necessary to digitize all polygons each year, regardless of whether there had been changes in all polygons. This process did introduce a slight amount of *error.* Several experiments were conducted to identify this error. It appeared that the placement of a digitized line could be incorrect by the width of a .5mm pencil lead at 1:6000 scale on -the map base, or 3 meters on the ground, as a maximum. This was probably not a significant error.

The possible digitizing error was considered when selecting a 3 meter cell size for the rasterization process. It was assumed that picking a cell size of approximately the same size as the maximum potential digitizing error would prevent the addition of any positional error that might have been introduced otherwise.

Interpretation accuracy was assessed by a U.S.B.R. biologist who had studied the Las Vegas Wash area for several years. After reviewing the first set of interpretations, the biologist found the typing to be very accurate and at the correct level of detail.

4.3 ACREAGE SUMMARIES

4.3.1 OBSERVED VEGETATION CHANGES

The Las Vegas Wash study area covered a total of 4126.8 acres. Desert and mixed shrub categories made up approximately 50 percent of the total area. These classes dominated in the margins of the floodplain, covering a large number of acres because of the extended study boundaries. The majority of the barren/disturbed lands and facilities *were* located along the outer margins of the study area. Acreage figures varied considerably between the reaches for the other vegetation types delineated. Therefore, the following discussion examines acreage summaries of all the delineated covertypes by reach, with the exception of mixed shrub, desert, barren/disturbed, and facilities.

Reach 1 contained the least amount of acreage, and except for 1986, salt cedar was the dominant vegetation type. In 1986, the mixed marsh community was dominant as a result of the establishment of marsh species on areas that were eroded or scoured in 1984 and 1985, This establishment occurred primarily along the stream channel and on new sediments in Las Vegas Bay.

Salt cedar was also dominant in Reach 2 throughout the study period. Marsh species were negligible, with 1975 having the highest percentage of marsh for the observed years (.025 percent).

Unlike Reach 2, cattail marsh was abundant in Reach 3 in 1975. Approximately 144 acres of cattail marsh existed, however, acreages have significantly declined, with only 4 acres remaining in 1986. Salt cedar has also been abundant, reaching a peak in 1982 of 192.2 acres, and a low of approximately 142 acres following the floods of 1984. This reach has been impacted by erosion and scouring, with a maximum extent in 1985 (84.6 acres). Areas that were formerly vegetated and now appear dead reached a maximum extent of 160.1 acres in 1982. In general, these dead areas have not revegetated except for some annual weedy growth.

The impacts of scouring and draining are evident in Reach 4. Over 130 acres of cattail marsh were lost from 1982 to 1986. Reed marsh is more abundant in this section of the wash, reaching a high of 42.2 acres in 1986. Wetland annuals have increased in this reach, however they only comprise approximately .02 percent of the total area. Salt cedar acreages remained constant in the 75 to 95 acre range in this reach.

Reach 5 has experienced a steady increase in salt cedar. There has also been a considerable increase in reed marsh from 1975 to 1986, although of the observed 90 acres, all but 20 acres existed by 1982. Cattail marsh, however, has decreased in extent by nearly 40 acres since 1975. Wetland annuals have fluctuated while mixed marsh acres have dropped considerably. Thistle and smotherweed have been reduced from 64.3 acres in 1975 to zero in 1986.

The dominant vegetation type in Reach 6 is salt cedar. This covertype averaged over 35 percent of the total reach area cover. Thistle and smotherweed were relatively abundant, although acres declined significantly in 1984 and 1985. All other vegetation types are of minimal importance.

4.3.2 RASTERIZATION EFFECTS

The raster acreage files generated as part of the overlay analysis do not match exactly the numbers of acres reported in the vector files. There is no difference, however, in the percentage present of a given covertype for a given reach when comparing the vector files with the raster files. This difference between raster and vector acreages has been noted before in other projects. Using 3 meter cells in the rasterization process helped to minimize the rasterization impact.

4.4 USE OF A DIGITAL DATABASE

To properly manage an area like the Las Vegas Hash, a manager needs to know what has happened in the area in the past, and how the past relates to the present. By knowing these things, the manager can make more informed management decisions. Digitizing photointerpreted data from previous years and referencing this data to a geographic base helps the manager see what has been occurring in a given area.

Geographically referenced data in a digital database can be manipulated, as was done in this project, to show changes between years - both visually with map plots and numerically with acreage summaries. This manipulation allows the manager to see the effects of natural and human impacts on the area in a very clear and precise way. A digital

database is very easy to update. New information is digitized and entered into the database as it is received. In this manner, the database is always current.

The plots and acreage summaries for the Las Vegas Wash area very graphically show the changes that have occurred in the Wash between 1975 and 1986, especially the decline in marsh vegetation types. By looking at photos, the manager, or resource specialist, can get a feel for impacts, but without digitally combining data sets, it is difficult to see the full impact and extent of the changes occurring in the Wash area.

A geographically referenced database can contain more than just photointerpreted data. Some data sets that could be used in a digitai database are soils information, elevation, slope, and aspect, road networks, urban centers, mining claims, and ownership. When studying potential impacts on the Wash, it is much easier to use the computer to merge data sets in the digital database, than to try to manually combine data from several different maps onto a single hand-drawn overlay.

By visually seeing the changes in the Wash between years, and knowing what natural and human impacts occurred in those years, the manager can make management decisions for future years. Being better informed about the area and how it has changed with time, will allow the manager to make better decisions.

The map plots produced to help the manager are also very useful for public presentations. Often the public doesn't understand the reasons for proposed management decisions. Visually showing them what has occurred over time in an area will help them understand management decisions and future impacts.

5.0 REFERENCES

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APPENDIX 1

DOCUMENTATION OF GEOBLOCKS, OVERLAYS, AND CLASS LISTINGS USED IN THE LAS VEGAS WASH PROJECT

Account Name: **LVWASH.LVWASH.GIS**

Geoblock Directory File: GDF

Location and Dimension of Geoblocks: LL: 36 00 00 N Xidth: 15.0 min.
115 07 30 **W** Height: 15.0 min.
UTM Zone 11

Transmatrix File: TXGEOBLO.LVWASH.GIS

Plot Transformations: Las Vegas NE LVNE
Las Vegas Se LVSE
Frenchman Mtn FRENCH
Henderson HNDERSON

Geoblocks and Overlays: GEOBLO 1982 photointerpreted data

1. CONTROL **(P)**
2. LINE **(L)**
3. **R1VEG82** (A)
4. **R2VEG82 (A)**
5. **R3VEG82 (A)**
6. **R4VEG82** (A)
7. **R5VEG82 (A)**
8. **R6VEG82 (A)**
9. SECTIONS **(A)**
10. **R2LVEG82 (L)**
11. **R3LVEG82 (L)**

GEOBL2 1984 photointerpreted data

1. CONTROL **(P)**
2. LINE **(L)**
3. **R1VEG84 (A)**
4. **R2VEG84 (A)**
5. **R3VEG84** (A)
6. **R4VEG84 (A)**
7. **R5VEG84 (A)**
8. **R6VEG84** (A)

GEOBL3 1985 photointerpreted data

1. CONTROL **(P)**
2. LINE **(L)**
3. **R1VEG85 (A)**
4. **R2VEG85 (A)**
5. **R3VEG85 (A)**
6. **R4VEG85** (A)
7. **R5VEG85 (A)**
8. **R6VEG85** (A)

GEOBL4 1986 photointerpreted data
1. CONTROL **(P)**
2. LINE **(L)**
3. **R1VEG86 (A)**
4. **R2VEG86 (A)**
5. **R3VEG86 (A)**
6. **R4VEG86 (A)**
7. **R5VEG86 (A)**
8. **R6VEG86 (A)**

GEOBL5 1975 photointerpreted data
1. CONTROL **(P)**
2. LINE **(L)**
3. **R1VEG75 (A)**
4. **R2VEG75** (A)
5. **R3VEG75 (A)**
6. **R4VEG75** (A)
7. **R5VEG75 (A)**
8. **R6VEG75 (A)**

Class Values in Each Overlay:

OVERLAY 1 - CONTROL
- Class 1 - All control points.
- Class 2 - State Plane Points
- Class 3 - Subdivision of 1 for map registration

OVERLAY 2 - LINE
- Class 1 - Improved Roads
- Class 2 - Trails
- Class 3 - Drain
- Class 4 - Lateral
- Class 5 - Transect
- Class 30 - Open Water

OVERLAYS 3 **to** 8 - VEG by Reach
- Class 10 - SC = Salt Cedar
- Class 11 - MS = Mixed Shrub
- Class 12 - TS = **Thistle/Smotherweed**
- Class 13 - RM = Reed Marsh
- Class 14 - CM = Cattail Marsh
- Class 15 - HA = Wetland Annuals
- Class 16 - MM = Mixed Marsh

- Class 2C - DS = Desert
- Class 21 - BD = Barren/Disturbed
- Class 22 - ES = Eroded/Scoured
- Class 23 - Dd = Dead

- Class 30 - OW = Open Water

- Class 40 - FAC = **Facilities**

OVERLAY 9 - SECTIONS
Classes 1 - 36

Appendix 2.1

Estimation of Stormwater Flows in Las Vegas Wash, Nevada and Potential Stormwater Capture

By

Jeffrey Johnson

Southern Nevada Water Authority
SNWA Resources Department

SOUTHERN NEVADA
WATER AUTHORITY

September 1999

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Abstract

Comprehensive planning for the Las Vegas Wash (Wash) is evaluating and addressing water quality and erosion issues. In determining appropriate actions, planning efforts need to analyze the volume and frequency of stormwater flows in the Wash and also evaluate stormwater capture as a potential management strategy in the Wash and/or water resource for Southern Nevada.

Stormwater flows in the Wash were estimated using two independent methods. One approach uses the estimated daily volume of precipitation that occurs in the Valley based on historical precipitation gage records and subtracts assumed transmission losses and ground-water percolation to derive a stormwater flow volume in the Wash. The second approach uses historical daily mean flows in the Wash and subtracts the estimated baseflow to derive the remaining stormwater flow. Both methods demonstrate that the average annual stormwater volume conveyed by the Wash from 1980 to 1997 was less than 3,500 acre-feet per year (afy) with the highest year between 10,000 afy and 17,000 afy and the lowest year around 0 to 400 afy.

Frequency analyses on the stormwater flows derived from the second method (daily mean flows), which are considered more accurate because of the numerous assumptions in the first method, illustrate that the Wash from 1980 to 1997 has conveyed stormwater flows an average of 13.3 days per year, and 87% of these days have yielded stormflow volumes between 1 and 400 acre-feet. Because the average annual volume of stormwater flow is so small and occurs sporadically and infrequently, preliminary analyses indicate that the facilities needed to capture, treat, and distribute the water make this potential resource very expensive relative to other resource options. However, small-scale stormwater capture in the Wash may be a viable management strategy for riparian habitat and erosion control. Cost-benefit analyses on capture facilities must consider the volume and frequency of stormwater flows, impacts to return flow credits and type of capture facilities, reasons for capturing stormwater and the use or disposal of the stormwater, as well as existing surface water rights.

Introduction

Comprehensive planning for the Las Vegas Wash (Wash) is evaluating and addressing water quality and erosion issues. In determining appropriate actions, planning efforts need to analyze the volume and frequency of stormwater flows in the Wash and also evaluate stormwater capture as a potential management strategy in the Wash and/or water resource for Southern Nevada.

This paper estimates the volume of stormwater flows in the Wash using two independent methods, and shows how stormwater is accounted for in the return flow credit methodology used to determine Nevada's Colorado River water "credit" from flows in the Wash. Basic premises on potential stormwater capture both in the Wash as well as upstream of the Wash are also discussed based on the calculated stormflow volumes and frequency. The information presented is designed to support policy decisions regarding the feasibility of capturing stormwater flows for beneficial use. It is not meant to provide a detailed engineering estimate of flows on which to base design of specific structures.

Las Vegas Valley and Surface Water Flows in Las Vegas Wash

The Las Vegas Valley (Valley) is tributary to Lake Mead and the Colorado River system and encompasses approximately 1,600 square miles (Figure 1). The urbanized area of the Valley is located near the central and southern end of the Valley. Elevations in the Valley range from 11,918 feet at Charleston Peak in the Spring Mountains to about 1,500 feet at the eastern edge of the Valley. The Valley floor in the Las Vegas metropolitan area generally lies between 3,000 and 1,500 feet mean sea level (msl).

The Valley is drained to the southeast by the Las Vegas Wash and its major tributaries, Range Wash, Las Vegas Creek, Red Rock Wash, Flamingo Wash, Tropicana Wash, Duck Creek, Pittman Wash, and C-1 Channel (Figure 1). Since the 1950s, the lower reaches of these streams have been perennial, partly due to their interception of the shallow ground-water table and partly due to drainage of urban irrigation and treated wastewater discharges (Hines, Cole, and Donovan, 1993). Today, more than 90% of the perennial flow on the lower reach of Las Vegas Wash is comprised of treated wastewater from the City of Las Vegas, the Clark County Sanitation District and the Advanced Wastewater Treatment Plant, and the City of Henderson along with raw water returns from Basic Management Incorporated (BMI) (Figure 1). Figure 2 shows annual total flows in Las Vegas Wash from 1980 to 1997 (in acre-feet per year) downstream of the wastewater treatment plants, BMI returns, and the majority of tributary inflows.

Perennial baseflow in the Wash is characterized as having three components, 1) intercepted shallow ground-water, 2) drainage from urban irrigation, and 3) metered returns, which include treated wastewater and BMI returns. Stormwater flow resulting from occasional precipitation events adds an additional flow component to the perennial baseflow of the Wash.

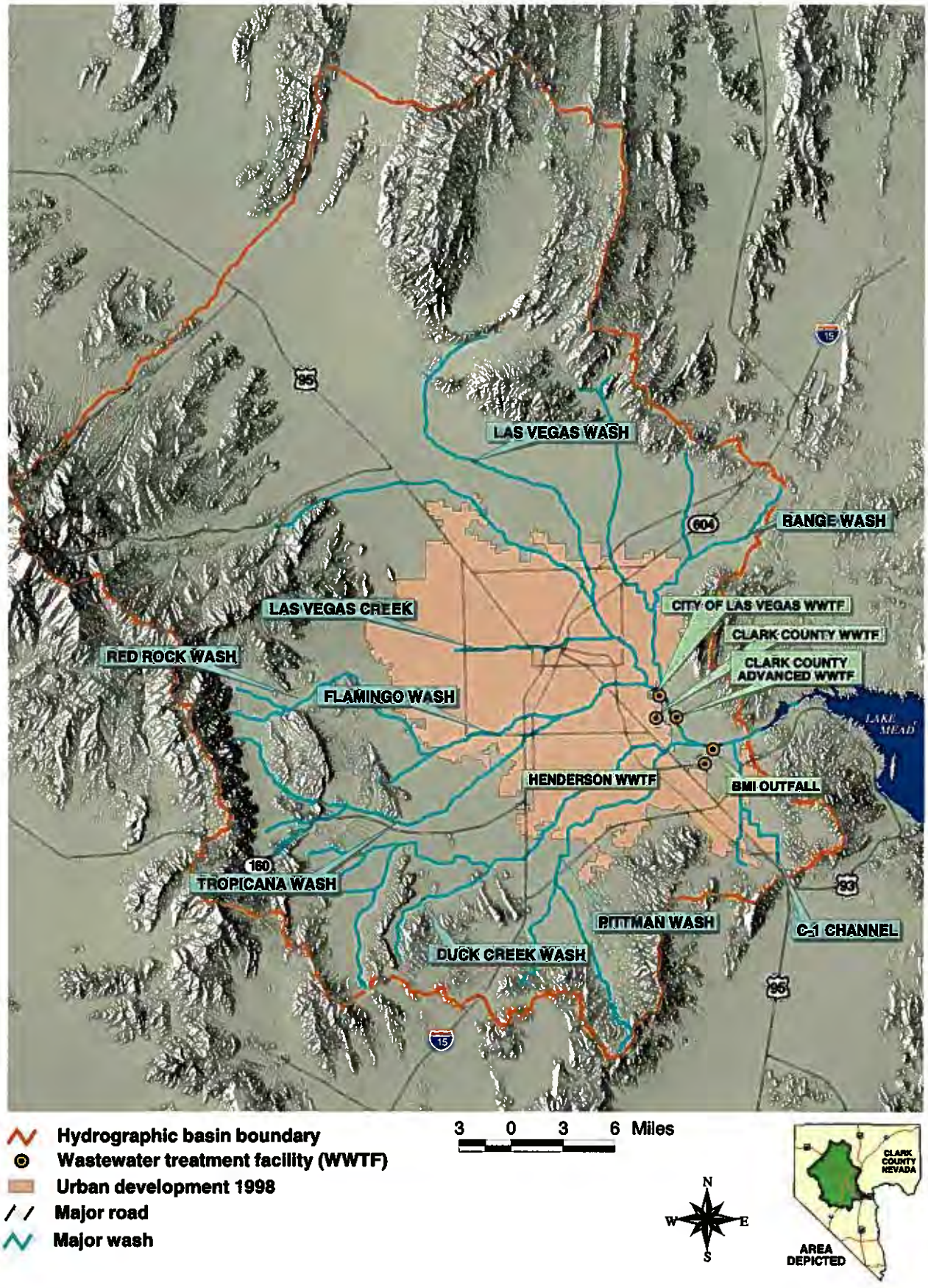

Figure 1. Las Vegas Valley hydrographic basin.

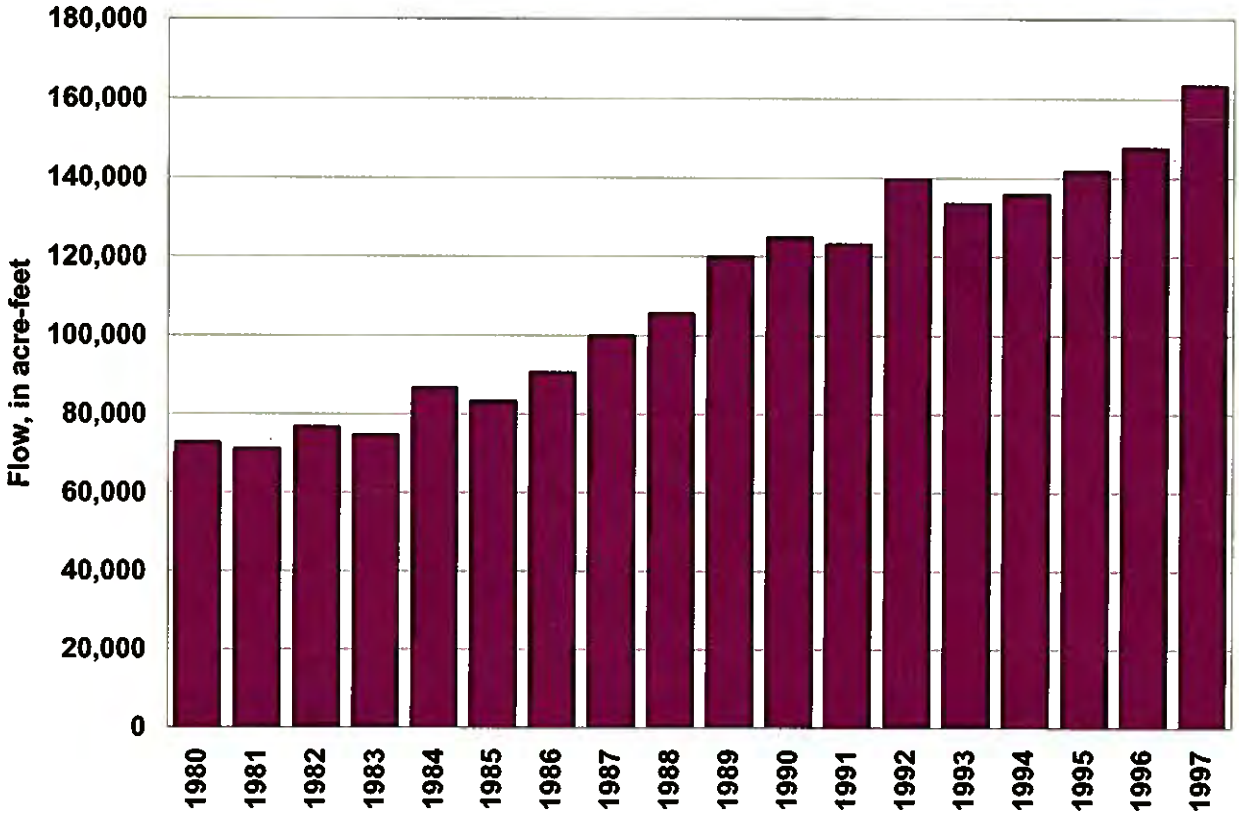

Figure 2. Annual flows in Las Vegas Wash at USGS gaging stations from 1980 through 1997.

Stormwater Flows in Las Vegas Wash

The separation of stormwater flow from the baseflow in the Wash is difficult, due to the lack of flow data on main tributaries to the Wash, as well as the variable inflow of urban irrigation and the unknown volume of ground-water interception. The U.S. Geological Survey (USGS) and the Clark County Regional Flood Control District (Flood Control District) operate and maintain surface water gages on many but not all of the tributaries. This lack of data combined with the vast area of the Las Vegas Valley drainage system and the sporadic nature of precipitation events over the area make it impossible to definitively measure stormwater flows.

Stormwater flows in the Wash, however, can be estimated by at least two independent methods. Method 1 uses the estimated daily volume of precipitation that occurs in the Valley based on historical precipitation gage records and subtracts assumed transmission losses and ground-water percolation to derive a stormwater flow volume in the Wash. The second approach uses historical daily mean flows in the Wash and subtracts the estimated baseflow to derive the remaining stormwater flow. Both methods and their results are presented for comparison purposes. Because of the relatively numerous assumptions in Method 1, stormwater volumes derived from Method 2, which uses daily mean flows in the Wash, is considered more accurate.

Method 1: Stormwater Flows Based on Precipitation

Stormwater flows in the Wash represent only a portion of the precipitation that occurs in the Valley. Much of the rainfall that hits the ground is captured or lost before it reaches the Wash. It pools on surfaces, evaporates and transpires from plants, and seeps into the ground prior to reaching tributaries that drain to the Wash. In order to estimate stormwater flows derived from precipitation, the actual volume of precipitation over the drainage area of the Wash must be estimated and the losses calculated between the water hitting the ground and actual flow in the Wash.

Estimate of Precipitation

The National Weather Service (NWS) maintains (or has maintained) at least ten precipitation gages that collect precipitation data in and adjacent to the Valley. Some of these gages are at high elevations where precipitation does not result in stormwater flows to Las Vegas Wash. Because of this, the actual surface water drainage for the Las Vegas Wash is an area smaller than the entire Las Vegas Valley.

Figure 3 depicts a January 1998 satellite image of the Las Vegas Valley along with elevation contours. At an elevation of approximately 4,500 feet msl the mountain blocks grade into alluvial fans. Above this contour, winter precipitation generally occurs as snowfall, which is the source of natural recharge to the Valley's principal ground-water aquifers. Summer precipitation above 4,500 feet generally seeps into the ground through course sediments prior to reaching the alluvial fans. Therefore, precipitation contributing to stormwater runoff in the Wash is estimated to be derived from elevations less than 4,500 feet msl.

The satellite image in Figure 3 also shows a playa in the northwest portion of the Valley below the 4,500-foot contour. This playa exists because surface water runoff from the northern end of the Valley (area crosshatched in Figure 3) drains to this location and pools. While this playa has a narrow channel that connects it to the lower portion of the Valley, it is thought that very little water from this area contributes to flow in the Wash. Therefore, this area is also not considered part of the Las Vegas Wash drainage area. Excluding this northern area and portions of the Valley above 4,500 feet msl results in an area contributing to stormwater flows in the Wash of approximately 923 square miles.

Eight precipitation gages have been maintained by the NWS at elevations less than 4,500 feet msl (Figure 4) in and around the Valley. Table 1 summarizes the average annual precipitation for each of these gages over its period of record. Additional agencies (USGS, Flood Control District, and the Nevada State Engineer's Office) collect precipitation data in the Valley, but very few of the gages have daily, long-term precipitation records similar to the NWS gages.

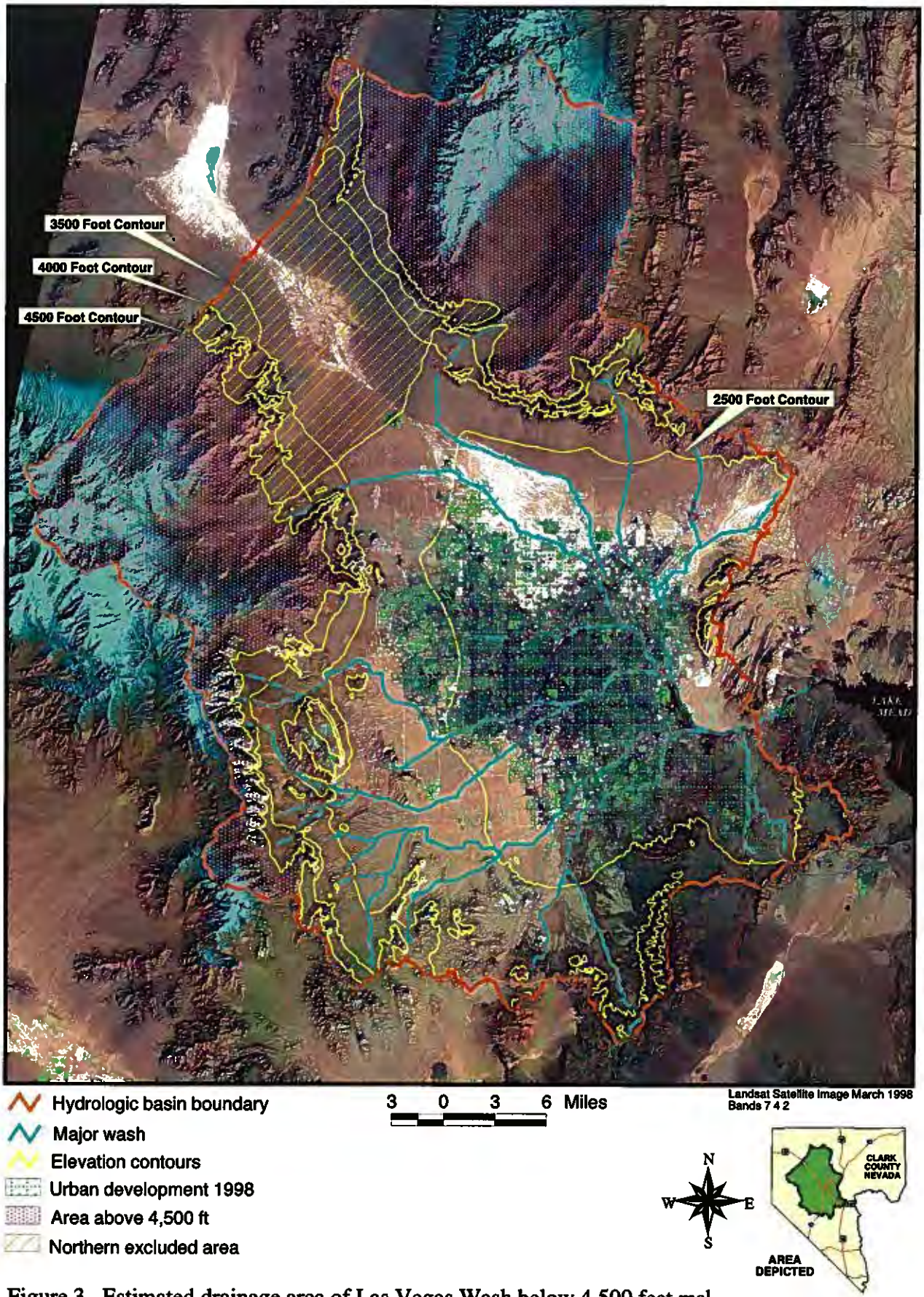

Figure 3. Estimated drainage area of Las Vegas Wash below 4,500 feet msl.

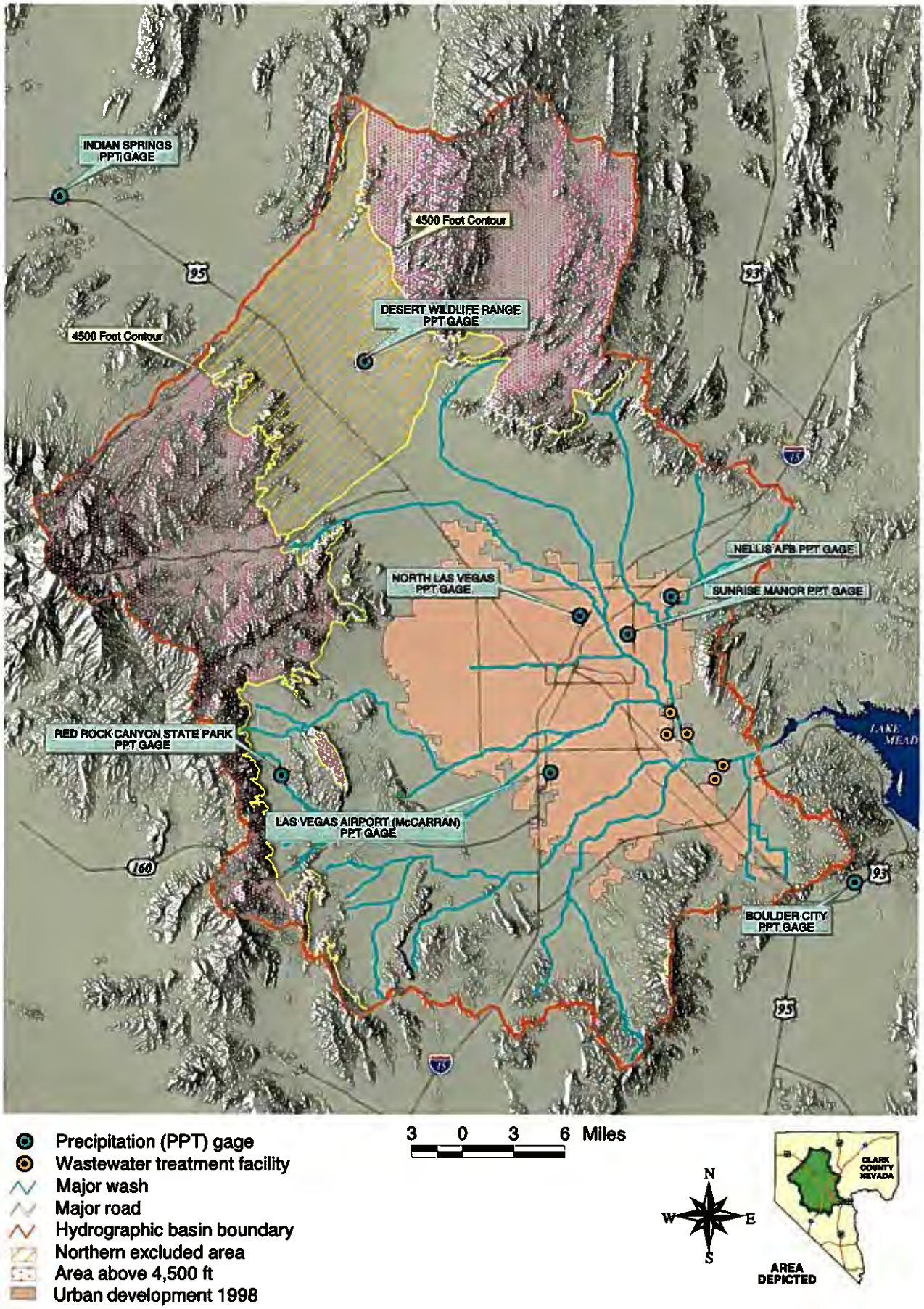

Figure 4. Location of National Weather Service precipitation gages below 4,500 feet msl.

Table 1. Average annual precipitation at National Weather Service gages below 4,500 ft msl.

Station Name	Elevation (feet above msl)	Period of Record	Mean Annual Precipitation, in inches
Las Vegas Airport (McCarran)	2,162	1949-1998	4.22
Desert Wildlife Range	2,922	1948-1998	4.42
Boulder City	2,525	1931-1998	5.73
Red Rock Canyon State Park	3,780	1977-1998	12.37
Sunrise Manor	1,820	1961-1987	4.52
North Las Vegas	1,880	1951-1998	4.33
Indian Springs	3,120	1948-1964	2.90
Nellis Air Force Base	1,881	1942-1993	4.25

Data obtained from:

1) Western Regional Climatic Center (WRCC) 1998. [online 3/99] Western Historical Summaries, Nevada, "http://www.wrcc.dri.edu/summary/climsmnv.html"
2) Buchanan, 1997

The average annual precipitation in and around the Valley at elevations below 4,500 feet msl recorded at NWS gages, with the exception of the Red Rock Canyon State Park gage, ranges between 5.73 and 2.90 inches per year (Table 1). The Red Rock Canyon State Park gage is believed to have a higher annual precipitation value because of its location in the Spring Mountains, which results in higher than normal precipitation. Because the annual average precipitation across the Valley is fairly consistent and a long-term record of precipitation is needed, the McCarran Airport gage, with an average annual precipitation of 4.2 inches over 59-years of complete record, is considered in this analysis as representative of precipitation in the Valley below 4,500 feet msl.

It is important to note that, of the 4.2 inches of average annual precipitation at the McCarran gage, approximately 1.5 inches occurs during the summer months of May through September. During these months, moist tropical air from the south/southeast causes scattered and occasionally severe convective thunderstorm activity. Winter precipitation averages 2.7 inches per year, and is generally the result of winter frontal systems which tend to be regional in nature (Buchanan, 1997). This phenomenon was used by French, 1983, to calculate rainfall intensities based on summer and winter seasons and is one factor used to estimate precipitation losses.

Calculated Estimation of Precipitation Losses

Given the average annual precipitation within the drainage area of the Wash (as determined above), it is possible to estimate the total *potential* stormwater flows by multiplying the depth of precipitation (4.2 inches) by the area of the drainage basin (923 square miles). However, this assumes all the precipitation runs off the surfaces of the Wash's drainage area and results in flow to the Wash, which is not true. In order to estimate the *actual* runoff volume from precipitation in the Wash, losses due to water pooling on surfaces, evaporation, evapotranspiration, and soil infiltration need to be estimated.

Precipitation losses within drainage basins have been studied extensively by the Soil Conservation Service (SCS) (which is now the Natural Resources Conservation Service), the Army Corp of Engineers, and the National Oceanic and Atmospheric Administration (NOAA) (to name of few). These studies have resulted in mathematical relationships that derive actual runoff from precipitation based on factors such as drainage basin size, precipitation intensity, soil and vegetation characteristics, and channel conveyance characteristics.

Buchanan, 1997, developed a technique that derives actual runoff from historical daily precipitation data using these established methods for estimating precipitation losses. His technique was applied to the Red Rock drainage basin, which terminated at the Red Rock detention basin. Buchanan's method, which utilizes a Fortran program to compile the data, was simplified for this analysis, so it could be performed in spreadsheets.

Under Buchanan's method and this analysis, precipitation losses are estimated in three principal steps. The first step accounts for the fact that precipitation over a drainage basin is not uniform. It reduces the recorded daily precipitation based on the size of the drainage basin, interpolated rainfall intensity, and the season in which the precipitation occurred (summer or winter). This reduction is calculated using NOAA's HYDRO-40 area-reduction curves. Step two accounts for water that does not run off surfaces, and is instead captured in small pools and/or infiltrates into the ground. This is accomplished by reducing the precipitation volume generated from step one by estimating losses due to soil infiltration and water pooling on surfaces, which are functions of soil type, vegetation cover, and soil moisture from precipitation over the previous five days. These losses are calculated using SCS curve numbers. The third step accounts for transmission losses as a result of additional soil infiltration once the water begins to flow and is derived using SCS channel-loss reduction curves. (These three steps are explained in more detail in Appendix I.)

Results of Method 1

Buchanan's method was applied to the daily precipitation data collected at the McCarran Airport gage from 1980 to 1997. The analysis shows that the average annual stormwater runoff estimated to reach the Wash over the 18-year period was between 440 and 5,700 acre-feet per year (afy), with a most likely 18-year average annual stormwater runoff of about 2,500 afy. The range in average annual stormwater runoff is a function of which SCS curve number and transmission loss coefficient is used.

The curve numbers for the drainage area of the Wash is estimated to range from 87 to 93, based on soil and vegetation classifications, and the transmission loss coefficient is estimated to be 0.15 to 0.65 based on climatic factors and channel characteristics. Figure 5 shows how this variability derives a range for the 18-year average annual stormwater runoff in the Wash. The curves in Figure 5 represent different transmission loss coefficients plotted against different curve numbers. The y-axis then shows the calculated average annual stormwater runoff in acre-feet per year. The vertical bars on the graph bracket the range of curve numbers and transmission loss coefficients estimated for the drainage area of the Wash. Thus, the 18-year average annual stormwater runoff in the Wash ranges from a low of 440 afy (curve number of 87 and transmission loss coefficient of .15) and a high of 5,700 afy (curve number of 93 and transmission loss coefficient of .65).

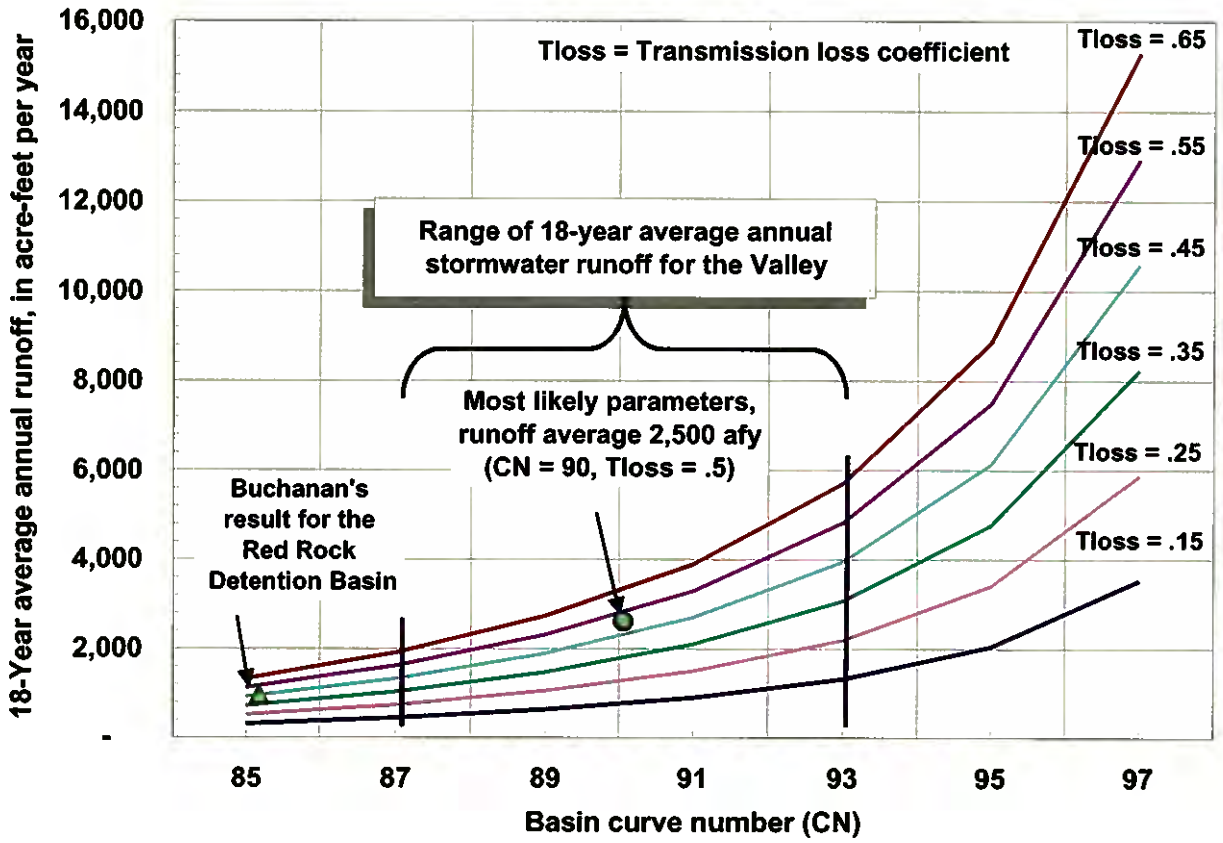

Figure 5. Range of 18-year average annual stormwater flow in Las Vegas Wash based on Method 1.

The most likely average annual stormwater runoff to reach the Wash is 2,500 afy and is based on a curve number of 90 and a transmission loss coefficient of 0.5. These numbers best approximate the overall characteristics of the Wash's drainage area, which encompasses about 30% developed area (high runoff potential) and 70% undeveloped area (low runoff potential). Developed portions of the drainage area have a higher runoff potential because of impermeable surfaces (streets and buildings) and drainage channels that are concrete lined or saturated due to urban irrigation and/or intercepted shallow ground-water (curve numbers 90 to 95 and transmission loss coefficients between 0.4 and 0.65). This high runoff potential is balanced with undeveloped areas that have low runoff potential due to exposed soils and drainage channels that consist of course sediments, which remain dry until it rains (curve numbers 85 to 90 and transmission loss coefficients between 0.15 to 0.25). Combining both the high and low runoff potentials in the Valley results in the "most likely runoff."

Table 2 shows the daily stormwater runoff in acre-feet summed by month under the most likely annual runoff determination. Many of the months over the 18-year period had no stormflows. In fact, of the 500 days with recorded precipitation at the McCarran precipitation gage from 1980 to 1997, only 26 of these days (5%) under this method resulted in stormwater flows in the Wash, the maximum of which was 6,800 acre-feet. Categorizing these runoff events by volume shows that 18 out of the 26 stormflows events (69%) are under 1,500 acre-feet.

Table 2. Total monthly stormwater flows derived from Method 1, based on historical precipitation.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1980	-	8,097	-	-	-	-	-	-	-	-	-	-	8,097
1981	-	-	1,562	-	-	-	-	-	-	-	-	-	1,562
1982	-	2,438	-	-	-	-	-	-	-	-	-	-	2,438
1983	-	-	-	-	-	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	-	1,109	-	-	-	1,266	-	2,375
1985	-	-	-	-	-	-	-	-	-	-	-	-	-
1986	-	-	-	-	-	-	-	-	-	-	1,687	-	1,687
1987	752	-	-	-	3	-	-	-	-	-	1,392	-	2,147
1988	-	-	-	-	-	-	-	-	-	-	-	-	-
1989	-	-	-	-	-	-	-	-	-	-	-	-	-
1990	578	-	-	-	-	1	-	-	-	-	-	-	580
1991	-	-	-	-	-	-	-	-	-	-	-	-	-
1992	-	-	12,894	-	-	-	-	-	-	3,448	-	1,382	17,724
1993	-	5,600	-	-	-	-	-	-	-	-	-	-	5,600
1994	-	-	-	-	-	-	-	-	-	-	-	846	846
1995	2,065	-	-	-	-	-	-	-	-	-	-	-	2,065
1996	-	-	-	-	-	-	-	-	-	-	-	-	-
1997	-	-	-	-	-	-	-	-	-	-	-	-	-

18-year average annual stormflow 2,500 afy

This method of determining the volume of stormwater flow reaching the Las Vegas Wash uses well studied drainage basin characteristics, but only derives a rough estimate of stormwater flow. A more accurate estimate of stormwater flows can be made by examining actual flow data in the Wash that has been collected by the USGS.

Method 2: Stormwater Flows Derived from Daily Mean Flows in Las Vegas Wash

The USGS has monitored and published daily mean flows in the Wash since 1957. Daily mean flows are comprised of baseflows (intercepted shallow ground-water, drainage from urban irrigation, and treated wastewater discharge) plus sporadic stormwater flows. Using historical daily mean flows, it is possible to identify stormflow events and calculate the volume of stormwater by subtracting the estimated baseflow of the Wash during the storm event.

Surface Water Gage Data

Figure 6 shows the locations of four gaging stations operated and maintained by the USGS to measure flows in the Wash during water years 1980 to 1997. (A water year is from October 1 to September 30.) Table 3 lists these gages along with their period of record. The common names used for the gages are the underlined portion of the USGS name.

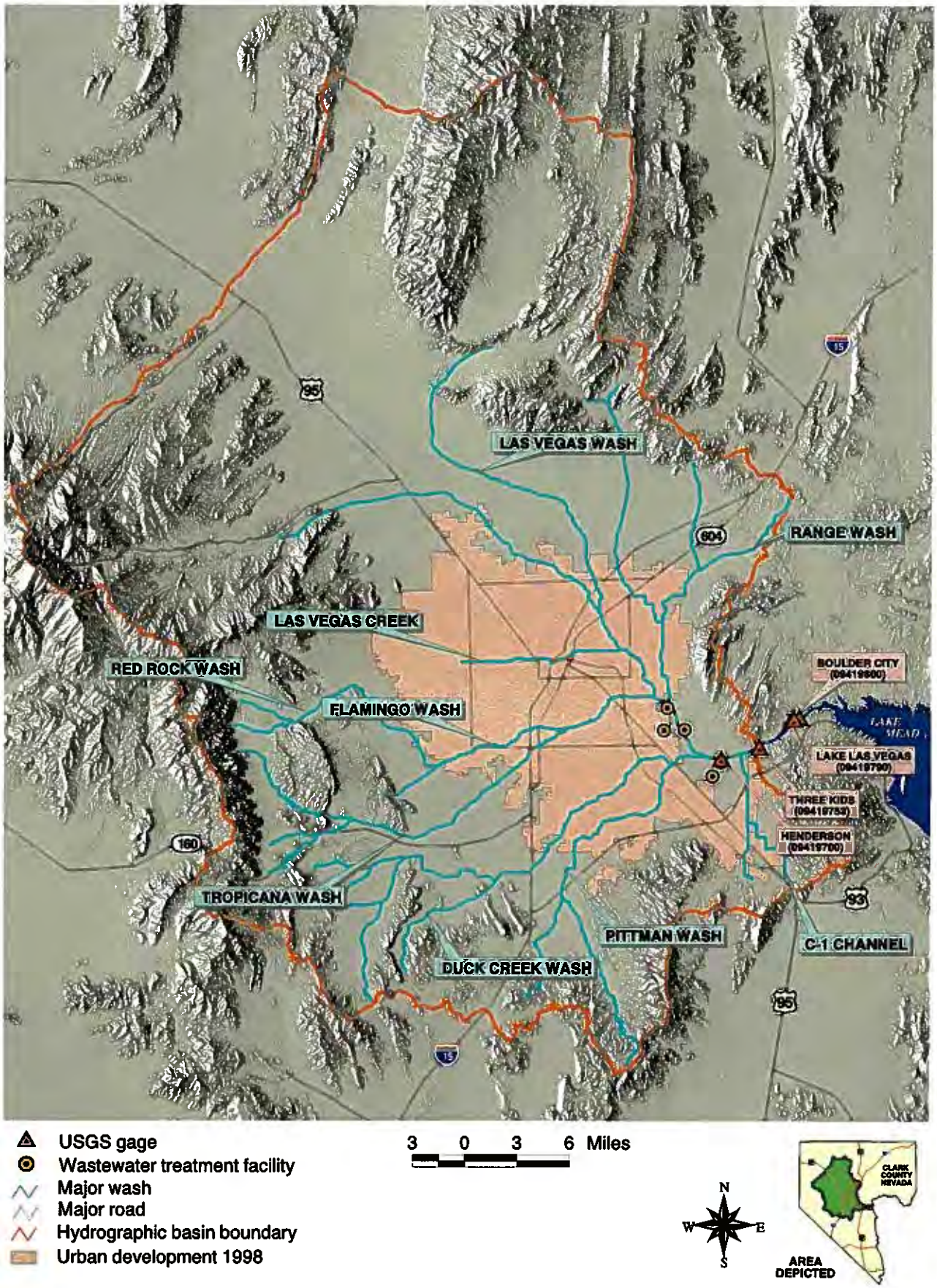

Figure 6. U.S. Geological Survey surface water gaging stations in Las Vegas Wash.

Table 3. Period of records for USGS gaging stations in Las Vegas Wash

USGS Station Number and Name	Period of Record
09419800 Las Vegas Wash near Boulder City	1969 – 1984
09419700 Las Vegas Wash near Henderson	1957 – 1988
09419753 Las Vegas Wash above Three Kids Wash near Henderson	1988 – 1998
09419790 Las Vegas Wash below Lake Las Vegas below Henderson	1991 – present

These gages collect instantaneous water surface elevations every 15 to 60 minutes. Elevation data is then converted to discharge in cubic-feet per second (cfs) using a stage-discharge relationship and then compiled to derive daily mean flows. Daily mean flows are the data published by the USGS on Las Vegas Wash from 1980 to 1997.

When more than one gage is present on the Wash, the USGS is able to compare records between the gages to derive more definitive daily mean flow values (USGS, personal communication). Calendar year 1992 is an example of this, when both the Three Kids and Lake Las Vegas gages were present on the Wash, and each gage had periods of estimated or missing record. Since the estimated or missing records generally did not occur simultaneously, a complete record could be generated for each gage. Flow data from calendar year 1992 at the Three Kids gage is used to help explain how Method 2 functions; calendar year 1992 also has the highest annual stormwater flow volume from 1980 to 1997.

Separating Stormflow from Baseflow

The daily mean flows in the Wash from January 1, 1980 to December 31, 1997, are shown in Figure 7, as recorded at the *Boulder City* gage (1980 - 1981, and water year 1984), the *Henderson* gage (1983 and 1985 - 1988), and the *Three Kids* gage (1989 - 1997). The spikes in the graph indicate stormflow events in which baseflows need to be estimated in order to determine the remaining stormflow volume. To separate stormflow volumes from the baseflows, two things must be accomplished. First, a determination must be made as to when the daily mean flow values include stormflows, and second, what the actual estimated baseflow is, if the daily mean flow includes stormflows.

To determine whether or not a daily mean flow in the Wash includes stormflows, an exceedance threshold is used which approximates the baseflow of the Wash at that period in time plus some constant flow which accounts for measurement errors and fluctuations in treated wastewater discharge. If flows exceed the threshold, then they are assumed to include stormflows. Although the flow rate in the Wash has increased over time (due to increased treated wastewater discharge and possibly increased urban irrigation and shallow ground-water interception), examination of daily mean flows indicates that flows in the Wash over a short time interval are relatively steady. A good representation of the baseflow over a short time interval is the monthly mean flow. Figure 8 shows the monthly mean flows as well as the daily mean flows in the Wash for calendar year 1992.

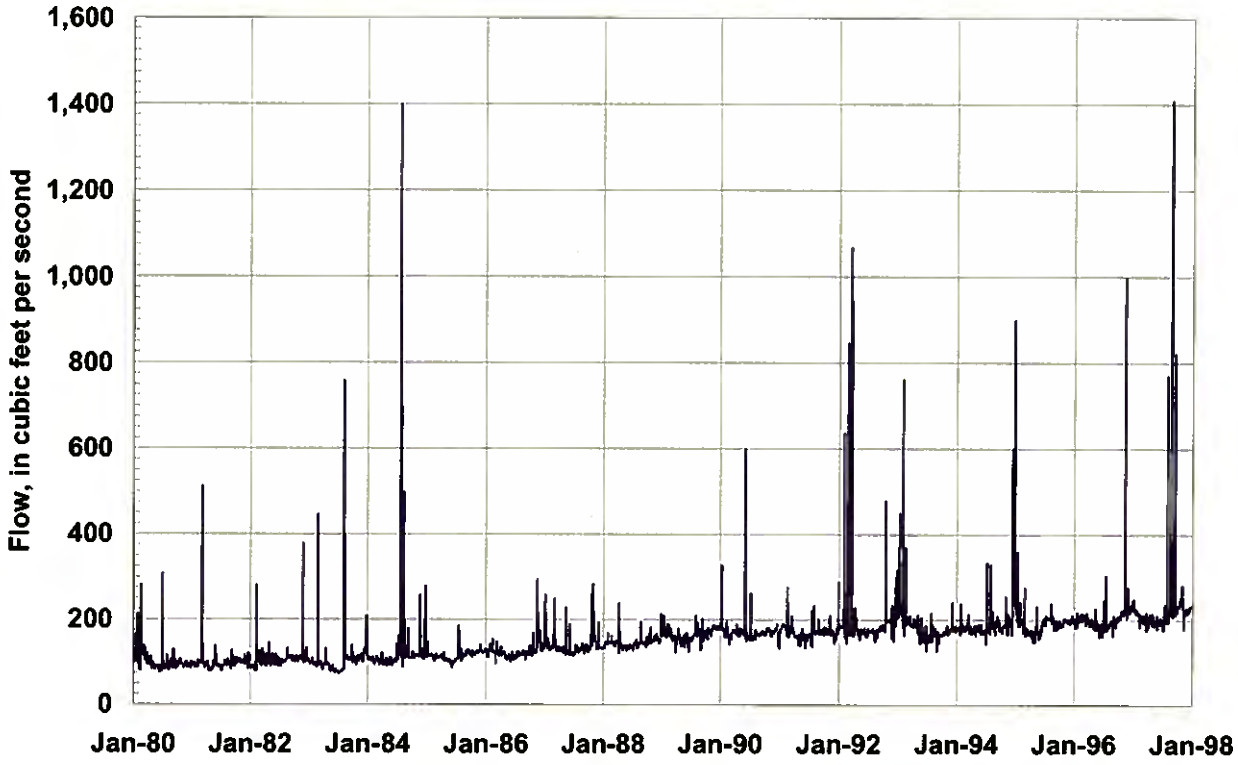

Figure 7. Daily mean flows in Las Vegas Wash from 1980 through 1997 at the USGS Gages.

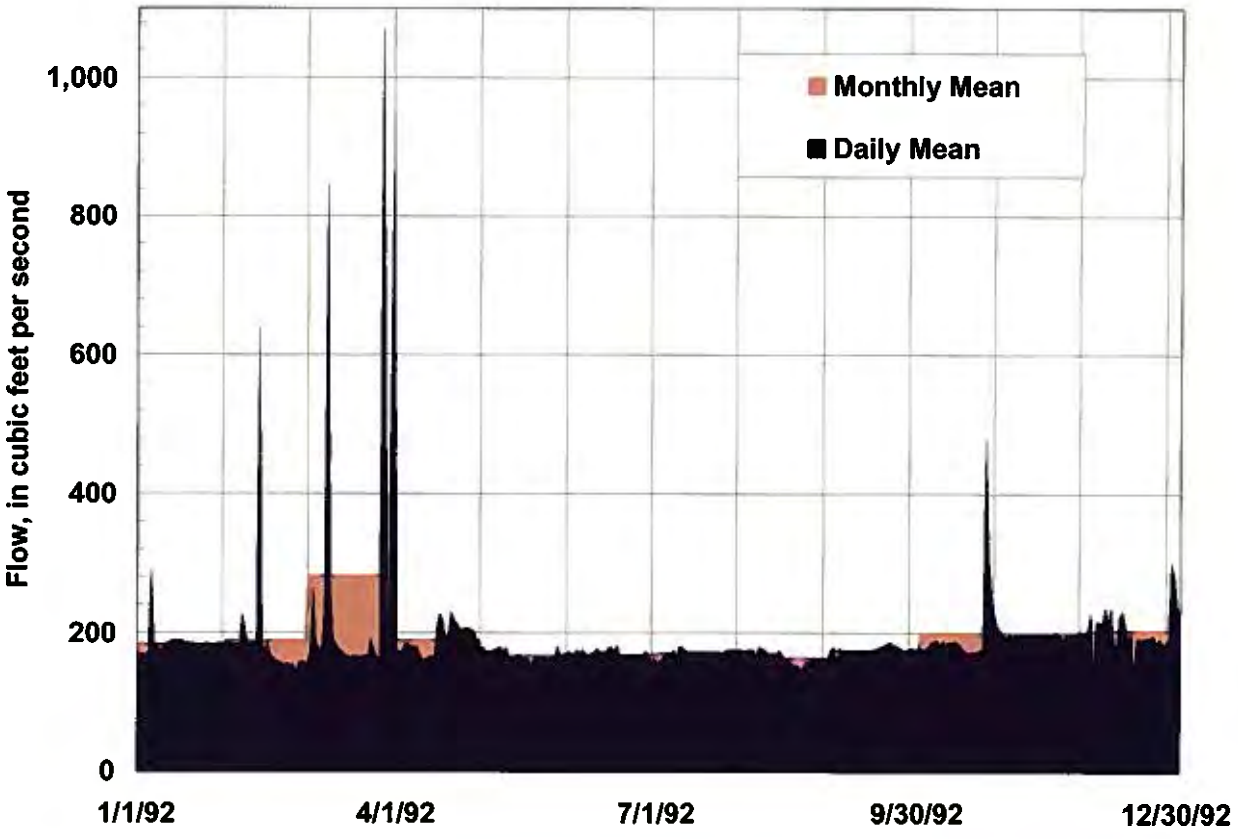

Figure 8. 1992 daily mean and monthly mean flows in Las Vegas Wash.

To ensure that the exceedance threshold identifies only daily flows that include stormflow, a constant of 20 cfs is added to the monthly mean flow. The 20 cfs accounts for flow variability in the Wash caused by fluctuating treated wastewater discharge and gaging errors, which are generally less than 15% of the total mean daily flow. Comparing the exceedance threshold (monthly mean flow + 20 cfs) to the daily flow data in the Wash from 1980 to 1997 allows each day that includes stormflows to be identified (Figure 9).

The second step determines what the baseflow should be during the days that stormflows occurred. This is accomplished by recalculating the monthly mean flow without the identified stormflow days. The result is a new monthly mean flow that excludes stormwater flows and represents the baseflow of the Wash for that month. The volume of stormwater flow then equals the total daily mean flow minus the calculated baseflow which excludes stormwater flows. Figure 10 shows the stormflow volume calculated using this method.

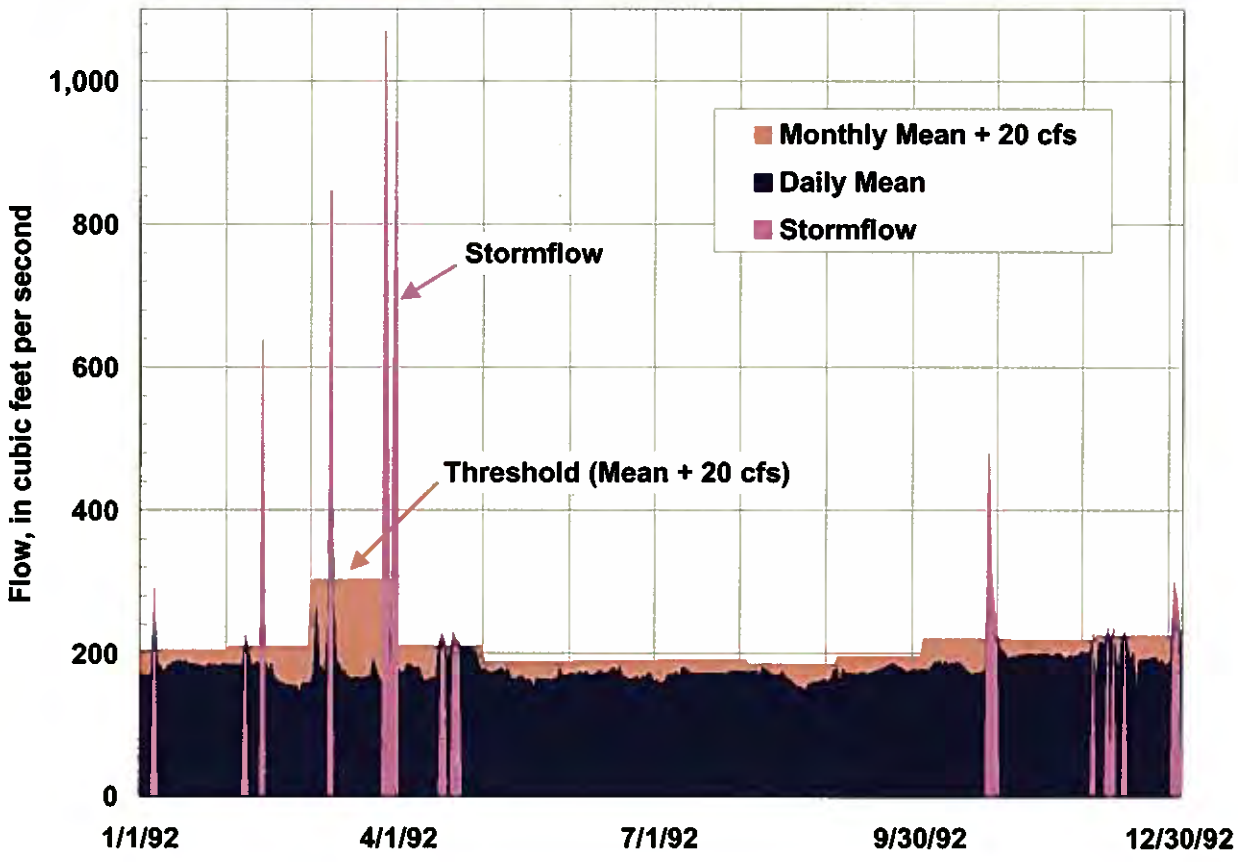

Figure 9. Identified stormflow days in 1992 using a threshold of the mean monthly flow + 20 cfs.

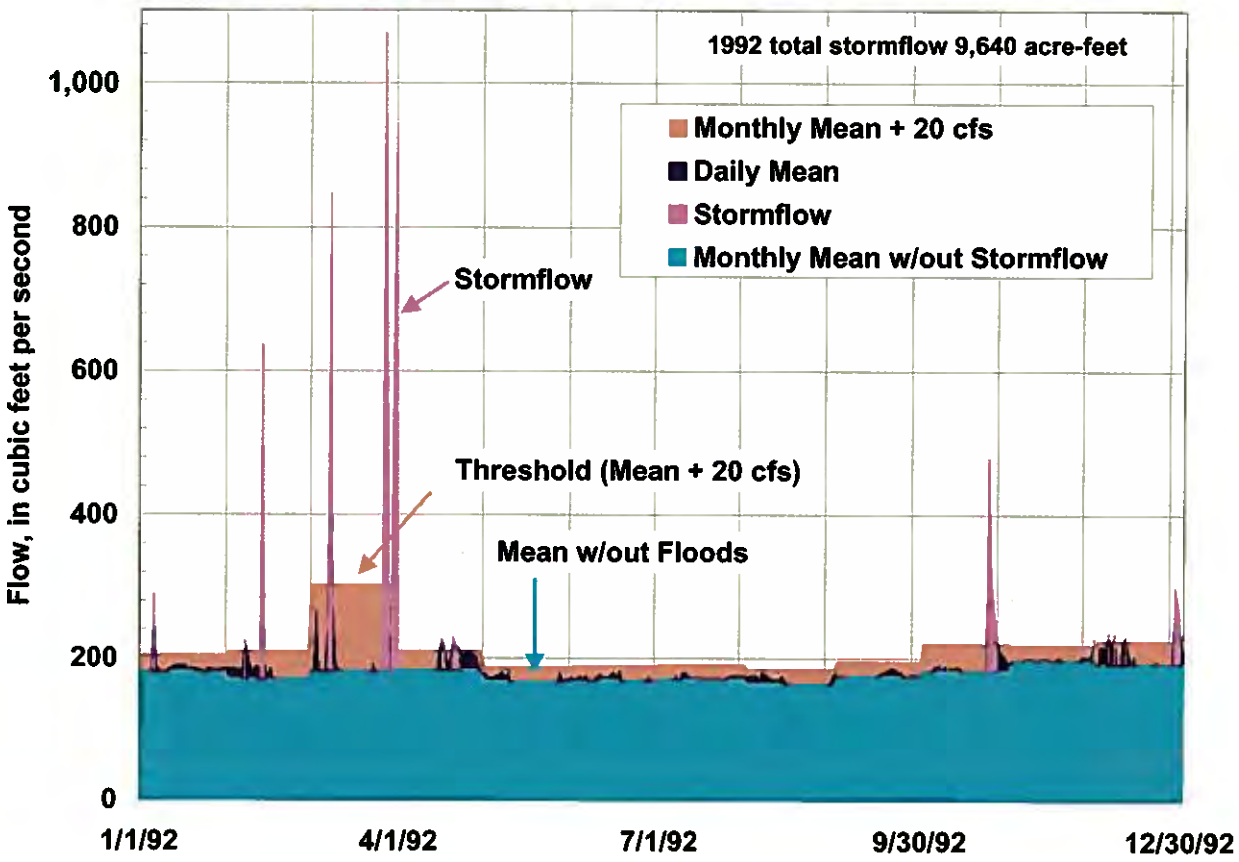

Figure 10. 1992 stormwater flows resulting from Method 2 using a threshold of the mean monthly flow + 20 cfs.

Results of Method 2

This method, using an exceedance threshold equal to the monthly mean flow + 20 cfs, was applied to the flow data published by the USGS in Wash from 1980 to 1997. The analysis showed that the average annual stormwater runoff in the Wash was 3,190 afy over the 18-year period. Figure 11 shows the yearly stormflow volumes computed for each year and its relative proportion to the annual baseflow in the Wash. Examining the stormflows on a daily basis over the 18-year period showed that 239 days (out of a total of 6,575 days) had stormflow events, and 87% of these stormflows ranged between 1 and 400 acre-feet.

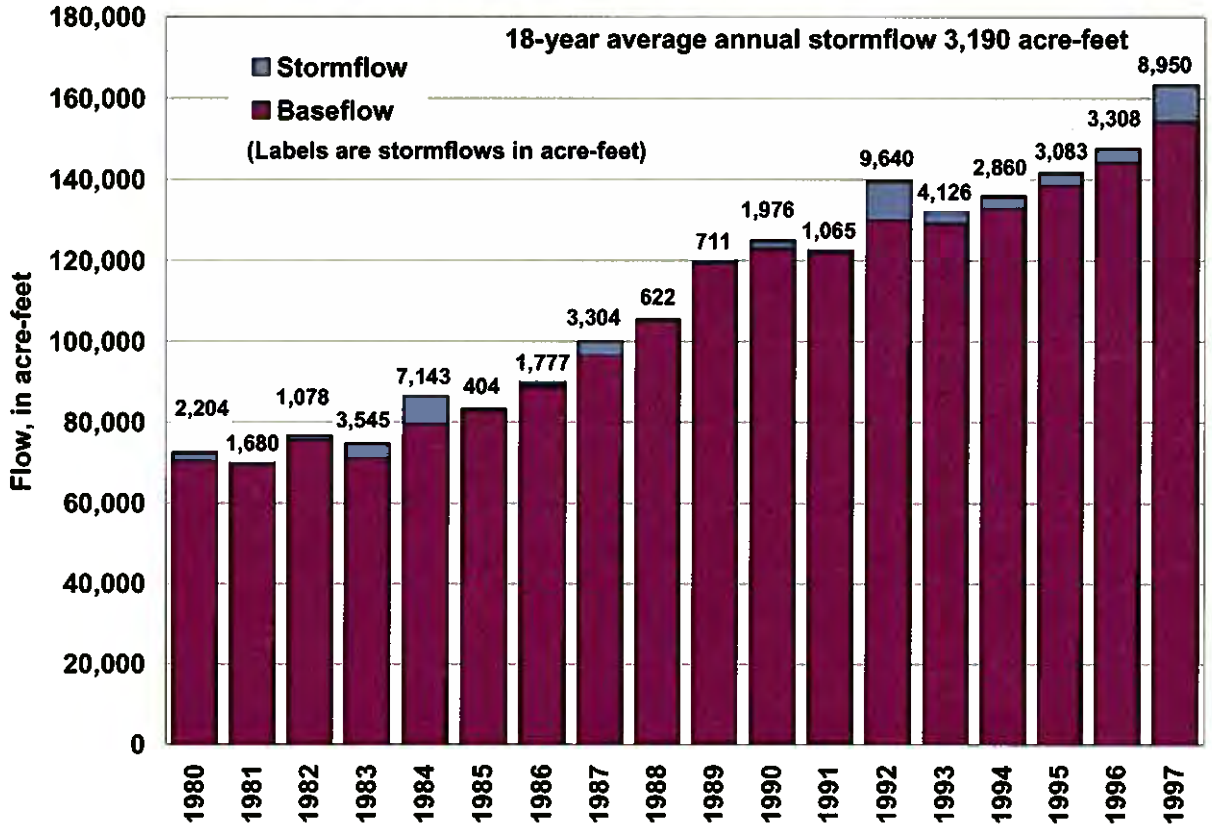

Figure 11. Yearly stormwater flow volumes from 1980 to 1997 resulting from Method 2 using a threshold of the mean monthly flow + 20 cfs.

Alternative for Method 2: Median + 20 cfs

An alternative exceedance threshold can be utilized to determine when stormflows occur and how the baseflow is estimated. Instead of using the *monthly mean flow* + 20 cfs, the *monthly median flow* + 20 cfs can be used. Utilizing the monthly median flow slightly lowers the exceedance threshold that determines if the daily mean flow incorporates stormflows. This is because the median is not affected by a few high flow days like the monthly mean flow. Figure 12 shows both the mean and median thresholds applied to flows in the Wash for 1992. The graph shows that the median threshold identifies a few more days than the mean threshold. In addition, the baseflow, from which the total flow on identified stormflow days is subtracted, is derived from the monthly median flow. Figure 13 depicts the use of an exceedance threshold equal to the monthly median flow + 20 cfs and a baseflow on stormflow days of the monthly median flow.

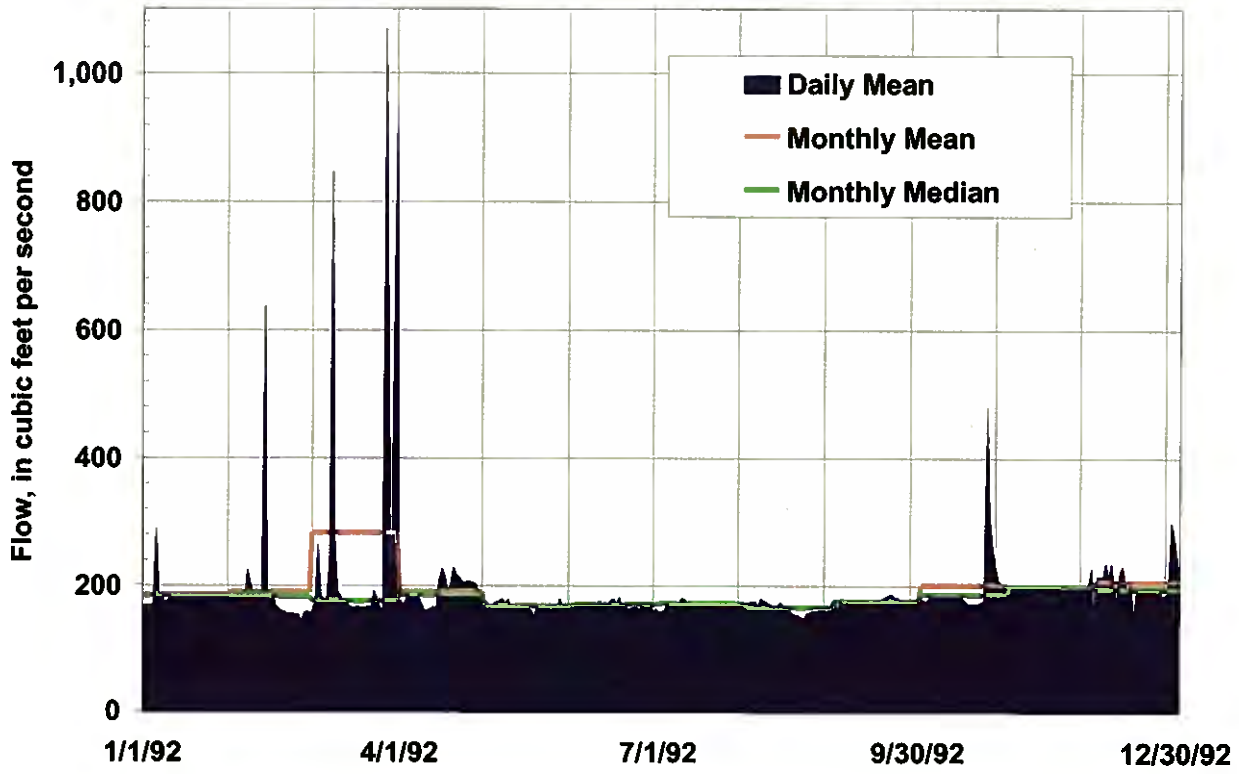

Figure 12. 1992 monthly mean and monthly median flows in Las Vegas Wash.

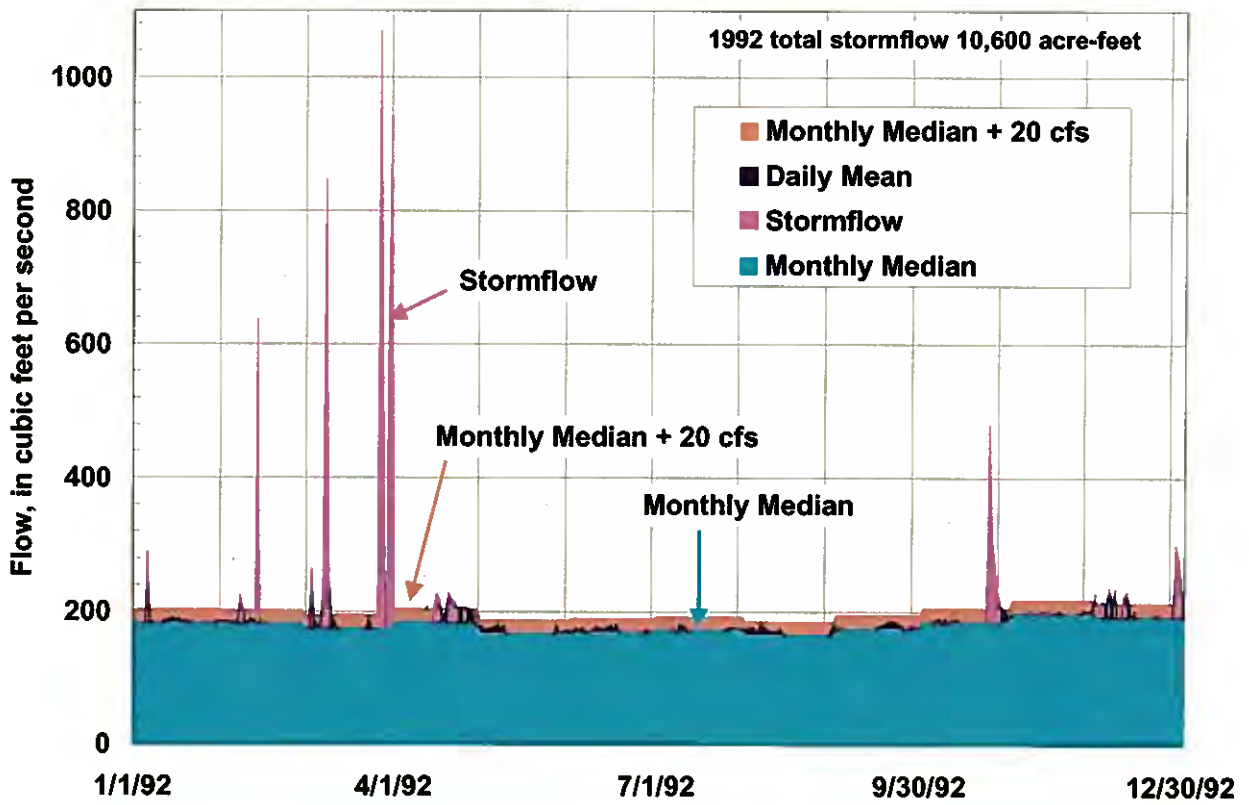

Figure 13. Stormwater flow volumes resulting from Method 2 using a threshold of the monthly median flow + 20 cfs.

The monthly median + 20 cfs alternative was applied to the flow data published by the USGS in Wash from 1980 to 1997. The analysis showed that the average annual stormwater runoff in the Wash was 3,390 afy over the 18-year period, an increase of only 200 afy compared to the previous method which used the monthly mean flow + 20 cfs as the exceedance threshold.

Alternative for Method 2: Median + 0 cfs

To examine the influence that the 20 cfs addition to the monthly mean or monthly median flow has on the stormflow volumes, an exceedance threshold equal to just the monthly median flow, without the additional 20 cfs, was applied to the flows in the Wash from 1980 to 1998. When this is done, half of the days in every month over the entire 18-year period are identified as having stormflows, since the median is the middle ranked number in a data set. The identified stormflow days were then subtracted from the individual monthly medians to derive the stormflow volume. Application of this threshold and baseflow calculated an 18-year average stormflow volume of 4,920 afy. This volume of stormflows clearly over estimates the actual stormflow volume but does calculate a hypothetical maximum. It also demonstrates that both the Mean + 20 cfs and Median + 20 cfs methods calculate very representative stormwater flow volumes for the Las Vegas Wash. Figure 14 compares all three results of stormwater flow calculations based on historical daily mean flows in the Wash from 1980 to 1997.

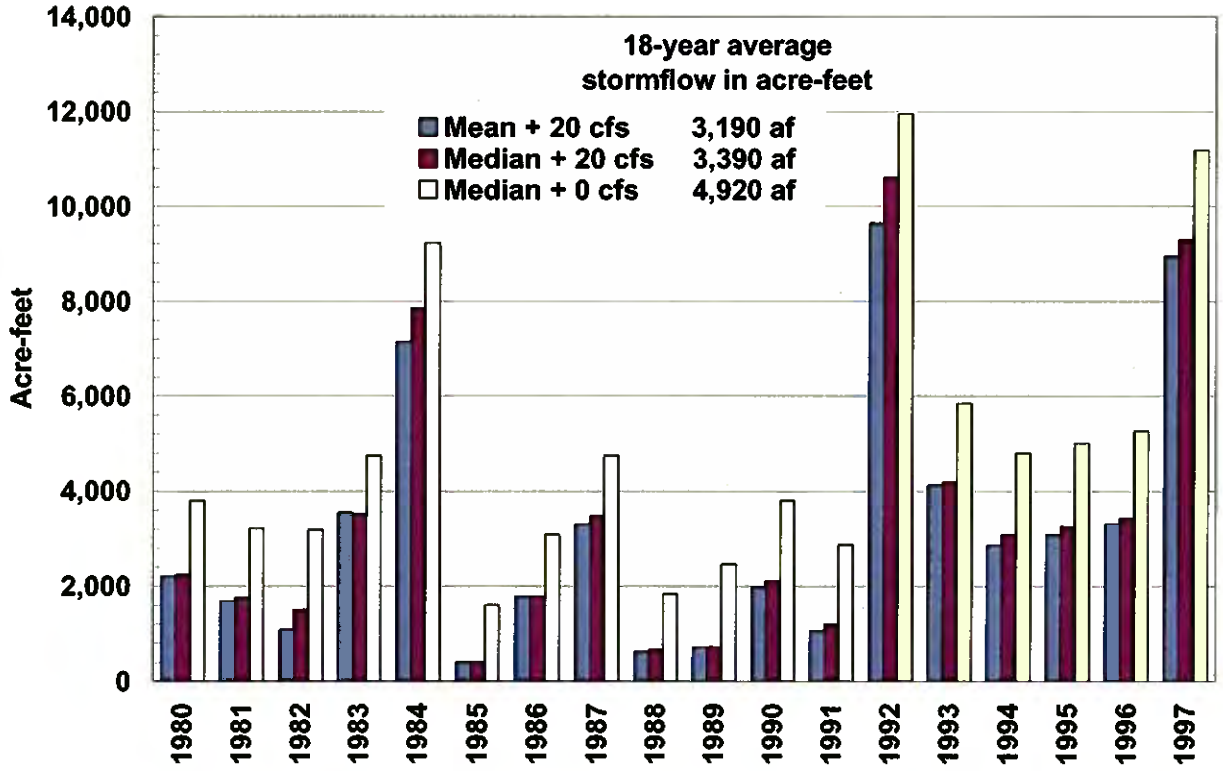

Figure 14. Comparison of annual stormwater flow volumes resulting from Method 2 using the three different thresholds.

Comparison and Evaluation of Methods 1 and 2

Similar stormflow volumes in Las Vegas Wash were calculated using both the historical daily precipitation data for the Las Vegas Wash drainage basin (Method 1) and the historical daily mean flows in the Wash (Method 2) (Table 4).

Table 4. Comparison of results from Methods 1 and 2.

	18-year Average Annual Stormflow from 1980 to 1997
Method 1. (Precipitation)	
Range dependent on drainage characteristics	440 afy to 5,700 afy
Most likely stormflow	2,500 afy
Method 2. (Daily mean flow)	
Exceedance threshold = monthly mean + 20 cfs	3,190 afy
Exceedance threshold = monthly median + 20 cfs	3,390 afy
*Exceedance threshold = monthly median + 0 cfs	4,920 afy

*The use of an exceedance threshold equal to the monthly median flow without an additional 20 cfs, in Method 2, represents an unrealistic maximum stormflow and is listed only to show the validity of the other estimates.

While both methods give similar results (Figure 15), the stormflow volume calculated using Method 2, which uses historical daily mean flows in the Wash, is considered more accurate, because of the relatively numerous assumptions in Method 1. Method 1 is based on statistically derived loss factors that are applied to the daily precipitation volume. These losses, while well studied, may not accurately represent actual conditions in the Las Vegas Valley. Historical daily mean flows in Las Vegas Wash, on the other hand, represent the results of both actual precipitation and actual precipitation losses in the Valley.

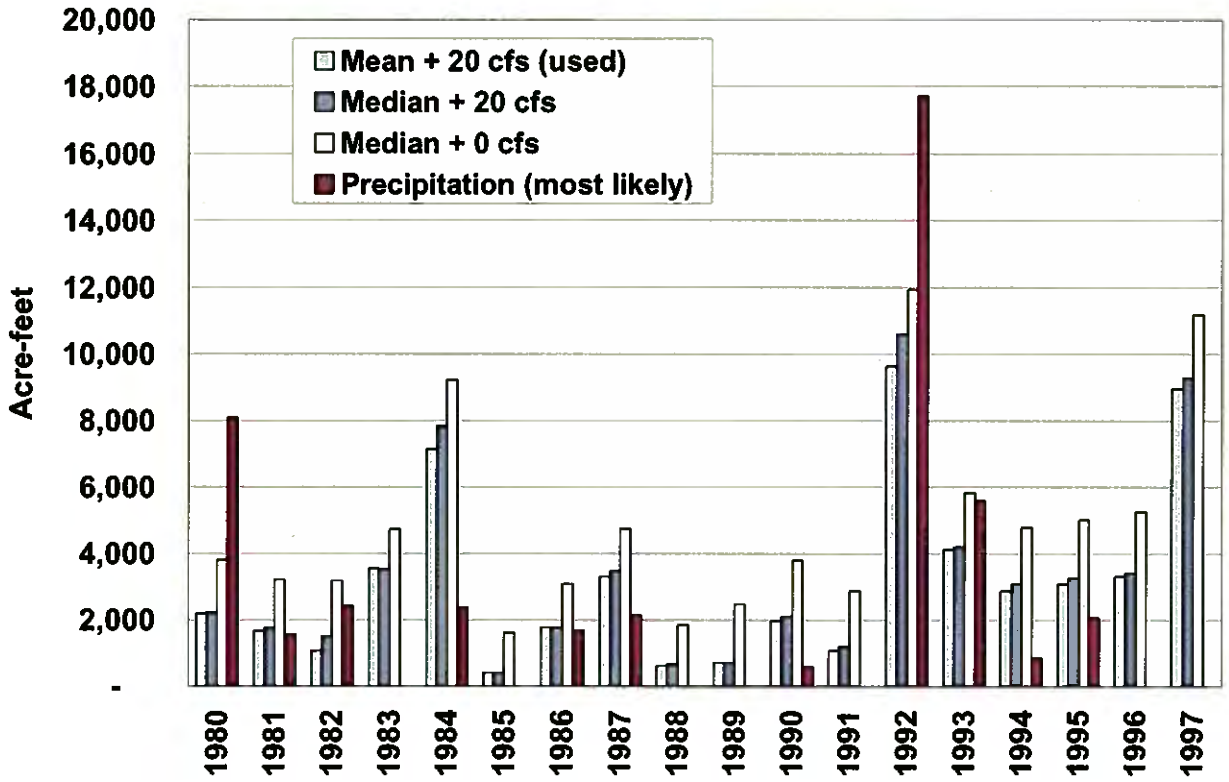

Figure 15. Comparison of annual stormwater flow volumes derived from Methods 1 and 2.

Return flow credits

Nevada's apportionment of Colorado River water is based on consumptive use or "net" use units. Consumptive use is defined by the laws governing Colorado River water as "diversions less return flows."

Nevada is apportioned 300,000 acre-feet of Colorado River consumptive use. Because Southern Nevada returns flows back to the Colorado River (i.e., Lake Mead) that were originally Colorado River water – mostly in the form of treated wastewater via Las Vegas Wash – Nevada receives a credit for that volume and therefore can take or divert that much more Colorado River water in the same year. Return flow credits constitute about a third of Southern Nevada's permanent resource. (1999 SNWA Water Resource Plan)

Of the four sources of flow in the Wash, metered returns (i.e., treated wastewater and BMI returns), urban runoff, intercepted shallow ground-water, and stormwater, Nevada receives credit for only those return flows that are considered Colorado River water. Nevada, by definition, does not get credit for returned Las Vegas Valley ground water or stormwater.

In 1984, the Bureau of Reclamation and the Nevada Colorado River Commission (CRC) agreed upon a method to calculate how much of the flows in the Wash would be Colorado River water and therefore a "return flow credit," and how much would be ground water and stormwater.

Stormwater calculated using Method 2, mean monthly flows + 20 cfs as described in this paper, was developed by the CRC to derive stormwater flow estimates for use in the return flow credit methodology. In the return flow credit methodology, all flows in the Wash are summed to the total gage flows as measured by the USGS. Total gaged flows equal metered return flows plus estimated stormwater flows plus urban runoff and intercepted shallow ground-water. (Urban runoff and shallow ground-water are called "accruals" or "unmeasured returns" in the return flow credit method.) (Figure 16)

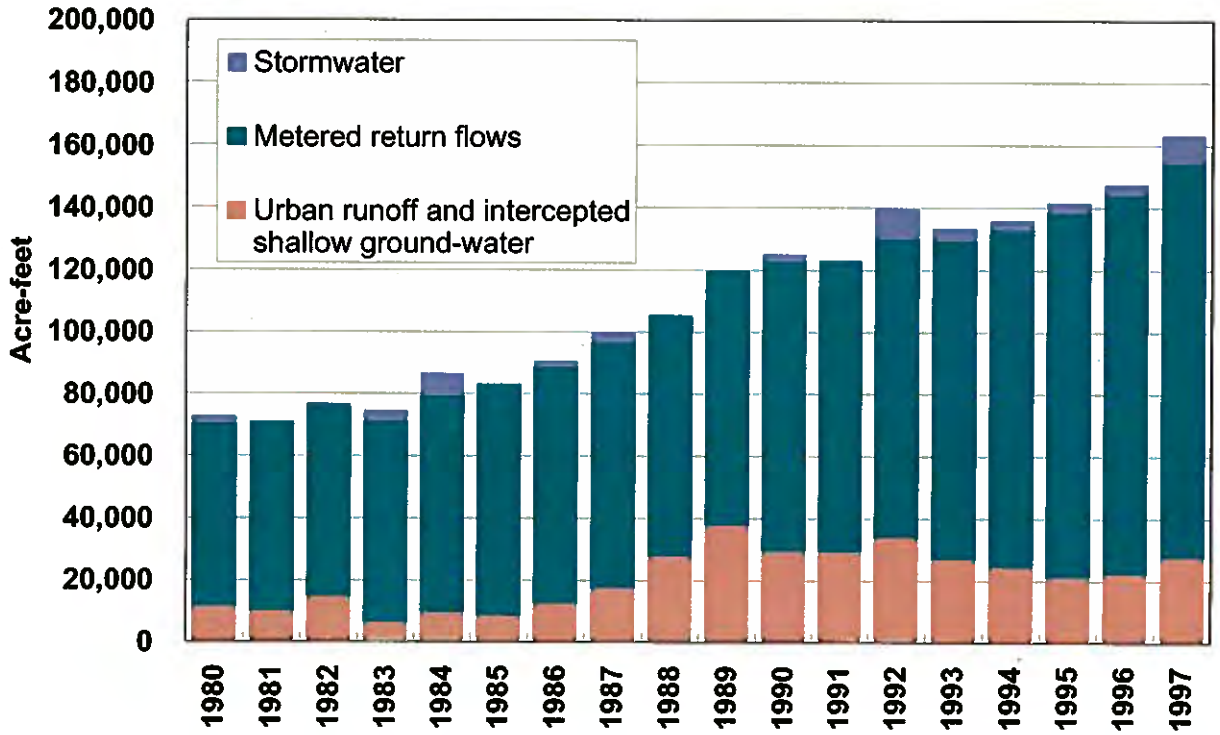

Figure 16. Total annual flow in Las Vegas Wash from 1980 to 1997 showing the flow components used in Nevada's return flow credit methodology.

By simple math, if stormwater is estimated higher, then accruals are correspondingly lower, because the total gaged flows and the treated wastewater return flows are known (fixed). Since a higher estimate of stormwater flow results in lower accruals, the Colorado River component of the accruals for which Nevada receives return flow credit is also lower. Because of this mathematical relationship among the volumes of the different flows in the Wash – particularly the accruals and stormwater – estimates of stormwater need to be as accurate as possible, so that potential capture of stormwater does not capture existing resources (i.e., accruals).

Potential Capture and Use of Stormflows

Because Nevada does not receive Colorado River return flow credit for stormwater flows generated from the Las Vegas Valley, there may be some potential benefit to capturing

stormwater flows without reducing the regions Colorado River water resources. These beneficial uses include water resources augmentation, reduction of erosion, and water quality improvement. Ideas for stormwater impoundments have centered on either capturing stormwater flows once they've reached the Wash or capturing the flows before they reach the Wash in existing detention basins. The stormwater flow-volume analysis summarized in this paper provides information on historical stormwater flows which is useful for discussing stormwater capture both upstream and in lower Las Vegas Wash.

Stormwater Capture Upstream of Lower Las Vegas Wash

Discussions on stormwater capture facilities have brought up the concept of potentially utilizing existing Flood Control District detention basins to capture stormflows. Currently there are approximately 39 detention basins (total capacity approximately 30,000 af) in the Las Vegas Valley (plus 30 proposed basins) that are designed to reduce peak flows by temporarily detaining stormwater for less than 48-hours and releasing it through flow-reducing structures (Figure 17). These facilities are designed to contain a 100-year storm event, which means that the basin has a 1% chance of filling to capacity in any given year or statistically will fill to capacity once in 100-years. This design criteria meets the legal objective of the Flood Control District which is to protect life and property by conveying stormwater flows through the Las Vegas Valley. Because of the design criteria, existing detention basins can not be used to *store* stormwater. Stormwater capture above the Wash is then reduced to three primary alternatives, 1) expand existing detention basins, 2) construct new retention basins, or 3) retain, treat, and convey stormwater out of existing detention basins in a period less than 24-hours via artificial recharge or treatment/distribution system.

While existing detention facilities could theoretically be expanded or new facilities constructed, the volume of stormwater potentially captured in these basins on a yearly basis is equal to or less than the volume capturable in the Wash. This is because each detention basin only captures a portion of the stormwater flows in the Valley based on its location within the Las Vegas Valley drainage system. Capturing stormwater volumes which approximate the average annual stormwater runoff in the Wash of 3,190 afy would require constructing or expanding at least as many facilities as are currently operated by the Flood Control District, and the facilities would have to tie into existing structures.

Constructing individual treatment/distribution systems on existing or new detention basins to capture and utilize only a portion of stormwater flows above the Wash is no doubt more costly than a single system constructed in the Wash. Capture of stormwater in the lower Wash is discussed in the *Stormwater Capture in Lower Las Vegas Wash* sub-section.

Capturing stormwater in existing detention basins for artificial recharge into the Valley's aquifers was examined by Bax-Valentine, Preator, and Hess, 1990, and by Buchanan, 1997. Bax-Valentine, Preator, and Hess examined the economic feasibility of constructing wells in two existing, off-channel detention basins and recharging stormwater. The study concluded that these two detention basins (the North Las Vegas Detention Basin and the Meadows Detention Basin) should not be used for artificial recharge of stormwater due to potential water quality concerns for the principal aquifer, which supplies 15% of the Valley's water resources. The

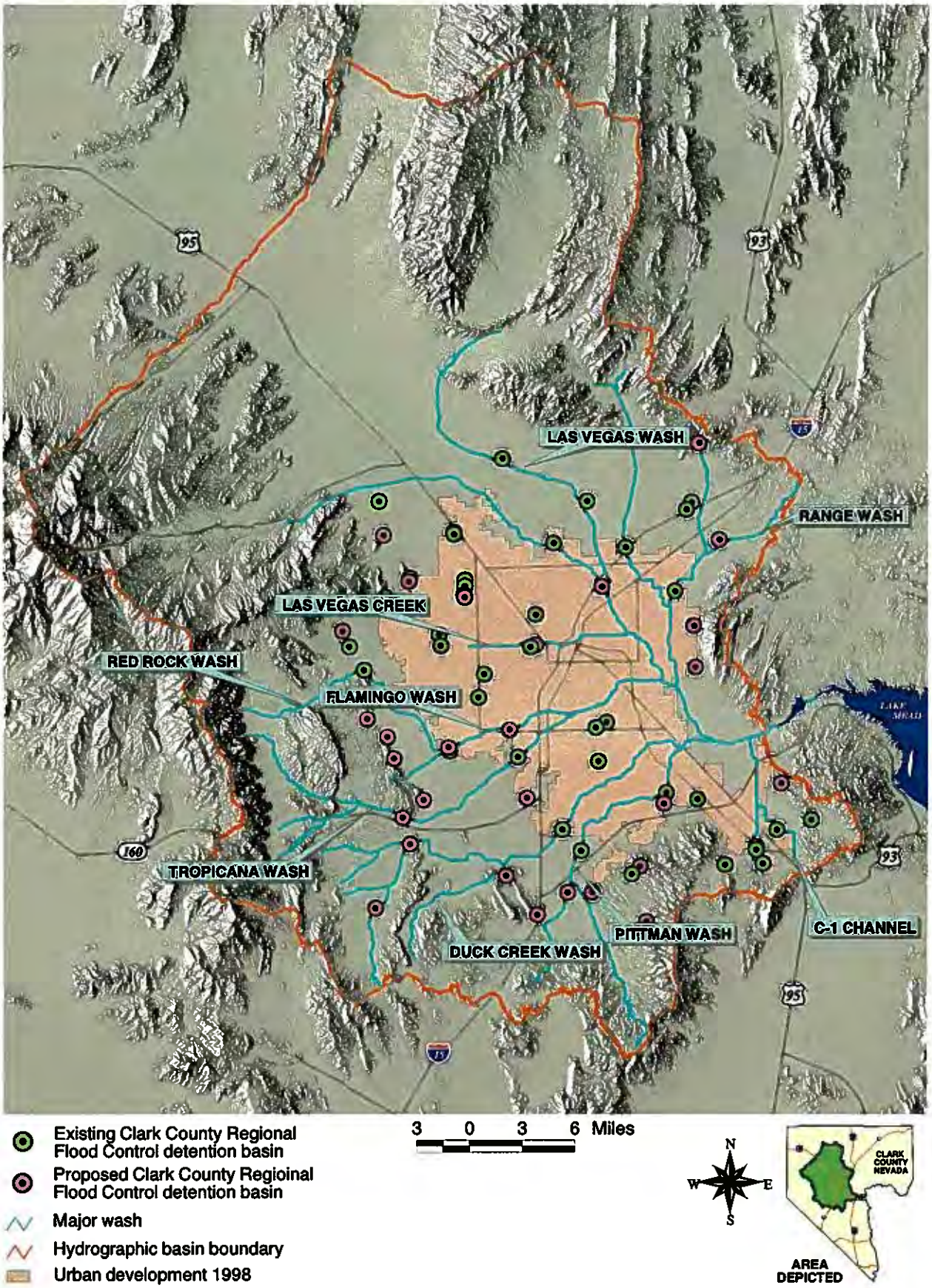

Figure 17. Clark County Regional Flood Control District's existing and proposed detention basins.

study also concluded that it was not economically feasible to use this type of recharge in the Red Rock Detention Basin which is located upstream of the urban area where stormwater quality may not be an issue. Cost of artificial recharge of stormwater in the Red Rock Detention Basin at the time was over four times the cost of delivering Colorado River water to the Las Vegas Valley.

In 1997, Buchanan re-examined the potential of artificially recharging stormwater; he also concluded that water quality restrictions were a major obstacle. Legally, only potable water can be recharged into the aquifer; therefore, stormwater would have to be treated to potable standards prior to recharge. Buchanan also concluded that the volume of stormwater that might meet recharge standards (generally in detention basins on the peripheral areas of the Las Vegas Valley) is small. He pointed out that cost-benefit analyses on the use of stormwater need to take into account the "significant temporal variability of stormwater flows" and that "the use of [annual] average flows in an economic analysis will not provide an accurate estimate of the return investment for a [stormwater] harvest/recharge system."

Stormwater Capture in Lower Las Vegas Wash

Many discussions on stormwater capture have also focused on capturing stormwater in or adjacent to the lower Wash. When considering whether stormwater capture in the lower Wash is economically feasible, the following four factors should be considered: 1) the volume and frequency of stormwater flows, 2) impacts to return flow credits and type of capture facilities, 3) reasons for capturing stormwater and the use or disposal of the stormwater, and 4) existing surface water rights. Each of these factors is discussed briefly.

Volume and Frequency of Stormwater Flows

The frequency of stormflow in the Wash from 1980 to 1997, based on actual daily mean flows, shows that the Wash has conveyed stormflows an average of 13.3 days per year (Figure 18), and 87% of these days have yielded stormflow volumes between 1 and 400 acre-feet (Figure 19). The analysis also shows that 43% (102 out of 239 days) of the stormflow days occurred during two or more consecutive days. In addition, 59% of the total stormflow volume that flowed down the Wash from 1980 to 1997 occurred during the winter months of October through the end of April. These statistics combined with the fact that the average annual stormflow in the Wash from 1980 to 1997 is approximately 3,190 afy is the foundation on which to consider future cost analyses associated with a facility design option.

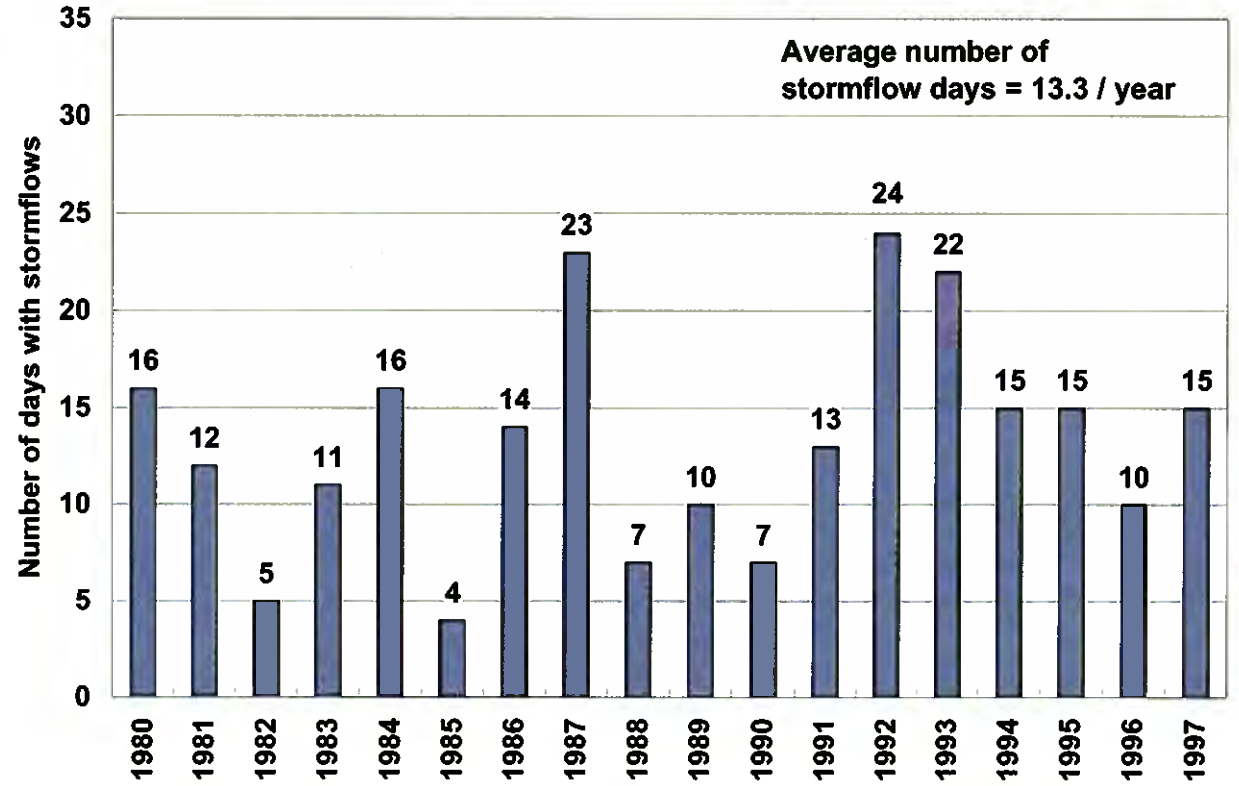

Figure 18. Number of stormflow days in each year from 1980 to 1997.

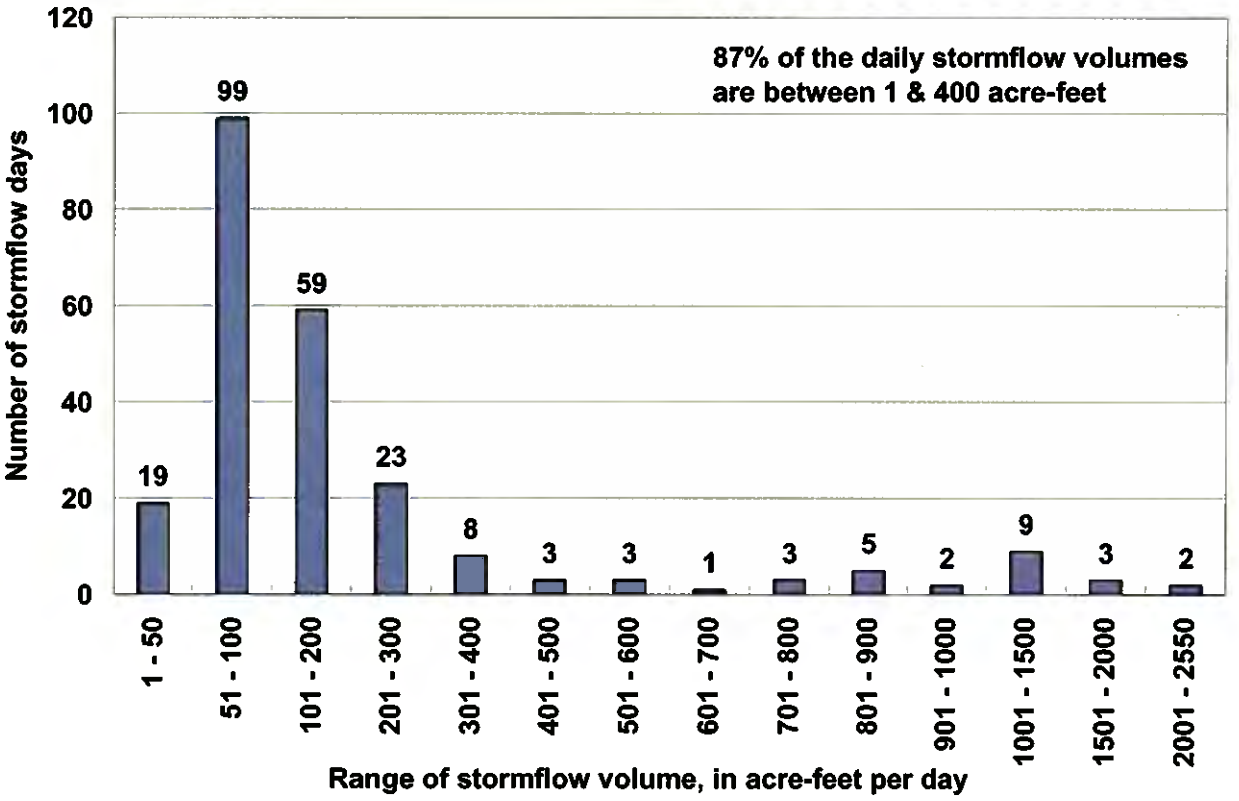

Figure 19. Stormflow days from 1980 to 1997 categorized by stormflow volume.

Return Flow Credit Impacts and in-Wash Capture Facilities

Design of stormwater capture facilities will depend on the reason the stormwater is being captured and how the stormwater will be disposed of or utilized. If Colorado River return flow credits are not to be captured, the basic design must capture only stormflows. To do this the basic design of the facility will have to be similar to Lake Las Vegas. At Lake Las Vegas the baseflow of the Wash is routed under and around the reservoir (Lake Las Vegas), only during high flow events caused by stormwater flows does the flow in the Wash enter the reservoir. A stormwater capture facility would also have to function in this manner, and by its basic design will not be able to capture the entire annual average stormwater flow of approximately 3,190 af.

Two basic design options exist for a stormwater capture facilities, 1) a facility that leaves the baseflow of the Wash in the main channel and exclusively diverts stormwater flows to a large off-stream retention basin that retains the majority of stormwater flows, or 2) a facility that diverts the baseflow of the Wash around a portion of the main channel and has a large retention (or detention) basin in the main channel. Under both options the basin would have to be sized appropriately, take the 100-year flood plain into consideration, and equip the diversion structure with entrance gates that enable the volume of water routed through the facility to be regulated.

The size of a constructed retention/detention basin would depend on the reason the stormwater was captured. If the purpose was to capture the maximum volume of stormflow, the retention basin would have to have a capacity of at least 800 acre-feet (80 acres, 10-feet deep). The stormflow frequency analysis showed that 87% of the stormflow days were between 1 and 400 acre-feet and that 43% of the stormflow days occurred consecutively over two or more days. Therefore, a facility smaller than 800 acre-feet would only be able to capture a portion of the 43% of the events that occur consecutively and would capture less than 87% of the total stormflow days. Even a facility twice this size (1,600 acre-feet) would not capture all stormwater flows, because storm events do occur over 4 or more days or at extremely high volumes like the recent September 1998 and July 1999 events.

Construction of a stormflow retention basin would also have to consider impacts to the 100-year flood plain. According to federal regulations enforced by the Federal Emergency Management Agency (FEMA), new construction generally is not allowed to raise the 100-year flood plain by more than a foot, and if it does, land within the modified 100-year flood plain may have to be purchased by the entity modifying the flood plain. Design criteria for an off-stream retention basin would have to adhere to these guidelines.

Entrance gates or weirs, regulating flow through the facility, would also have to be capable of accommodating the variable flows of the Wash to avoid diverting baseflows and impacting return flow credits. This is because the baseflow in the Wash over the course of a day varies by as much as 50 cfs as a result of daily operations at the wastewater treatment plants (Figure 20). This varied flow, combined with additional seasonal variability and gradually increasing flows caused by additional treated wastewater flows, make the design of the regulating gate, weir, or other control structure critical. Overall, the design of both the detention/retention basin and diversion control structure will restrict the volume of stormwater flows that could be captured to a volume less than the calculated average annual stormwater flow volume of 3,190 af.

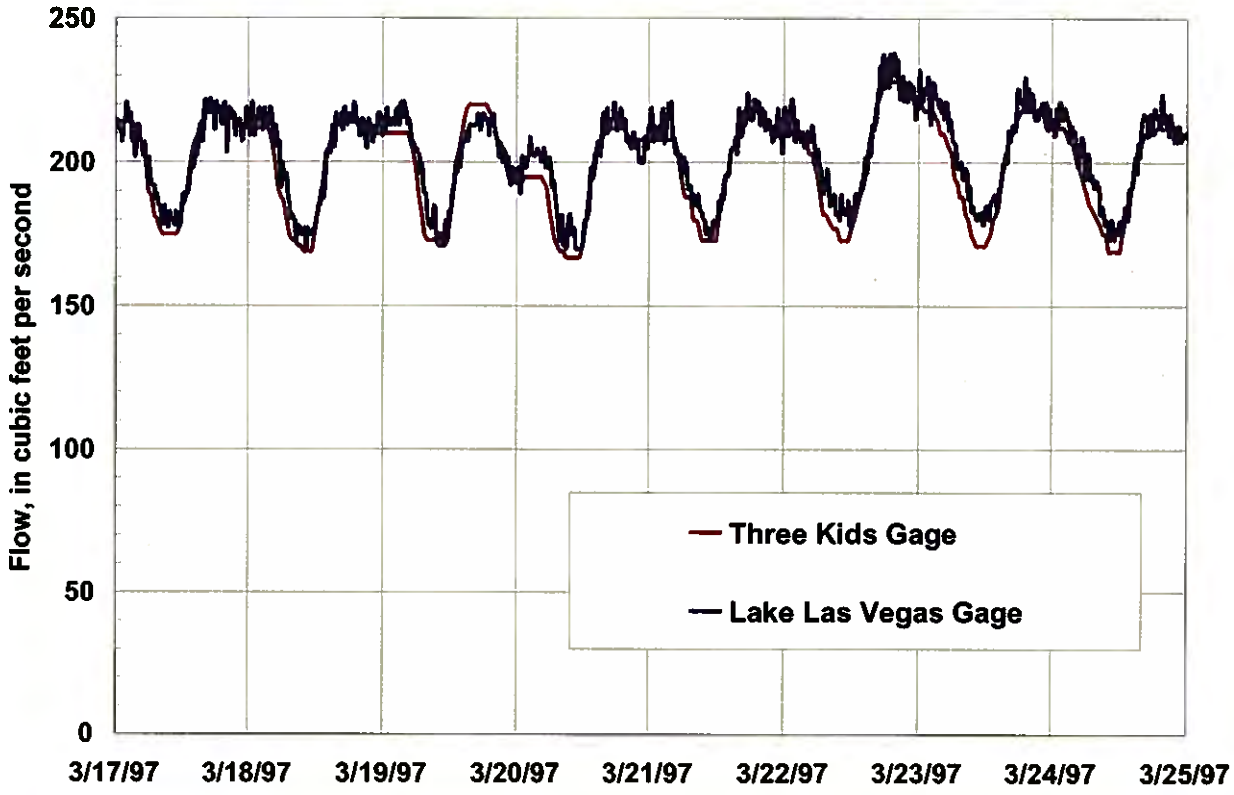

Figure 20. Example of fluctuating daily flows in Las Vegas Wash.

Reasons to Capture Stormwater and Use or Disposal of the Stormwater

The use or benefit of captured stormwater is the key criteria for determining if it is economically feasible to capture stormwater flows. Use of stormwater flows could range from augmentation of existing water resources by treating the water to potable standards to simply containing stormwater flows to avoid the addition of non-point source pollution (carried by stormwater) into Lake Mead (the receiving body of water for the Las Vegas Wash) or reducing erosion in the Wash channel.

Augmenting water resources in the Valley would require treating the stormwater to a specific standard depending on use. Treatment facilities would have to be capable of treating water with a varied water quality and would have to be able to treat the retained volume of stormwater in a relatively short period of time. Stormwater quality is anticipated to vary with the magnitude of runoff event and the location of the rainfall. These factors influence the concentration of different dissolved, chemical constituents in the water and will vary the amount of suspended sediments in the stormwater. Treatment facilities would also have to be capable of processing the water relatively quickly due to losses of water and concentration of salts from evaporation. Yearly evaporation rates for Lake Mead exceed 6.5 feet per year and would be higher for a smaller body of water like a stormwater retention basin.

Capturing stormwater to reduce non-point source pollution carried by stormwater is also a possibility. Currently there are no numerical water quality standards for primary stormwater contributions to the Wash under the Flood Control District's National Pollutant Discharge Elimination System (NPDES) permit. Under this permit, the Flood Control District has sampled stormwater quality since 1990 on tributaries to the Las Vegas Wash (1997-1998 Annual Report for Las Vegas Valley NPDES Municipal Stormwater Discharge Permit, July 1998). The data collected demonstrate that primary stormwater quality (with minor exceptions) does not contribute concentrations of constituents that exceed numerical water quality standards required in the lower reaches of the Wash or Las Vegas Bay. Work by the Flood Control District and Clark County to implement "best management practices" to reduce non-point source pollution in stormwater is on going.

Reducing erosion in the Wash through stormwater capture has been a focus of stormwater capture discussions and is probably the most viable reason to construct stormwater capture facilities. Capture facilities designed to reduce erosion would have to comply with the facility restrictions discussed above. In addition, the detention basin would have to be large enough to detain the majority of the stormflow events and would have to tie into both existing and new structures in the Wash, because the basin would not reduce erosion occurring from baseflows. If these criteria can be met, the cost-benefit of capture facilities to reduce erosion will need to be weighed against costs of other erosion-reducing facilities.

Water Rights to Stormwater Flows

To capture and use stormwater flows, a surface water right has to be granted by the State of Nevada Division of Water Resources. Currently the Division of Water Resources has granted at least one right to divert stormwater flows from the Wash. The right is held by Lake Las Vegas in the amount of 2,029 afy. Additional rights to stormwater flows would be subordinate to this existing right under Nevada State Law. Based on the average annual volume of stormflow in the Wash, from 1980 to 1997 (3,190 afy), Lake Las Vegas has the first-priority right to approximately 64% of the stormwater in Las Vegas Wash.

Conclusion

Stormwater flows from 1980 to 1997 were estimated using two independent methods. Method 1 uses the estimated daily volume of precipitation that occurs in the Valley based on historical gage records and subtracts assumed transmission losses and ground-water percolation to derive a stormwater flow volume in the Wash. This method estimated that the 18-year average annual stormwater runoff in the Wash was between 440 and 5,700 afy, with a most likely 18-year average annual stormwater volume of 2,500 afy. While Method 1 uses well-studied drainage basin characteristics, it only derives a rough estimate of stormwater flows. A more accurate estimate of stormwater flows is made with Method 2, using actual historic surface water flows in the Wash.

Historical surface water flows in the Wash have been measured by the USGS from 1980 to 1997 using four different gaging stations, each having a slightly different period of record. Method 2

uses the historical daily mean flows in the Wash and subtracts the estimated baseflow of the Wash to derive the remaining stormwater flow. Method 2 estimated that the 18-year average annual stormwater runoff in the Wash was 3,190 afy. Frequency analysis of the stormwater flows showed that 87% of these flows were between 1 and 400 acre-feet, and 43% of the stormflow days occur consecutively over two or more days.

Based on previous studies and the Flood Control District's restriction on existing facilities, potential capture of stormwater above the Wash would require construction of more facilities than if capture facilities were constructed in the Wash.

When considering whether stormwater capture in the Wash is economically feasible, the following factors, at a minimum, should be considered: 1) the volume and extreme temporal variability of stormwater flows, 2) impacts to return flow credits and type of capture facilities 3) reasons for capturing stormwater and the use or disposal of the stormwater, and 4) existing surface water rights.

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Appendix I

Detailed Explanation of Method 1. –Stormflows based on historical daily precipitation

Under Buchanan's method and in this analysis, precipitation losses are estimated in three principal steps. The first step reduces the recorded daily precipitation based on the size of the drainage basin, interpolated rainfall intensity, and the season (summer or winter) in which the precipitation occurred. The second step further reduces the precipitation by estimating losses due to soil infiltration and water capture, which are functions of soil type, vegetation cover, and soil moisture from precipitation over the previous 5-days. The third step accounts for transmission losses once the water begins to run off surfaces and is due to additional soil infiltration. These three steps were applied to daily total precipitation data in this analysis using spreadsheets.

Step 1

Precipitation over a drainage basin is not uniform. Because of this, recorded daily depths of precipitation must be reduced in relationship to the size of the drainage basin to represent the true depths over the entire basin. This is accomplished using depth-area reduction curves developed by NOAA. Figure 1 is a re-production of NOAA's HYDRO-40 depth-area reduction curves (extended to 1,000-square miles) which Buchanan's method utilizes, as recommend by the Flood Control District (NOAA, 1984 and Buchanan, 1997).

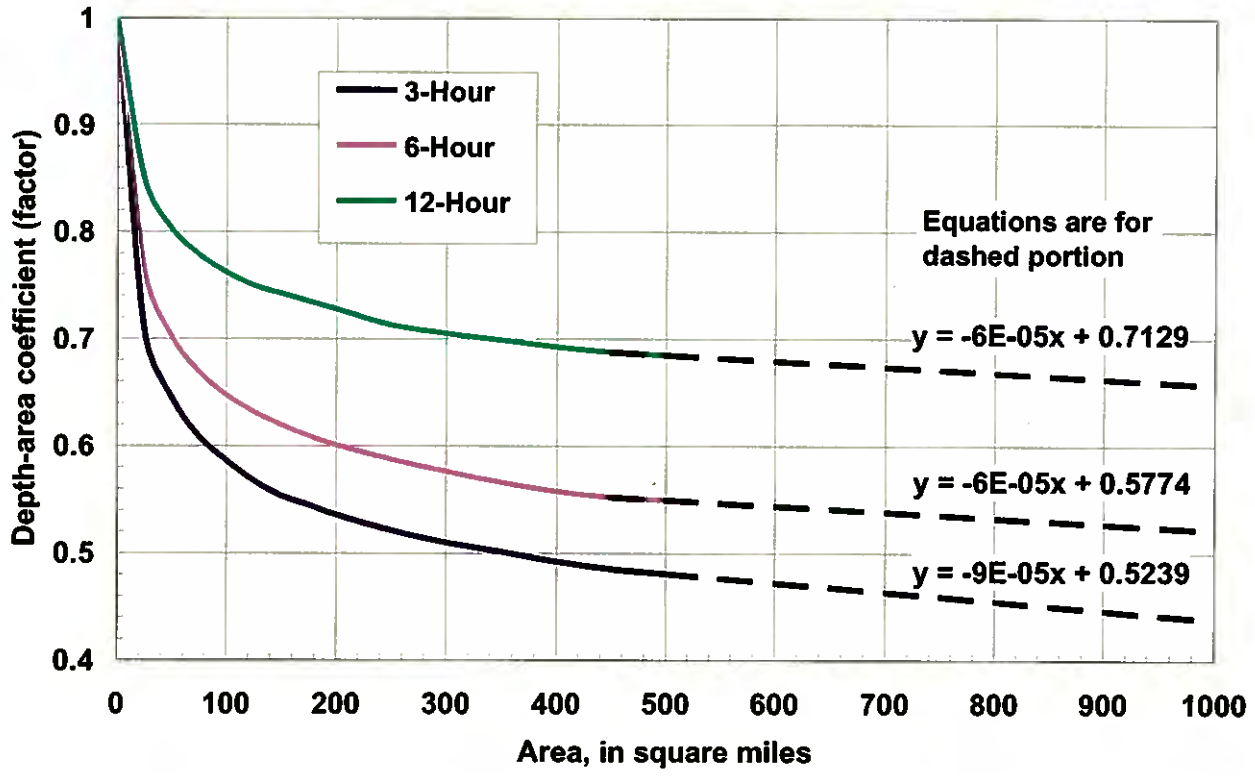

Figure 1. Modified National Oceanic and Atmospheric Administration HYDRO-40 depth-area reduction curves.

Daily rainfall intensities applied to the NOAA depth-area reduction curves are derived from studies conducted by French, 1983, which analyzed a total of 855 summer and winter storms occurring at the McCarran Airport gage over a 29-year period. Based on French's study and Buchanan's method, daily precipitation data is classified into 3-hour, 6-hour, and 12-hour intensities based on total daily precipitation (Table 1). These intensities are plotted on the depth-area reduction curves to yield a coefficient that is used to reduce the recorded daily precipitation.

Table 1. Interpolation of storm duration from total daily precipitation and depth-area reduction coefficient (Buchanan, 1997).

Winter Daily Precipitation (ppt) Range in inches	Summer Daily Precipitation (ppt) Range in inches	Derived Storm Duration	Depth-Area Reduction Coefficient based on Wash's 923-square miles drainage
$0.00 \leq ppt \leq 0.075$	$0.00 \leq ppt \leq 0.15$	3 hour	0.44
$0.075 \leq ppt \leq 0.25$	$0.15 \leq ppt \leq 0.42$	6 hour	0.52
$0.25 < ppt$	$0.42 < ppt$	12 hour	0.66

Step 2

The second step further reduces the daily precipitation and accounts for losses due to soil infiltration and depression storage, which are functions of soil type, vegetation cover, and antecedent moisture conditions from the previous 5-days. The SCS Method of Abstractions represents these losses using curve numbers (Buchanan, 1997), and the Flood Control District recommends using this method to determine runoff in the Clark County area (WRC Engineering, 1990).

Buchanan represents the equation for direct runoff and its variables using the SCS Method of Abstractions as follows:

$$Pe = \frac{(P - 0.2S)^2}{(P + 0.8S)}$$

Where: Pe = Direct runoff (or effective runoff)
P = Total precipitation (resulting from Step 1)
S = Potential maximum retention of water

And, $P > .2(S)$ P must be greater than .2(S) or Pe = 0.0 inches

$$S = \frac{1000}{CN} - 10$$

CN = the SCS curve number

The mathematical relationships between total precipitation (Pe), potential maximum retention of water (S), and the SCS curve number (CN) is depicted in Figure 2.

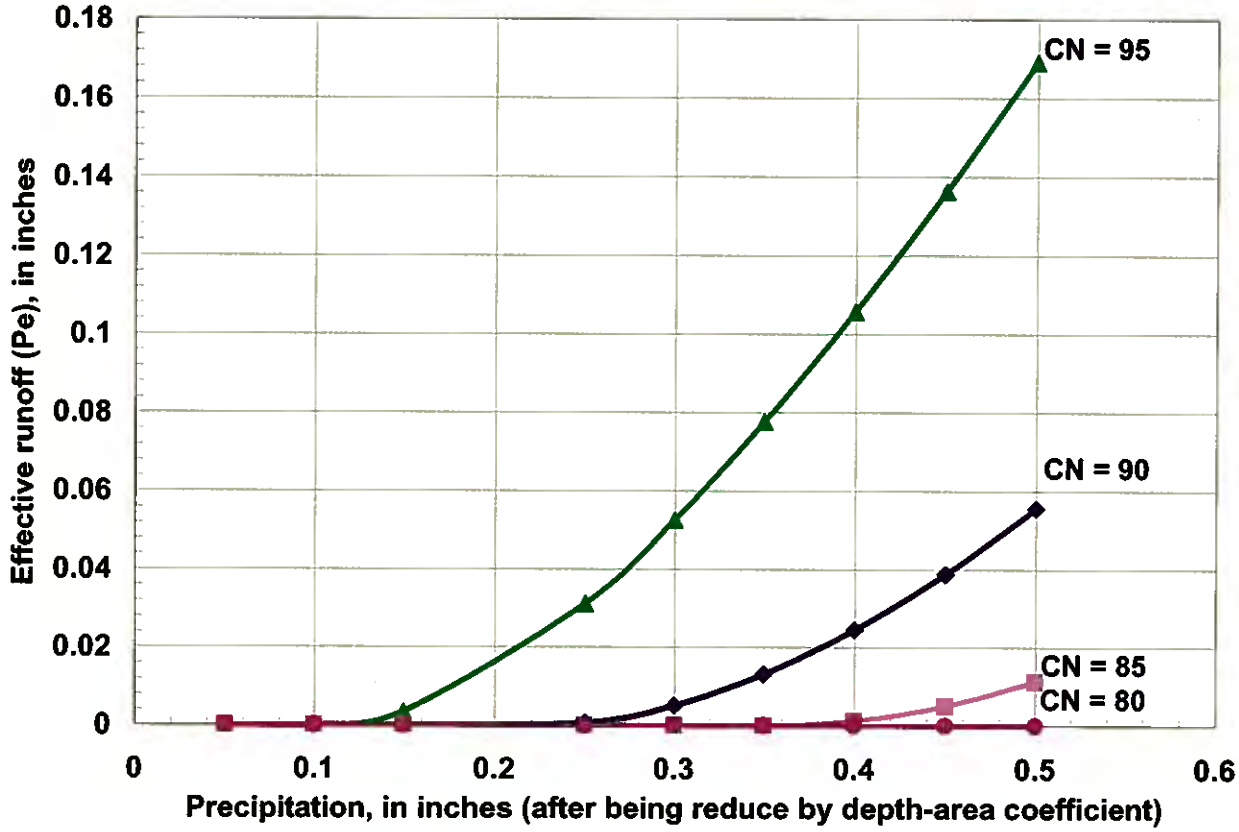

Figure 2. Mathematical relationship between Pe, S, and CN.

The curve number for the drainage basin of the Wash (the area of the Las Vegas Valley hydrographic basin below 4,500 ft) is estimated to be between 87 and 93. A single curve number, however, may change based on antecedent moisture content of the soils when calculating direct runoff (P). To estimate antecedent soil moisture and its affects on the curve number, the total rainfall over the previous 5-days is totaled, and the curve number is modified according to Table 2.

Table 2. Modification of the inputted curve number based on antecedent soil moisture.

Antecedent Moisture Condition	Total 5-day Antecedent Precipitation		Equation Used to Calculate Dry and Wet Curve-Numbers based on Antecedent Soil Moisture
	Winter Daily Precipitation (ppt) Range in inches	Summer Daily Precipitation (ppt) Range in inches	
Dry (I)	$0.00 \leq ppt \leq 0.50$	$0.00 \leq ppt \leq 1.40$	$CN = \frac{4.2(CNII)}{10 - 0.058(CNII)}$
Normal (II)	$0.5 < ppt \leq 1.10$	$1.40 < ppt \leq 2.10$	Given (Inputted Curve Number)
Wet (III)	$1.10 < ppt$	$2.10 < ppt$	$CN = \frac{23(CNII)}{10 + 0.13(CNII)}$

Step 3

The third step accounts for losses that occur once the water begins flow. These transmission losses are the result of infiltration into the bed and banks of the channel and can be significant in watershed runoff calculations (Buchanan, 1997). Transmission losses in Buchanan's method are estimated using an SCS method which generates a single coefficient that is applied to the precipitation volume resulting from steps one and two. The method uses a calculated climatic-index that is then used to determine the channel loss reduction coefficient based on empirically-derived relationships between the climatic index, channel loss, and basin area (similar to the depth-are reduction calculation).

Using the climatic index and drainage basin size, Buchanan estimated a transmission-loss coefficient for the Red Rock drainage basin of less than 0.2. Application of this method on the Wash drainage-area also estimated a loss coefficient of less than 0.2. This estimate, while appropriate for the dry channels of the Red Rock drainage, over estimates transmission losses in the Wash drainage because many of the tributaries to the Wash are concrete lined or are saturated due to urban irrigation and/or intercepted shallow ground-water. For this reason transmission losses in the Las Vegas Valley are estimated to range from 0.15 in the undeveloped portions of the Valley to as high as 0.65 in the highly developed areas.

Appendix II

Detailed Explanation of Method 2. –Stormflows based on historical daily mean flows

The example calculations below show how stormwater flows are calculated using the Mean + 20 cfs method, Median + 20 cfs method, and Median + 0 cfs method.

Method 2 using a threshold of the monthly mean + 20 cfs

Given daily mean flows in cfs for a single month:

1) Calculate the monthly mean flow in cfs
2) Note each daily mean flow in the month that exceeds the mean monthly flow + 20 cfs
3) Sum the daily mean flows in cfs that exceeds the mean monthly flow + 20 cfs
4) Determine the mean for the month without stormflows (stormflows are the days that exceeded the mean monthly flow + 20 cfs) as follows:

$$\text{Mean monthly flow w/out stormflows} = \frac{\text{Total monthly cfs} - \text{total cfs of days exceeding mean monthly + 20 cfs}}{\text{\# of days in month} - \text{\# of days that exceeded mean monthly + 20 cfs}}$$

5) Determine the volume of flow on stormflow days that exceed the new monthly mean (i.e., baseflow):

$$\text{Total monthly stormwater flow in cfs} = \text{(Sum of flows (in cfs) that exceeded actual monthly mean flow + 20 cfs} - \text{(\# of days that exceeded monthly mean flow + 20 cfs) * (mean w/out stormflows)}$$

6) Convert total monthly stormwater flows in cfs to acre-feet by multiplying total cfs by 1.9835. Determine daily stormflows in acre-feet by subtracting the total cfs on the stormflow day from the monthly mean flow without stormflows and multiply by 1.9835.

Method 2 using a threshold of the monthly median + 20 cfs

Given daily mean flows in cfs for a single month:

1) Calculate the monthly median flow in cfs
2) Note each day in the month that exceeds the monthly median + 20 cfs
3) Monthly stormwater flows then equal

$$\text{Total monthly stormwater flows in cfs} = \text{Sum of daily mean flows that exceed the monthly median + 20 cfs} - \text{(Monthly median flow) * (\# of days that exceeded monthly median + 20 cfs)}$$

Method 2 using a threshold of the monthly median + 0 cfs

Same as Median + 20 cfs method without adding 20 cfs to the monthly median flow.

Appendix 2.2

Colorado River water return flow credits – An important component of Southern Nevada's current water resources

By

Susan Selby

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SOUTHERN NEVADA
WATER AUTHORITY

October 1999

The Las Vegas region in Southern Nevada receives the majority of its water from the Colorado River at Lake Mead. Nevada also receives what are called "return flow credits" for the majority of the flows in the Las Vegas Wash that reach Lake Mead, thereby increasing existing Colorado River water resources considerably.

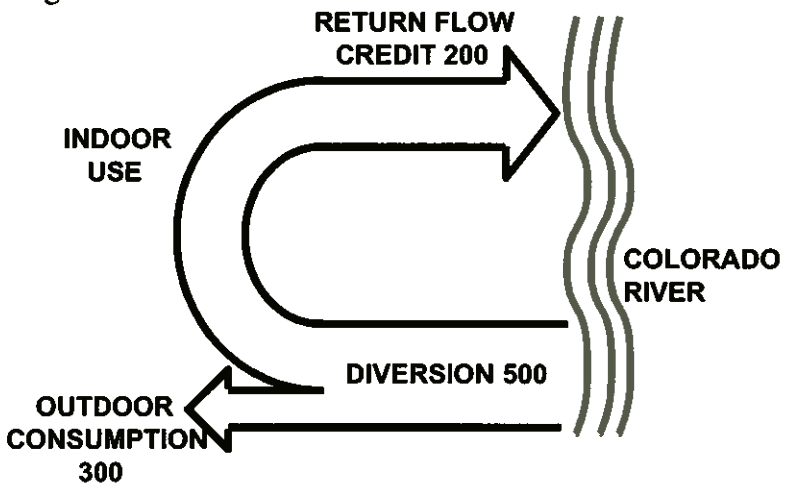
Consumptive use/return flow credit concept

The Colorado River is apportioned among the seven Colorado River basin states in consumptive use or "net" use units. Consumptive use is defined in Colorado River law as "diversions less return flows."

Nevada receives 300,000 acre-feet of Colorado River consumptive use. If Nevada returns flows back to the River that were originally Colorado River water, then Nevada receives a credit for that volume and therefore can take or divert that much more Colorado River water in the same year. (See **Figure 1**.) Parenthetically, because the Colorado River only borders the southern part of the state, the state's Colorado River apportionment is only utilized by southern Nevada, primarily the Las Vegas region.

Colorado River water is southern Nevada's primary source of water. Because the Las Vegas Valley treats and returns the majority of its wastewater back to the River via the Las Vegas Wash, Nevada receives credit for those return flows and southern Nevada is able to divert more than 300,000 acre-feet in the same year. As shown in **Figure 2**, return flow credits allow southern Nevada to divert more water than the apportionment and constitute about a third of the region's permanent resource.

Figure 1

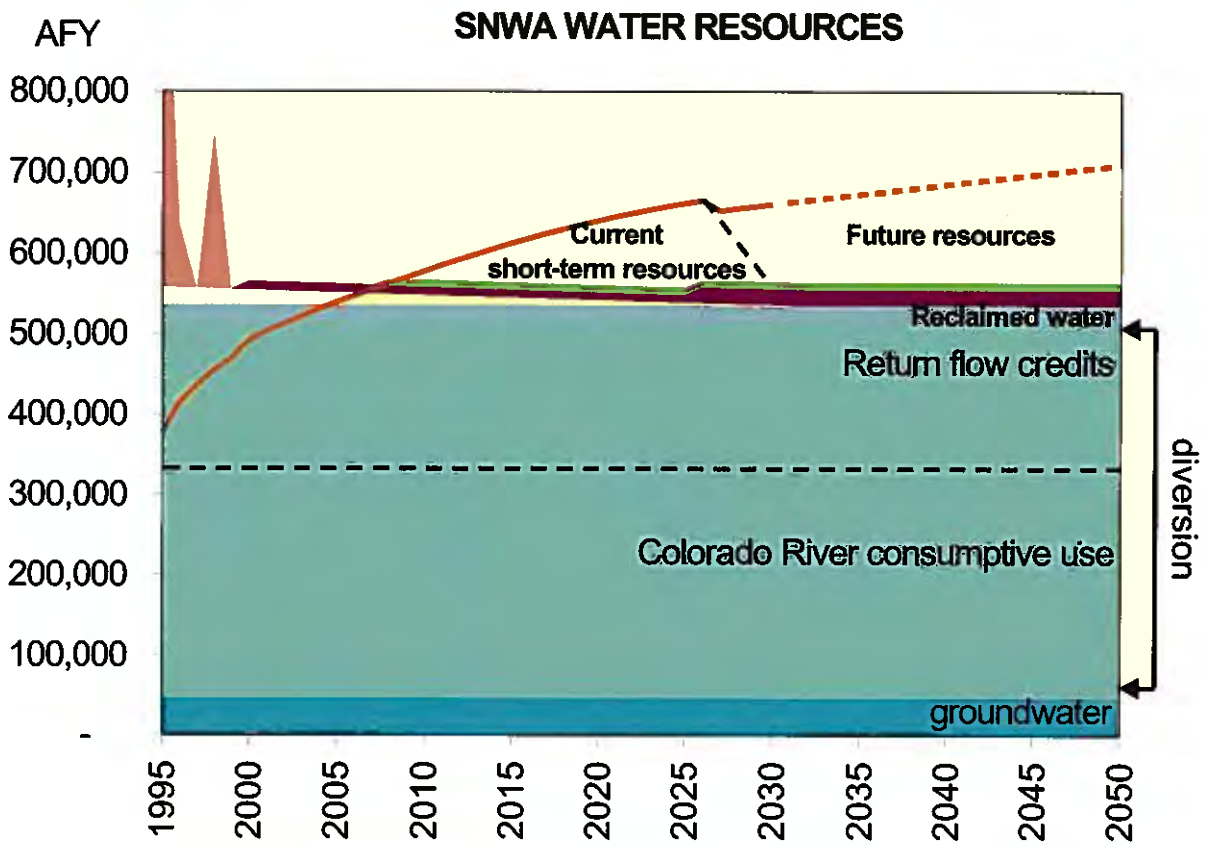


Return flow credit method

There are three sources of water in the Wash: Metered returns which are mostly treated wastewater flows, urban runoff and intercepted shallow groundwater, and stormwater. By definition (diversions less return flows) Nevada only receives credit for those return flows that are considered Colorado River, not for groundwater nor for stormwater.

There currently is no way to actually measure how much of the flows in the Wash were originally Colorado River diversions to the Valley. There are only meters on the wastewater flows exiting the wastewater treatment plants, a meter on BMI's surface

Figure 2



return flows, and the Three Kids Wash and Lake Las Vegas gauges that measure total flow in the Wash. Given only the meter and gauge measurements, in 1984 the Bureau of Reclamation (Reclamation) and the Nevada Colorado River Commission (CRC) agreed to a return flow credit methodology that would calculate how much of the flows in the Wash were originally Colorado River water diversions.

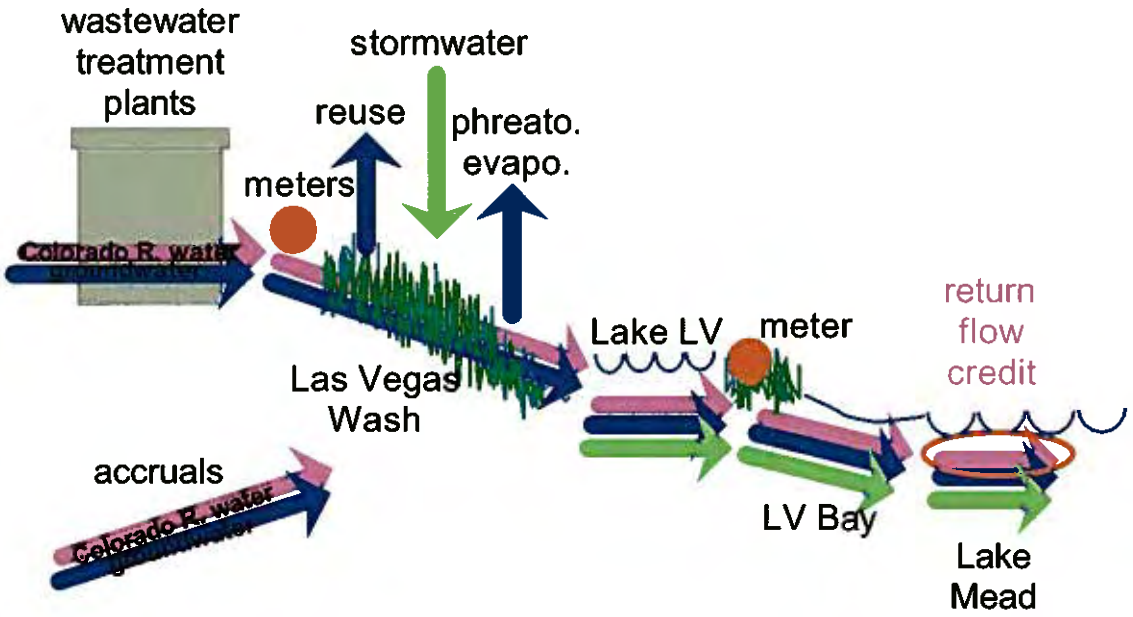
To calculate the total Colorado River component in the Wash, the method calculates the "groundwater" and Colorado River water components of metered returns and of "accruals."(See **Figure 3**.)

Accruals – part of the return flow credit

Unmeasured return flows are called "accruals" in the return flow credit method; hydrologically speaking they are urban runoff and intercepted shallow groundwater. These flows truly are unmeasured. In the method, they are the remaining flows in the Wash, once the measured wastewater flows and the estimated stormwater flows are subtracted from the total gauged flows. (Note: In the method, what is called

Figure 3

RETURN FLOW CREDIT



"groundwater" is that flow in the Wash that originated from groundwater used in the Valley and is delineated in this paper with quotes (" "); it is NOT used in the hydrological sense, which would mean the intercepted shallow groundwater.)

Accruals are not an unutilized resource. This is generally not understood, because it is always simpler to explain that return flow credits are, in concept, wastewater returns. In reality, the method also calculates credits for the Colorado River component of the accruals. In 1997, accruals were about 28,000 acre-feet, 89% of which Nevada received return flow credit – about 25,000 acre-feet. **(See Figure 4.)**

<u>"Groundwater" returns – an unutilized resource</u>

Nevada does not receive credit for return flows considered "groundwater." The general concept of the method is that the flows in the Wash (excluding stormwater flows) are in the same proportions of Colorado River water and groundwater as those used in the Valley (83% - 17% in 1997). One would then expect that Nevada would not receive credit for about 17% of the flows considered "groundwater." However, there are several assumptions in the method agreed to by the CRC and Reclamation that reduce the "groundwater" component, thereby minimizing the amount of lost "groundwater" returns.

- Up to 9,190 acre-feet per year (AFY) of wastewater reuse is assumed to come completely from the "groundwater" component of the wastewater, not from an mix of Colorado River water (return flow credit) and "ground water" (no return flow credit). This is based on Valley history whereby the maximum reuse (9,190) occurred when only groundwater was used by customers engendering wastewater flows, prior to

importation of Colorado River water in the Valley through the Southern Nevada Water System.

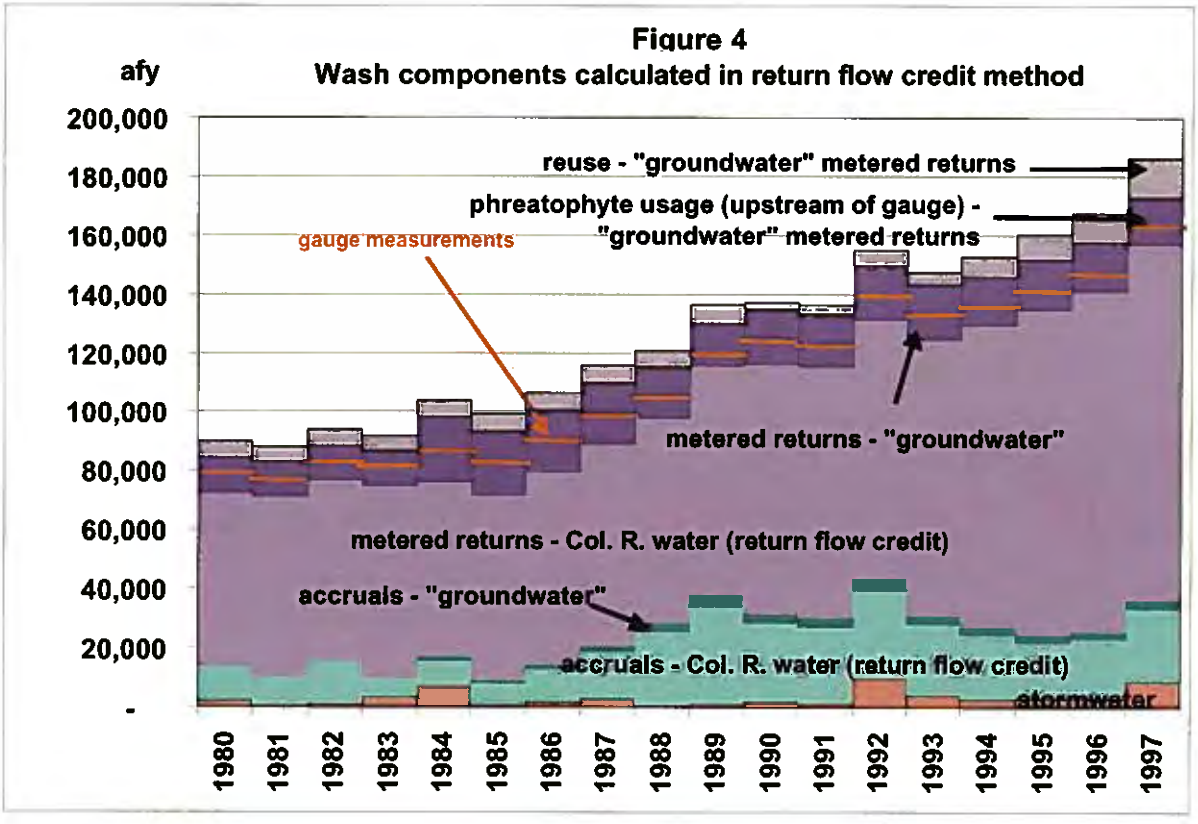
- Water consumed by phreatophytes in the Wash is assumed to come solely from the "groundwater" component of the wastewater flows, not from a mix of Colorado River and "groundwater" wastewater flows. Maximum historical phreatophyte usage was estimated at 12,000 acre-feet and was prior to the Southern Nevada Water System.

- Studies utilized by Reclamation showed that only 11% of the "accruals" (urban runoff and intercepted shallow groundwater) should be assumed to be "groundwater," not the portion of groundwater pumped in the Valley which in 1997 would have been 17%.

As a consequence of these assumptions, the "groundwater" flows lost to Lake Mead were, for instance in 1997, 6% of the dry weather flows in the Wash or 9,000 acre-feet; they were not 17% or 26,000 acre-feet. **(See Figure 4.)**

Stormwater flows in the Wash – an unutilized resource

Stormwater is currently an unutilized resource. We do not capture it and use it directly, nor do we receive credit for it, because it does not originate from Colorado River water used in the Valley. The stormwater volume in the Wash is estimated by the CRC, using the daily flow measured at the Three Kids Wash gauge or, in recent years, the Lake Las



Vegas gauge. From 1980 – 1997, the average annual stormwater flows in the Wash as estimated to be about 3,200 acre-feet. (Johnson, 1999.)

Because annual stormwater flows are estimated and not explicitly measured, then they are subject to question. In discussions of potential stormwater capture, it is tempting to estimate on the high side. However, if one of the intended purposes for capturing stormwater is to increase our water resource, estimating a large volume of stormwater in support of that purpose in reality does not make the total resource any larger. As shown in **Figure 4**, in the return flow credit method, all flows in the Wash are summed to the total gauged flows, except those flows that have been removed upstream of the gauge (reuse and phreatophyte usage). Total gauged (measured) flow equals measured wastewater and other metered returns plus estimated stormwater plus accruals. By simple math, if stormwater is estimated higher, then accruals are lower, because the total flow and wastewater flow is known through measurements and therefore fixed. If accruals are lower, then the Colorado River component of the accruals for which we receive credit is lower. Conversely, if the stormwater estimate is lower, then the accruals are higher and the accrual return flow credit is higher.

<u>More reuse does not extend our supply</u>

SNWA purveyor member agencies reserve 21,800 AFY of the wastewater for reuse, not sending it to the River for return flow credit. If the agencies reuse more than 21,800 AFY, it does not increase (or decrease) the total water resource. Instead, more reuse or "reclaimed water" correspondingly decreases return flow credit, because a customer's water demand is switched from potable use (i.e., diversions, which equal consumptive use plus return flows) to non-potable reuse.

To illustrate, **Figures 5** and **6** show that the size of the total resource "pie" does not change, whether more wastewater is used to meet a reuse demand or to meet a potable demand.

Figure 5

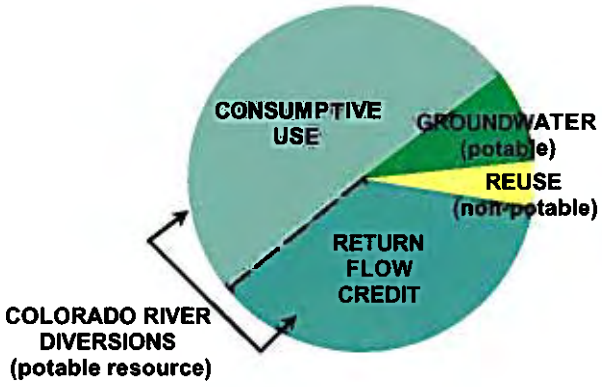
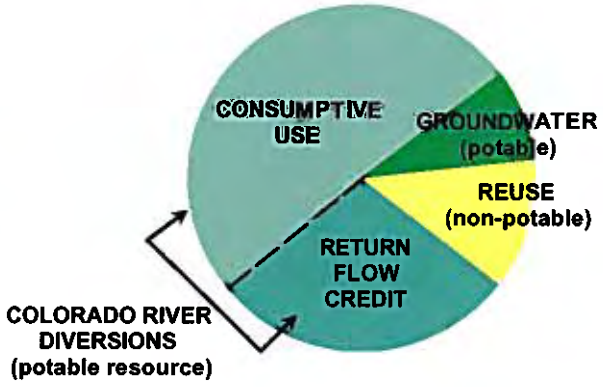


Figure 6



Reclaimed water (wastewater reuse) "threshold"

The 1991 SNWA Cooperative Agreement, amended in 1994 and 1996, creates thresholds of wastewater reuse for each purveyor, totaling 21,800 AFY, in order to ensure that most of the wastewater is returned to the Colorado River for return flow credits. The Agreement language on this subject has been interpreted as meaning, if a purveyor reused more than its threshold, then its potable supply would be reduced correspondingly.

However, in the actual language of the Cooperative Agreement there are a number of caveats which mean that, even if the threshold is exceeded, a purveyor does not necessarily have to reduce its potable supplies. If wastewater is reused in excess of the amount specified to the purveyor in the Agreement *and this causes a reduction in return flow credits, which in turn causes a reduction in other purveyors' Colorado River supplies,* the excess reuse quantity is subtracted from the potable water purveyor in whose service area the reuse provider resides.

Primarily because of increasing erosion in the Las Vegas Wash -- caused in part by treated wastewater being returned to the River for credit -- it is now generally accepted that reuse will increase above 21,800 AFY. However, it is not expected that this increased reuse will affect purveyors' abilities to meet their customer water demands, because the increased reuse is expected to replace existing and planned potable demand for Colorado River water.

If reuse increases above 21,800, it probably will reduce return flow credit and, hence, Colorado River diversions available to Southern Nevada. However, the increased reuse demand will likely replace existing or planned potable demand for Colorado River water, a phenomenon that is already occurring. This means less Colorado River water diversions (and return flow credits) are needed to meet potable customer demands. With replacement occurring, one of the intents of the Cooperative Agreement is maintained, namely, to ensure that no one purveyor's increased reuse reduces another purveyor's ability to meet its customer demands.

Reporting

The CRC is responsible for calculating the official return flow credit numbers for the Las Vegas Valley, using the method agreed upon between the CRC and Reclamation. On a monthly basis, the CRC collects from different agencies all numbers needed for the methodology (wastewater flows, total Wash gauge flows, etc.) and then calculates the credit. The CRC provides the monthly return flow credit numbers to Reclamation, who sums them in its annual "Decree Accounting" report. (Reclamation's report is required under the 1964 Supreme Court Decree in *Arizona v. California*, and shows annual and monthly diversions, return flow credit and consumptive use for Arizona, California, and Nevada.)

The CRC calculates return flow credits on a monthly basis, in order to know before the end of the year how close Nevada will be to its 300,000 AFY consumptive use

apportionment. SNWA also calculates return flow credit numbers using the official CRC-Reclamation method, to do future water planning as described in its water budgets and water resource plans. However, SNWA only calculates credits on an annual basis, not on a monthly basis, because forecasting credits on a monthly basis for 30 to 50 years into the future is pointless.

There can be a difference in historical annual return flow credit calculated by the two agencies of a couple of thousand acre-feet, because calculating twelve monthly credits and then adding them – CRC's method – is not mathematically the same as a single annual credit calculation – SNWA's variation of the method. However, both make sense, given different purposes. In addition, SNWA recognizes that Reclamation's Decree Accounting report is required under the Supreme Court Decree and views CRC's calculations as the official return flow credit numbers.

Summary

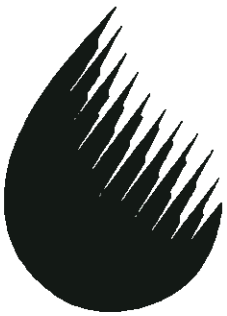
The region's wastewater is not an unutilized resource. Most of it is assumed to be returned to the Colorado River for return flow credit and equates to about one third of our permanent resource, as shown in SNWA's water resource plans. 21,800 AFY of the wastewater is reserved for reuse, rather than for return flow credit. Reuse of wastewater beyond 21,800 does not extend our current resource. It just changes our mix of resources from the currently estimated amount of return flow credit/diversion resource and reuse to less return flow credit/diversion and more reuse.

For the past five years, the "groundwater" component returning to Mead via the Wash is about 9,000 acre-feet of unutilized resource. Average annual stormwater over the last 18 years is about 3,200 acre-feet. To receive return flow credit for these two sources would involve convincing Reclamation to do so. Receiving credit for the stormwater is highly unlikely. Receiving credit for the groundwater might be slightly less unlikely, although it has been attempted in previous years. SNWA intends to explore that opportunity again, when the time is appropriate.

References:

Johnson, Jeffrey (1999). "Estimation of stormwater flows in Las Vegas Wash, Nevada and potential stormwater capture," September, 1999. Southern Nevada Water Authority.

Appendix 5.1



SOUTHERN NEVADA
WATER AUTHORITY

Water Quality
Citizens Advisory Committee

Recommendations Report

June 1998

SNWA Water Quality
Citizens Advisory Committee
Recommendations Report - June 1998

Introduction

The Las Vegas metropolitan area has an abiding interest in the availability and quality of its water resources. Because Las Vegas is a desert community that is now home to over one million residents and host to over 30 million tourists each year, it can be said to have a more acute interest in water and water quality than any other American city in the southwestern United States.

For years, local public entities have worked to provide the area with sufficient water resources to meet increasing demands. In response to the need for better coordination among entities, the Southern Nevada Water Authority (SNWA) was formed in 1991. The SNWA created a new era of cooperation and public participation in issues affecting water in Southern Nevada. By bringing together local entities and encouraging public involvement through the use of citizen advisory committees, SNWA has realized the goal of practical, long-term management of the area's most valuable resource.

However, while acquiring additional water resources is a primary goal for SNWA, an equally important goal is to protect and preserve the water resources already available. This is the essence of what is meant by "water quality."

In July 1997, the SNWA Board of Directors appointed a 22-member citizens advisory committee to review and discuss water quality issues as they related to the Las Vegas Wash, Las Vegas Bay, and Lake Mead. The creation of the citizens committee followed the formation of the Lake Mead Water Quality Forum in February 1997. The Forum brought together 19 local, state, and federal entities involved in water quality issues related to the Wash, Bay, and Lake Mead. The goal of the SNWA citizens committee was to develop water quality recommendations for submission to the SNWA Board of Directors.

The SNWA Water Quality Citizens Advisory Committee began meeting in August 1997. Over the next 10 months, the committee held 17 meetings, visited local water and wastewater facilities, toured the Las Vegas Bay and Las Vegas Wash, and discussed at length issues affecting water quality in Southern Nevada. The committee received extensive information on key water-related issues and spent approximately four months developing recommendations in nine areas for consideration by the SNWA Board.

This report provides the recommendations developed by the committee, along with an overview of the meetings and tours held by the committee as it learned and discussed the issues firsthand.

SNWA Water Quality Citizens Advisory Committee
Recommendations Report

I. Background

In the summer of 1997, the Southern Nevada Water Authority (SNWA) established a citizens committee to obtain public input on water quality issues related to the Las Vegas Wash, Las Vegas Bay, and Lake Mead. In the months preceding this action, important discussions on water quality issues had begun that increasingly called for a concerted approach by state and local entities. In February 1997, the Nevada Division of Environmental Protection (NDEP) had established the Lake Mead Water Quality Forum to facilitate the sharing of water quality information among government entities. The Forum brought together federal, state, and local entities, but lacked a mechanism for encouraging significant community participation and developing consensus from citizen stakeholders.

At approximately the same time, the SNWA and its member entities had begun considering ways to solicit public input on various water quality issues related to the Las Vegas Wash, Bay, and Lake Mead. This confluence of needs led SNWA to appoint a citizens advisory committee to develop and provide input on key water quality decisions to the SNWA Board of Directors. This input would also be forwarded to the Lake Mead Water Quality Forum for its consideration. The Water Quality Citizens Advisory Committee (WQCAC) was first convened in August 1997. Over the next ten months, the committee discussed such issues as:

- How to ensure compliance with future wastewater discharge regulations.
- How to address increasing volumes of treated wastewater and their impacts on the Las Vegas Wash and Bay.
- How to address erosion and the loss of wetlands in the Las Vegas Wash from all flows, including stormwater runoff and treated wastewater.
- How to address pollution entering the Wash from multiple sources, including groundwater seepage, point sources, and nonpoint sources (for example, runoff).

The committee's deliberations resulted in the nine recommendations contained in this report.

II. Structure of Advisory Committee

The members of the WQCAC were chosen to represent a broad cross-section of water quality and demographic interests in the Southern Nevada area. The time commitment required of committee members was considerable, so WQCAC members were chosen not only for their ability to represent diverse stakeholder interests, but also for their willingness to participate in an intensive, year-long series of meetings. Each of the seven members of the SNWA Board of Directors appointed three individuals to participate, resulting in a committee of 21 citizen members. In addition, a representative of the NDEP was included as an ad hoc member of the committee. The

NDEP representative provided a nexus between the SNWA citizen advisory process and the Lake Mead Water Quality Forum. To further enhance this relationship, the WQCAC also selected two of its members to serve as liaisons to the Forum. A list of WQCAC members and their affiliations is provided in Appendix A. A summary of the WQCAC meetings is provided in Appendix B.

III. Mission Statement and Decision-Making Process

At its first meeting, the WQCAC discussed and adopted a mission statement and set of ground rules for conducting its meetings. The mission statement read as follows:

> *To learn about and discuss facts, issues, and concerns regarding water quality in the Las Vegas Wash, Las Vegas Bay, and Lake Mead in order to make recommendation(s) to the SNWA Board of Directors on possible plans, studies, or solutions related to water quality needs in these areas.*

In the adopted ground rules, the committee agreed to abide by the following statement in making its decisions:

> *All perspectives are valued. The preferred approach to making decisions is collaborative problem-solving leading to consensus. In cases of non-consensus, however, minority viewpoints will be preserved.*

To assist the WQCAC in consensus building, SNWA employed an independent third party to conduct the meetings and provide neutral facilitation of discussions.

IV. Discussion Topics

The WQCAC deliberations can be divided roughly into two phases. The first phase was predominantly educational, consisting of an extensive presentation, review, and discussion of all facets of water quality issues in the region. This phase also included field visits to the area's drinking water and wastewater treatment facilities, the Las Vegas Wash, and the Las Vegas Bay.

Many issues were discussed during this phase. The following list indicates the breadth of the committee's activities:

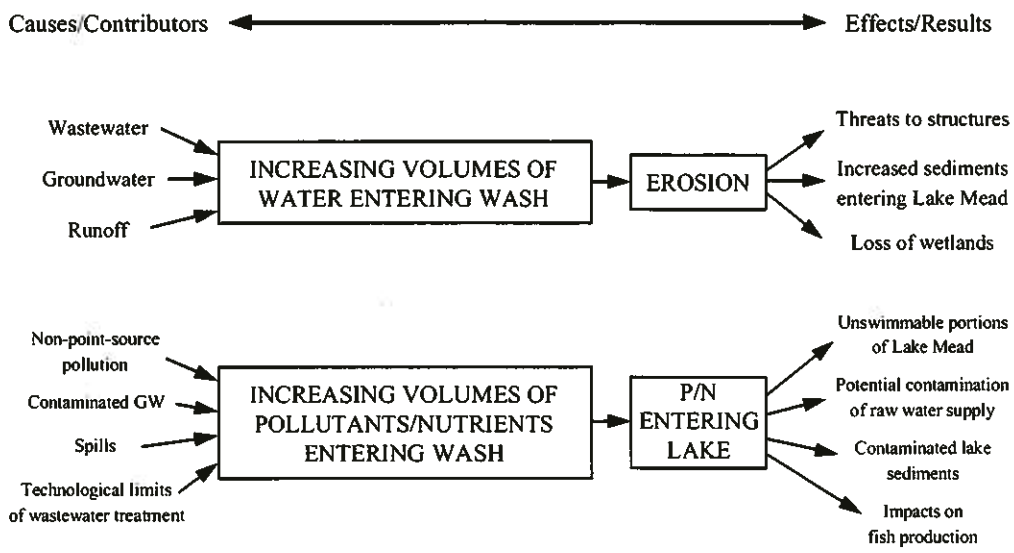
- Las Vegas Valley hydrologic cycle
- Lake Mead inflows and outflows
- Las Vegas Valley water consumption patterns
- Drinking water sources, quality, and treatment processes
- Wastewater treatment processes
- Water quality standards for drinking water and treated wastewater
- Contaminants present in the Wash, Bay, and Lake Mead
- Status of studies being conducted and cleanup efforts regarding perchlorate
- Water conservation programs
- Current and planned reclaimed water projects
- Stormwater runoff and nonpoint source pollution

- Flood control and erosion
- Loss of wetlands and potential for restoration
- Endocrine disruption, fisheries, and the Wash intrusion
- Alternative discharge locations for treated wastewater
- Permitting and regulatory authorities that affect water quality in the region
- Water quality testing and monitoring
- Existing planning efforts (for example, 208 Water Quality Management Plan, Wastewater Needs Assessment, Wetlands Park Plan)
- Designated and proposed beneficial uses for the Wash, Bay, and Lake Mead

The first phase culminated in a shared understanding of the primary water quality problems that needed to be considered and addressed in the region, both from a technical standpoint and an institutional one.

For the second phase of deliberations, the committee discussed and agreed to a water quality "problem statement." This statement took the form of a diagram that described the basic physical, chemical, and biological cause-and-effect relationships the committee members believed should guide their discussion and development of recommendations (see Figure 1). By systematically considering and addressing all of the causes, the WQCAC was able to develop a comprehensive set of recommendations to deliver to the SNWA Board of Directors.

Figure 1. Diagram of Problem Statement



V. Recommendations

In developing its recommendations, the WQCAC made several important decisions about the process and form their recommendations would take. The committee members first decided they would use the problem statement diagram to guide their discussions. They also decided to develop their recommendations on what should be achieved regarding water quality before addressing the question of who should be responsible. Committee members agreed it would be difficult to discuss institutional issues until they had the full range of potential water quality objectives and solutions in front of them.

The members also decided it would be insufficient simply to suggest possible solutions without a clear statement of the problems the solutions were meant to address and the objectives the committee hoped to achieve. Accordingly, the committee agreed upon a structure for each of the recommendations. This structure took the form of a problem statement, an objective, and proposed solutions. These objectives form the heart of the WQCAC's message to the SNWA and other entities. Regardless of how any individual solution might fare in the future, it is the objectives that reflect the committee's fundamental goals and standards for water quality.

Before presenting the specific recommendations of the WQCAC, one other aspect of the recommendations should be acknowledged. While the committee believes the recommendations to be sound, the members were not able in all cases to determine the degree to which their proposals may already be under some form of development or implementation. The committee discussed trying to ascertain and reflect such efforts in their recommendations, but rejected the idea as time-consuming and cumbersome. Therefore, the WQCAC wishes to make clear that wherever any entity is already conducting activities that are consistent with the WQCAC recommendations, the committee supports those efforts and encourages that the activities be continued.

The committee recommendations are presented under the following titles:

1. Reducing wastewater flows in the Las Vegas Wash through reuse.
2. Reducing wastewater flows in the Las Vegas Wash through conservation.
3. Reducing wastewater flows in the Las Vegas Wash through alternate discharge.
4. Stormwater runoff and nonpoint sources.
5. Groundwater seepage.
6. Spills.
7. Water quality monitoring.
8. Public confidence and perception of water quality.
9. Comprehensive management of the Las Vegas Wash.

Following disposition of the enclosed recommendations by the SNWA Board of Directors, the WQCAC will remain active, although meetings will be held much less frequently. It is expected that the committee will be reconvened at appropriate times to receive progress reports and to allow staff to solicit additional feedback when necessary.

Recommendation 1:

Reducing wastewater flows in the Las Vegas Wash through reuse

Problem. Local wastewater agencies have predicted that given historical trends in the Las Vegas Valley, wastewater flows in the Las Vegas Wash will increase approximately 60% by 2027. If projected levels of reuse are not met, the increase in flows will be even greater. Left unaddressed, these flows are expected to exacerbate erosion in the Las Vegas Wash. Erosion in the Wash threatens water control structures, increases the amount of sediment entering Las Vegas Bay and Lake Mead, and contributes to the loss of wetlands in and along the Wash.

Objective. The Water Quality Citizens Advisory Committee (WQCAC) believes steps must be taken to slow the trend towards greater wastewater flows in the Wash. To do this, the WQCAC believes the highest priorities should be to pursue more reuse of wastewater from treatment plants than is currently planned and to reduce flows into the treatment plants by encouraging greater on-site reuse by water users within the Valley.

Solutions. In this respect, the committee recommends:

1. Member agencies of the SNWA should continue their efforts to increase reuse in the Valley, subject to certain conditions --

    a. Agencies should consider promoting additional reuse (beyond currently planned projects) primarily through the use of pricing mechanisms and other incentives.

    b. In calculating the cost-benefit of any future reuse projects, agencies should factor in the benefit of avoided costs, such as additional treatment, environmental restoration, or other indirect costs, where possible.

    c. Agencies should ensure that any new reuse project replaces an existing or projected demand for potable water, rather than create an additional demand for water. Reuse projects should be consistent with maintaining sufficient amounts of return flow credits.

2. Member agencies of the SNWA should consider the use of reuse mandates as an alternative means of promoting reuse.

Recommendation 2:

Reducing wastewater flows in the Las Vegas Wash through conservation

Problem. Local wastewater agencies have predicted that given historical trends in the Las Vegas Valley, wastewater flows in the Las Vegas Wash will increase approximately 60% by 2027. Left unaddressed, these flows are expected to exacerbate erosion and water quality problems in the Las Vegas Wash.

Objective. The Water Quality Citizens Advisory Committee (WQCAC) believes steps must be taken to slow the trend towards greater wastewater flows in the Wash. Recognizing the contribution that conservation can make to reducing flows, the WQCAC believes that efforts to reduce the per capita consumption of water should continue, not just to reduce the demand for potable water in the Valley, but also to reduce wastewater flows to treatment plants.

Solutions. Because indoor water use is the source of wastewater and various water conservation programs are already in place, the committee recommends that member agencies of the SNWA consider options where an opportunity still exists for reducing the amount of water used indoors. Suggestions include retrofits for older, larger users; tying sewer rates to indoor water use; educating users about products and practices that waste water; encouraging the sale of water efficient products; and considering the effect of increased water rates on reducing indoor consumption.

Recommendation 3:

Reducing wastewater flows in the Las Vegas Wash through alternate discharge

Problem. Although reuse and indoor conservation will slow the trend of increased wastewater flows in the Las Vegas Wash, they are insufficient to stop or reverse it. In addition, increased pollutant- and nutrient-loading in Lake Mead threatens the lake's recreational uses, impacts fish production, contaminates lake sediments, and poses a potential contamination threat to the raw water supply for drinking water.

Objective. Although the short-term goal is to slow the trend towards greater wastewater flows in the Wash, the Water Quality Citizens Advisory Committee (WQCAC) believes the long-term goal should be to reduce the flows into the Wash and Las Vegas Bay from their current levels. By diverting flows from the Wash, the wastewater agencies could help solve water quality problems in the Las Vegas Bay, protect drinking water supplies in the Las Vegas Valley, improve the fishery in Lake Mead, and promote sustainable wetlands development in the Wash.

Solutions. In this respect, the committee recommends:

1. The member agencies of the SNWA should pursue feasibility studies of an alternate discharge or diffuser pipeline. The studies should --

    a. Focus on locations in Lake Mead. This will allow the Las Vegas Valley to continue to benefit from the existing system of return flow credits.

    b. Take into consideration the minimum discharge to the Wash needed to maintain wastewater flows sufficient for wetlands propagation.

    c. Take into consideration the cost, environmental impact, and political feasibility of specific locations. However, cost should simply be one criterion and not necessarily the most important one.

    d. Include a cost-benefit analysis on further treatment for reducing pollutant-loading and consider the potential ramifications of such additional treatment on any alternate discharge approach.

Figure ES-2
Las Vegas Valley Average Wastewater Flow and Strength Increases (1991 -1996)

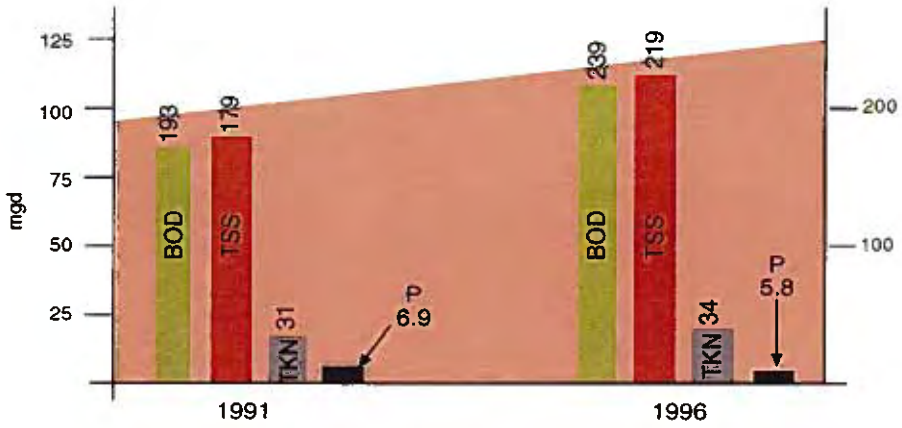


Table ES-1
Influent Wastewater Flow Peaking Factors

Conditions	Peaking Factors CoH	CLV	CCSD
Average Annual	1.0	1.0	1.0
Peak Month			
Recent	1.07	1.1	1.13
Past Studies and Reports	(a)	1.16	1.15
Peak Day	(a)	1.33	1.4
Peak Hour	2	1.5	1.6

(a) No data.

Table ES-2
Las Vegas Dischargers Average Annual Flow
Existing Treatment Plant Capacities

	CoH	CLV	CCSD	Total
As designed	19.5	57	88	173.5
As designed (LV Wash discharge)	10.0	57	88	164
As calculated (LV Wash discharge)	9.3	49	80	138
Limiting Factor	Oxidation ditch	Nitrification facility	Activated sludge-BNR	

provide sewer service to their respective service areas. Interlocal agreements between these agencies allow for sewer service across jurisdictional boundaries which reduces the potential for unsewered areas, increases efficiency, and minimizes cost to rate payers.

Figure ES-3 graphically depicts the institutional arrangements for wastewater in the Las Vegas Valley.

WATER QUALITY AND REGULATIONS

The Las Vegas Wash receives drainage from a 1,600 square mile area and discharges into the western end of Las Vegas Bay. The wash receives treated effluent flows from the Dischargers' wastewater treatment facilities and stormwater, nuisance water, and groundwater non-point discharges from the watershed.

Receiving Waters

In 1987, the Nevada Division of Environmental Protection (NDEP) published recommendations and revisions to the standards for pH, total phosphorus, chlorophyll a, and un-ionized ammonia concentrations for the Las Vegas Wash and Lake Mead. In 1989, the NDEP established Total Maximum Daily Loads (TMDLs) for phosphorus (434 lb/day) and ammonia (970 lb/day). These TMDLs are divided into wasteload allocations (WLAs) among the Dischargers with a portion of the phosphorus TMDL (100 lb/day) allocated to non-point sources. The phosphorus TMDL is in effect from March 1st through October 31st of each year; the ammonia TMDL is in effect from April 1st through September 30th of each year.

In accordance with their respective discharge permits, the Dischargers collect and analyze samples from Las Vegas Wash, Las Vegas Bay, and Lake

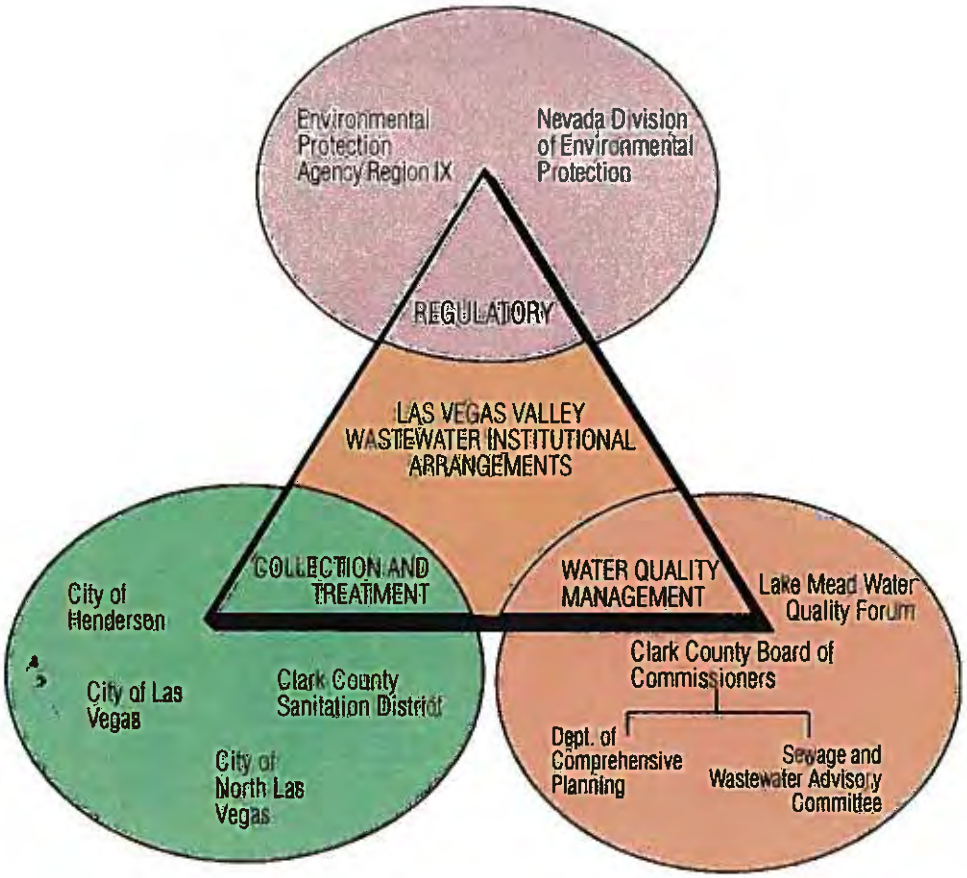


Figure ES-3
Las Vegas Valley Wastewater Institutional Arrangements

Executive Summary

Mead. Actual water quality, when considering chlorophyll a and un-ionized ammonia has significantly improved for both Stations LM2 (Las Vegas Bay) and LM3 (Lake Mead). The causative effect most likely is the construction of new treatment facilities at the CLV and CCSD. This data indicates a trend towards improved water quality. Data show that there is a considerable margin between the water quality standard and actual water quality at both Stations LM2 and LM3.

Water Sources

Wastewater treatment facility discharges account for the majority of flows in Las Vegas Wash, with an average of 125 mgd in 1996. These facilities treat almost all residential, commercial and industrial wastewater generated within the Las Vegas Valley watershed. The Dischargers monitor treated effluent from the facilities in accordance with the requirements of the NPDES permits. In many instances, effluent water quality far exceeds (is of significantly better quality than) the discharge limits.

Non-point sources also contribute nutrients (phosphorus and nitrogen) to the Las Vegas Wash through six major storm drainage outfalls, numerous minor outfalls, and overland flow. Total phosphorus loading from non-point sources discharged through the storm drainage system is computed as the total of the dry and wet weather loadings. A non-point load estimate using stormwater NPDES 1992-1995 data results in an estimated total phosphorus loading of 59 lb/day in an average year. The phosphorus load in a particular year could range from one-half to two to three times this amount based on actual hydrologic conditions affecting the wet weather contribution.

Most of the non-point phosphorus load is contributed to Las Vegas Wash during storm events. In an average year, 12 storms produce significant runoff in the Las Vegas Valley with about one-half of the mean annual rainfall occuring during the March - October TMDL allocation period.

The total phosphorus load of 100 lb/day appears to overestimate the actual load in dry and average years, but is reasonable for wet years. Further study of this issue may be warranted in order to lower the allocated non-point source total phosphorus load and thereby increase the total phosphorus TMDL available to the wastewater treatment plants.

FUTURE FLOWS AND LOADINGS

Wastewater influent and reuse flows are projected to significantly increase during the planning period. Influent wastewater strengths are a significant parameter in the design of future treatment facilities and have steadily increased during the last five years.

Wastewater Influent and Reuse Flows

Wastewater influent flows are expected to increase from the average annual 125 mgd flow of 1996 to 282 mgd in the year 2027. Reuse demand, currently a minor portion of total effluent flows, is also expected to increase as dedicated reclamation facilities are constructed. Figure ES-4 depicts the projected reuse and wastewater flows during the planning period.

Wastewater Influent Concentrations

Wastewater concentrations for BOD, TSS, nitrogen, and TDS have steadily increased over the past 5 years. The phosphorus concentrations, however, have continued to steadily decline over the same period. The concentrations of the various wastewater constituents have been assumed to remain constant over the entire planning period through the year 2027. This assumption could have a significant impact on the selection, sizing and overall cost of future wastewater treatment facilities and actual wastewater characteristics should continue to be monitored and evaluated to ensure that the design criteria used for new treatment facilities are appropriate.

The year 2027 projected influent and reuse flows and influent concentrations are presented in Table ES-3. Peak month values are reported for influent flows and concentrations.

FUTURE REGULATIONS

Future regulations for wastewater treatment may include more stringent requirements for a variety

Table ES-3
Summary of Projected Peak-Month Influent Wastewater Flows and Characteristics

PARAMETER	Units	Annual Average and Peak-Month Value for Year 2027					
		CoH		CLV		CCSD	
		Average	Pk Month	Average	Pk Month	Average	Pk Month
INFLUENT FLOW	mgd	40	43	111	122	131	148
REUSE FLOW	mgd	20	-	33	-	27	-
BOD5	mg/L	222	255	249	298	226	280
TSS	mg/L	230	299	218	247	248	376
TKN	mg/L	35	37	34	41	31	37
NH4-N	mg/L	22	23	21	26	19	22
TP	mg/L	6.3	7.9	5.7	6.3	5.7	6.8
TDS	mg/L	1225	1394	1083	1253	1416	1733

of constituents including phosphorus and bacteria. The current issues with respect to water quality and the location of wastewater discharge in relation to the Southern Nevada Water Authority water intake indicate that alternate discharge locations should be investigated. The potential future regulations that may result from more stringent discharge requirements and alternate discharge locations result in four distinct future scenarios summarized in Table ES-4.

The year 2027 Las Vegas Valley projected influent wastewater flow of 282 mgd is more than double the current flow. The current TMDLs for phosphorus and ammonia result in future effluent concentrations that are quite low and may, in the case of ammonia, be difficult to consistently achieve with conventional, biological treatment processes.

TREATMENT NEEDS

The Dischargers own and operate treatment facilities serving the Las Vegas Valley that have a combined, as-calculated treatment capacity of 138 mgd on an average daily flow basis. The average annual wastewater flow in 1996 was 125 mgd and by the year 2027, the total wastewater flow requiring treatment is estimated to be 282 mgd. Table ES-5 summarizes the existing facility capacities and future capacity needs for the year 2027.

A variety of treatment processes and configurations can be employed to meet future requirements. The alternative processes range from the continued application of the existing processes at each treatment facility to more advanced systems depending on the future scenarios as presented by Table ES-6.

The types of treatment processes that could be employed at each Discharger's facility to meet the requirements of these scenarios are discussed in the paragraphs below.

City of Henderson

The projected 2027 wastewater flows for the CoH are 40 mgd total. With an existing Las Vegas Wash discharge capacity of 9.3 mgd, the capacity deficit is 31 mgd.

Continued application of the existing treatment processes of the WRF can meet the stringent potential discharge requirements for phosphorus. The existing extended aeration process of the WRF is the most efficient biological process for ammonia reduction with the potential of achieving the lowest effluent ammonia concentrations. However, with the current ammonia TMDL applied in the future, the effluent ammonia concentrations that will be required may be difficult to achieve even with the extended aeration process.

Secondary level treatment only could be achieved by continued application of the extended aeration activated sludge process.

Figure ES-4
Total Las Vegas Valley Projected Reuse Water Demands and Wastewater Flows

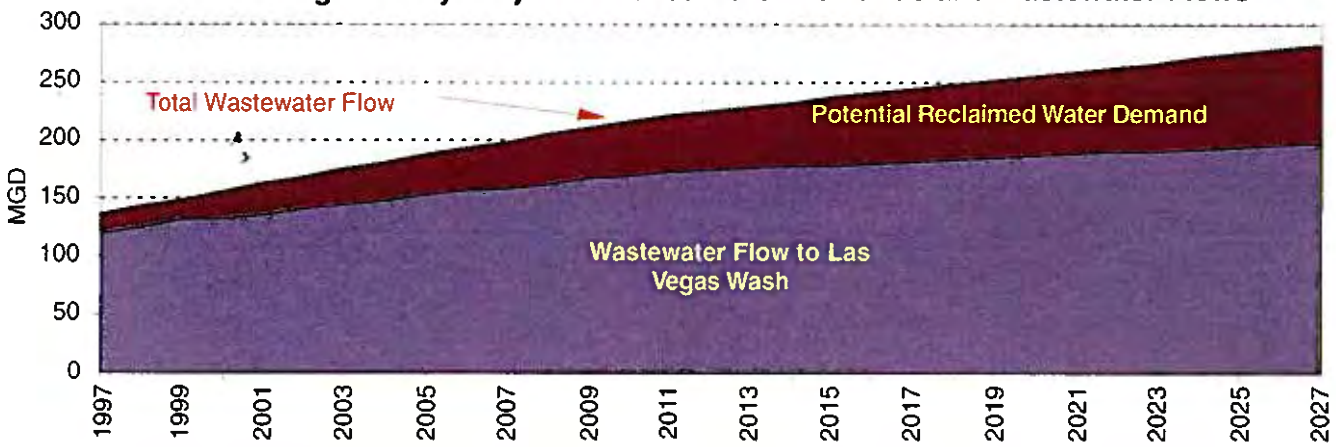


Table ES-4
Current and Potential Future Discharge Conditions

Scenario	Description	Current Conditions (at 282 mgd)	Future Conditions (at 282 mgd)
1. Existing	Current Requirements	-	-
2. Phosphorus restriction	50 percent reduction in WLA	WLA = 334 lb/day	WLA = 167 lb/day
3. Coliform level	Reduction to unrestricted use levels	200 mpn/100 ml Fecal	2.2 mpn/100 ml Total
4. Discharge location	Eliminate/reduce potential impact on water supply	Las Vegas Bay	Deep water outfall Alternate lake surface discharge Non-lake discharge

Table ES-5
Future Wastewater Facility Needs

Discharger	Nominal Average Annual Capacity, mgd	Capacity Under Current Conditions for Discharge to Las Vegas Wash, mgd	Projected Capacity Needs in 2027 for Discharge to Las Vegas Wash, mgd	Capacity Deficit, mgd
City of Henderson	19.5	9.3	40	31
City of Las Vegas	57	49	111	62
Clark County Sanitation District	88	80	131	51
Total	**165**	**138**	**282**	**144**

Table ES-6
Treatment Process Alternatives

Treatment Requirement	Treatment Alternative
Scenario 1 - Current Standards. Application of the current effluent discharge requirements.	• Biological nitrification and chemical phosphorus precipitation • Biological nitrification and enhanced biological phosphorus removal with chemical phosphorus precipitation • Biological treatment for BOD removal with membrane (reverse osmosis) processes for ammonia and phosphorus removal
Scenario 2 - Future Standards. Application of current regulations with a 50 percent reduction in the phosphorus waste load allocation and a more stringent disinfection criteria.	• Biological nitrification and chemical phosphorus precipitation • Biological nitrification and enhanced biological phosphorus removal with chemical phosphorus precipitation • Biological treatment for BOD removal with membrane (reverse osmosis) processes for ammonia and phosphorus removal
Scenario 3 - Tertiary Treatment Standards. Production of a filtered, disinfected effluent following secondary treatment, for non-bay, surface lake discharge.	• Conventional activated sludge process • Trickling filter process • Extended aeration activated sludge process • Any of the above secondary treatment systems followed by filtration
Scenario 4 - Secondary -Treatment Standards. Treatment to secondary level standards only for fully-diffused lake discharge or alternate discharge location.	• Conventional activated sludge process • Trickling filter process • Extended aeration activated sludge process
Pathogen Barrier. Current discharge standards with added requirement for inclusion of a pathogen barrier.	• Biological and chemical treatment for ammonia and phosphorus removal with ultrafiltration as a barrier to the passage of microorganisms

City of Las Vegas

The CLV's projected average annual wastewater flow rate is 111 mgd by the year 2027. With an existing capacity of 49 mgd, the capacity deficit is 62 mgd. To meet future capacity needs, the following facilities will be required:

- Upgrade the existing secondary treatment nitrification process to 57 mgd average annual capacity.
- Construct new primary, secondary and tertiary treatment facilities for 54 mgd of additional average annual capacity.

With the current ammonia TMDL, the future effluent ammonia concentrations that will be required will be difficult to achieve on a reliable basis. New facilities, and upgrades to the existing nitrification process, will require special consideration for improved performance. Alternatively, a higher degree of ammonia removal can be achieved through the implementation of break-point chlorination or the addition of reverse osmosis or ion exchange processes.

Clark County Sanitation District

The CCSD's projected average annual wastewater flow rate is 131 mgd by the year 2027. With an existing capacity of 80 mgd, the capacity deficit is 51 mgd. Facilities needed to satisfy this capacity deficit are:

- Upgrade the existing secondary treatment activated sludge process to 88 mgd.
- Construct new primary, secondary and tertiary treatment facilities for 43 mgd of additional capacity.

With the current ammonia TMDL, the future effluent ammonia concentrations that will be required will be difficult to achieve on a reliable basis. New facilities and upgrades to the existing activated sludge phosphorus and nitrogen removal process will require special consideration for improved performance. Alternatively, a higher degree of ammonia removal can be achieved through the addition of reverse osmosis or ion exchange processes. Given the CCSD's plans to utilize ultraviolet disinfection, breakpoint chlorination for the further reduction of ammonia may not be a viable option.

ALTERNATIVE DEVELOPMENT

Six alternatives were developed from the future discharge scenarios discussed previously. These alternatives are summarized in the paragraphs below.

Alternative 1. Las Vegas Wash

This alternative consists of providing future treatment through the continued application of treatment processes currently in use by the Dischargers.

Alternative 2. Full Biological Nutrient Removal (BNR)

This alternative consists of providing future treatment through the implementation of biological phosphorus removal (BPR) activated sludge processes that optimize phosphorus removal and nitrification performance. Key process requirements include anaerobic zones, anoxic zones for denitrification, and primary sludge fermentation. Tertiary treatment for chemical phosphorus polishing by precipitation with filtration and disinfection are also necessary.

Alternative 3. Tertiary Treatment with Discharge to Virgin Basin

This alternative consists of providing future treatment to meet tertiary treatment levels for an alternate location for surface discharge of effluent in Lake Mead. A non-Las Vegas Bay discharge point would remove the effluent disposal impacts on Las Vegas Bay and increase the separation between the effluent discharge and the water intake for the Las Vegas Valley. The downstream end of Lake Mead's Virgin Basin, just upstream of the Narrows region, was selected as the alternate surface discharge location due to its distance from the water intake, its proximity to a narrow and relatively active reach of the Lake, and the availability of roadway access along the majority of the conveyance route. A common conveyance system from the wastewater treatment plants to the Virgin Basin would be sized to pump peak month effluent flows. Figure ES-5 de-