DRAFT

RAINWATER HARVESTING

Sustainable Drainage Management for SSCAFCA, Sandoval County, City of Rio Rancho, Town of Bernalillo and Village of Corrales

SOUTHERN SANDOVAL COUNTY ARROYO FLOOD CONTROL AUTHORITY (SSCAFCA)

Prepared By

WHPacific

JUNE, 2011

WHP 212824

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CERTIFICATIONS PAGE

Engineer's Certification

State of New Mexico
County of Bernalillo
I, Clinton Dodge hereby certify that I am a professional engineer licensed in the state of New Mexico, qualified in Civil engineering; that the accompanying Rainwater Harvesting Report for SSCAFCA was prepared by me or under my supervision

_____
Clinton Dodge, P.E. Engineer of Record
License No. NM6410
Date submitted__ _____

Owner's Certification

State of New Mexico
County of Sandoval
I, David Stoliker, state that I am the Executive Engineer of the Southern Sandoval County Arroyo Flood Control Authority, a political subdivision organized under the laws of the state of New Mexico and that the accompanying SSCAFCA Rainwater Harvesting Report was made under the authority of the board of directors of said public subdivision and that, in their behalf, I have read and examined the statements and representations and all that is shown herein is done with their free consent and in accordance with their wishes and state that the same are true and correct to the best of my knowledge and belief.

_____
David Stoliker Date:_____
Executive Engineer

WHPacific

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June, 2011

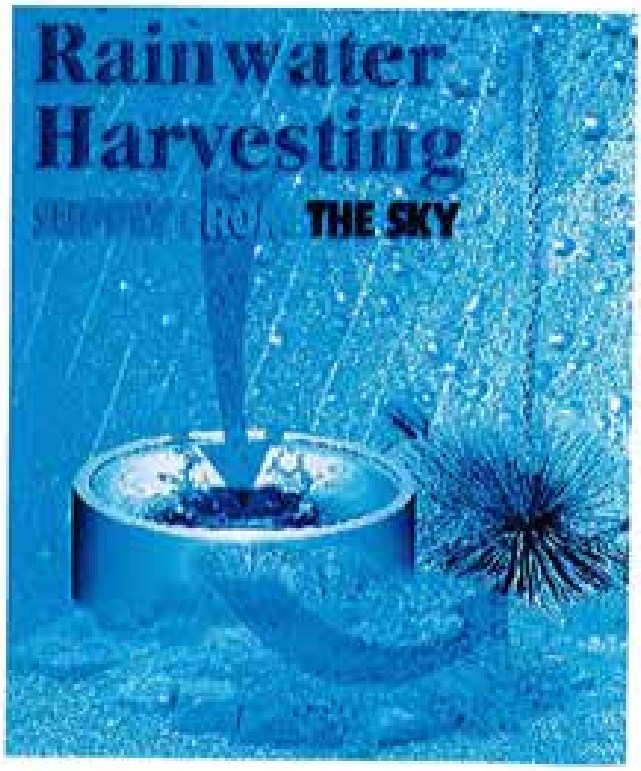
DRAFT

ABSTRACT

Depletion of the groundwater, arroyo erosion and water quality impairment of the Rio Grande are on-going public health, safety and welfare issues in the SSCAFCA jurisdiction. Urban and suburban development increases potable water use as well as both the volume of stormwater runoff and the frequency of runoff events. Allowing increased runoff from developed properties results in increased erosion and more pollutants conveyed to the river as well as the missed opportunity to use rainwater as a renewable resource to reduce potable water use.

Rainwater harvesting addresses these issues. It is one component of an overall drainage strategy to provide health, safety and welfare, effective use of tax dollars and quality of life. The strategy consists of two complimentary philosophies:

- Recognize the value of rainwater by using it where it falls. This is the rainwater harvesting objective.
- Manage the runoff that does occur with safe naturalistic features.



What is rainwater harvesting?

Rainwater harvesting is the art of intercepting and collecting precipitation so that it can be used to support life.

Why collect rainwater?

- Rainwater harvesting conserves water by making use of a sustainable renewable resource. Every gallon of rainwater used for irrigation is one less gallon of municipal or well water used.

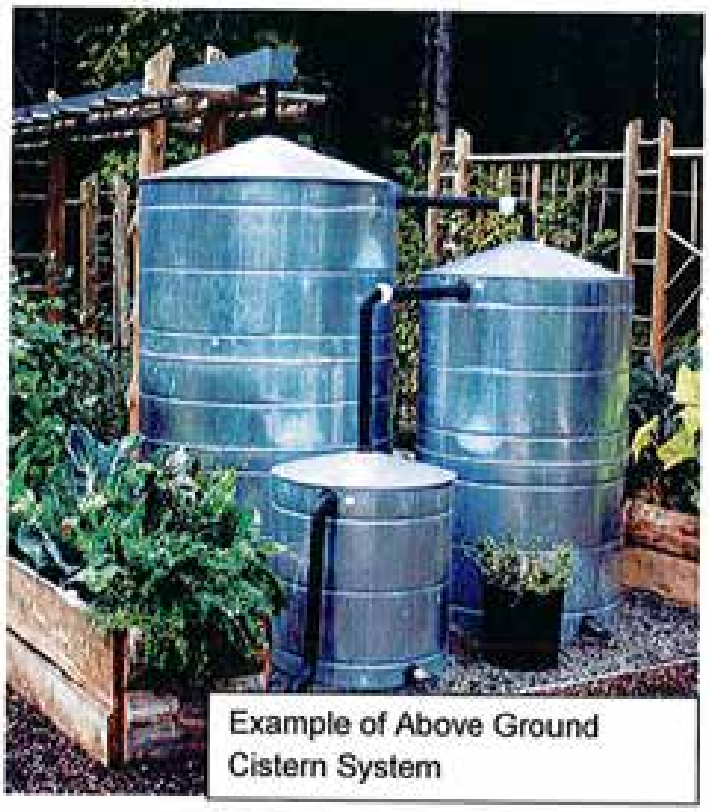
- Pollution in the Rio Grande is reduced. Runoff transports trash, fecal matter from animals, bacteria, nutrients, chemicals and other pollutants to the river through the arroyo system. Rainwater harvesting reduces runoff and thus the pollution entering the river is less.
- Rainwater is free. It doesn't come with a monthly utility bill.
- Rainwater harvesting conserves energy. Extracting, treating and distributing groundwater, whether for an individual well or for the municipal system, requires a tremendous amount of energy.
- Erosion is reduced. The collected rainwater doesn't leave the site and therefore doesn't increase erosion in the ditches along the roadways and in the arroyos.
- Rainwater is naturally low in salts (sodium), so plants thrive on it.
- Public funds are better utilized. Reduced erosion means less roadway ditch and arroyo maintenance, allowing those funds to be directed to other public needs.
- Rainwater Harvesting is straight forward and easy to implement. This program is to collect rainwater from the roof and use it for irrigation. The elevation of the collected roof water, which will be 6 to 10 feet above ground, provides the opportunity to store and use the water in numerous ways such as rain gardens, cisterns, infiltration beds, etc.

The Rainwater Harvesting Program includes of the following elements:

- Joint implementation by SSCAFCA, Rio Rancho, Sandoval Co., Bernalillo and Corrales.
- Develop agency agreements, policies, procedures and educational materials.
- Participation by all new single family residential (SFR) construction in previously platted areas.
- Promote a voluntary rainwater harvesting program for existing development with technical assistance.
- Consider a cost share or rebate component to the program.

Rainwaterwise Landscaping

- Develop a "how to" Guidance Manual with safety criteria, design standards, guidelines, examples and references.
- Capture rainwater runoff from all new SFR roof areas
- Retain and use on-site the initial 2/3 gallon per square foot of roof area runoff (equivalent to 1" over the roof area).
- Provide retention facilities with verifiable capacity such as cisterns, rain gardens with fixed boundaries, engineered infiltration beds, etc.
- Flood control is not recommended since the retention facilities may not be empty to attenuate the peak flow rate.
- Administration of the program includes:
  - A Grade & Drain Plan incorporating the Rainwater Harvesting Plan.
  - Engineer or Landscape Architect certification of construction conformance.
  - Annual homeowner verification that rainwater harvesting facilities are still in-place and functional.
  - Occasional follow-up verification by a public agency.
- Future implementation would include roads and streets, planned communities and non-residential development.

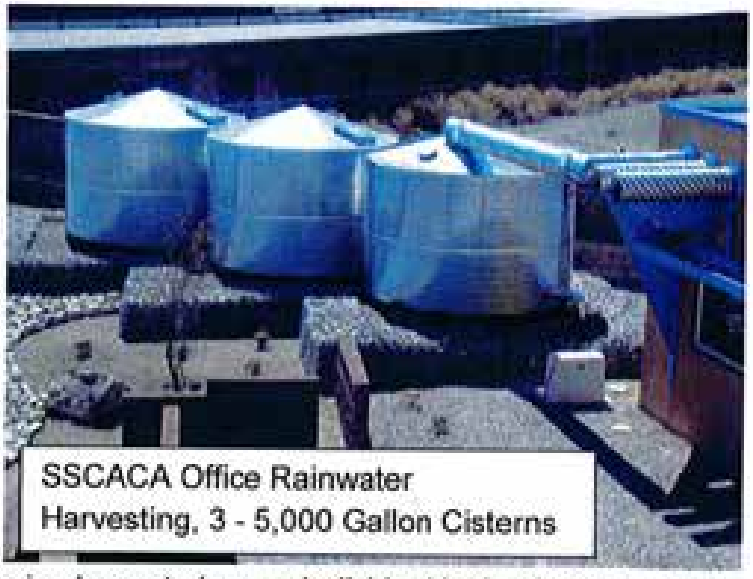


Example of Above Ground Cistern System

I. SSCAFCA RAINWATER HARVESTING & ARROYO UTILIZATION STRATEGY.

SSCAFCA has developed an overall drainage strategy to provide for the public health, safety and welfare. The goal is to recognize the value of rainfall in the high plains semi-arid SSCAFCA jurisdiction and maximize the community value of the arroyo system by implementing two complimentary principles:

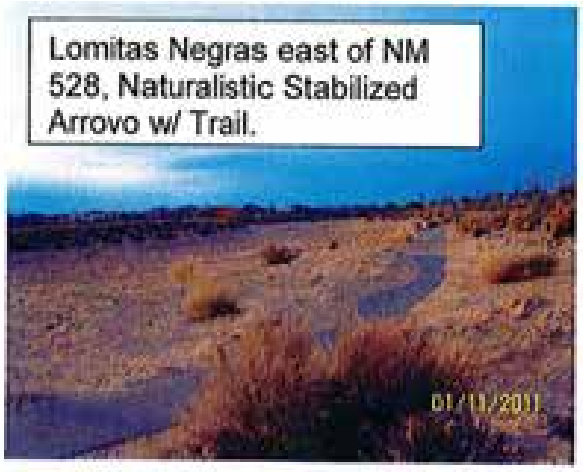
- RAINWATER HARVESTING – A RUNOFF REDUCTION TECHNIQUE
  Reduce runoff due to development at the source – Use the rain where it falls.



SSCACA Office Rainwater Harvesting, 3 - 5,000 Gallon Cisterns

Rainwater Harvesting is the technique of reducing runoff from development by intercepting and using the rainwater on-site. This low impact development method is to collect runoff from impervious areas such as roof tops and "micro-catchment" systems implemented on an individual lot basis for on-site use. Stormwater runoff volume and frequency of rain events that cause runoff from individual properties is reduced. The SSCAFCA Rainwater Harvesting analysis indicates that potable water use, arroyo erosion and pollutant discharges can all be reduced by 30% to 60%.

- ARROYO UTILIZATION - NATURALISTIC ARROYOS
  Provide flood and erosion control with naturalistic features and multiple-uses



Lomitas Negras east of NM 528, Naturalistic Stabilized Arroyo w/ Trail.

When upland development occurs, both the volume and velocity of the stormwater runoff increases, causing arroyo damage. Rainwater Harvesting reduces the volume of runoff, may not reduce the velocity and thus doesn't eliminate the need for flood control conveyance. The Naturalistic Arroyo concept is to mimic natural arroyos to maintain a healthy arroyo system using natural landforms and materials to provide flood and erosion control, multi-use for the public and wildlife habitat.

II. RAINWATER HARVESTING PROGRAM GOALS & OBJECTIVES

RAINWATER IS A VALUABLE SUSTAINABLE RESOURCE

Rainwater Harvesting is a cornerstone of the Rainwater Harvesting & Arroyo Utilization Strategy.

A. WHAT IS RAINWATER HARVESTING?

Rainwater harvesting is the art of intercepting or diverting and collecting precipitation so that it can be used to support life. Rainwater harvesting is an increasingly popular practice in arid climates, but it isn't a new idea. The native inhabitants of New Mexico knew that water was a precious commodity in the desert, so they collected rainwater for drinking and cooking, and they planted their crops where rainwater could be diverted.

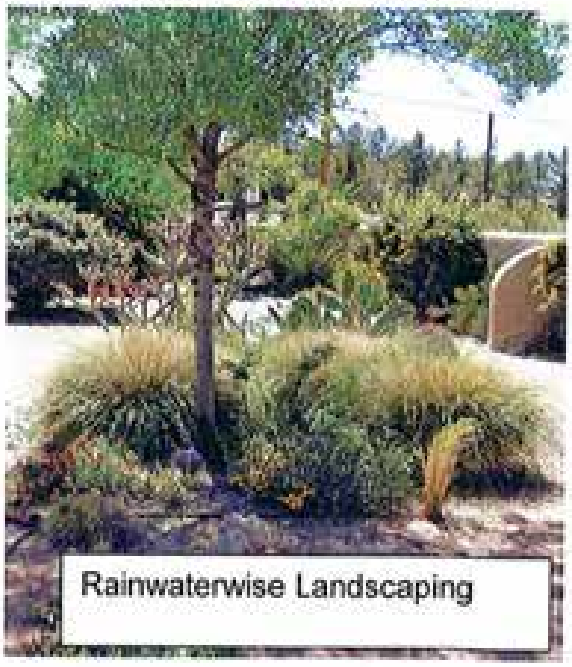
The term rainwater harvesting as proposed for the SSCAFCA program is a landscaping strategy designed to use naturally falling rainwater to irrigate landscape. No matter what kind of plants, rainwater harvesting can reduce the amount of supplemental irrigation required. The SSCAFCA program is for non-potable uses only, not for drinking water.

B. WHAT ARE THE ADVANTAGES OF COLLECTING RAINWATER?

- Rainwater harvesting conserves water. Every gallon of rainwater used for irrigation reduces the amount of potable municipal or well water used thus reducing groundwater depletion.
- Rainwater harvesting reduces pollution in the Rio Grande. Rainwater runoff transports trash, fecal matter from animals, bacteria, nutrients, chemicals and other pollutants to the river through the arroyo system. Rainwater harvesting reduces this runoff.
- Rainwater is free. It doesn't come with a monthly utility bill.
- Rainwater harvesting conserves energy. The energy to extract groundwater, whether for an individual well or for the municipal system, and to treat and distribute municipal water requires a tremendous amount of energy.
- Rainwater harvesting reduces erosion. The collected rainwater doesn't leave the site and therefore doesn't increase erosion on the homeowner's property, in the ditches along the roadways and in the arroyos.
- Rainwater is naturally low in salts (sodium), so plants thrive on it.
- Public funds are better utilized. Reduced erosion means less dirt roadway, ditch and arroyo maintenance, allowing those funds to be directed to other public needs.

C. GOALS AND OBJECTIVES OF THE RAINWATER HARVESTING PROGRAM

- Safety. Provide public health, safety and welfare and property preservation by reducing erosion, pollution and flooding.
- Financial Viability - Develop a system that provides long term financial stability.
- Security – Provide secure facilities for public safety.
- Water Conservation – Lessen City water demand and reduce groundwater depletion.
- Reduce Erosion Risk - Reduce risk of erosion damage to public and private properties.
- Water Quality – Reduce storm water pollutants in the system and into the Rio Grande.
- Watershed Park – Achieve community connectivity and enhanced quality of life.
- Recognize Rainwater as a Valuable Asset – Develop a public appreciation of rainwater as a valuable resource.



Rainwaterwise Landscaping

- Prudent Use of Public Funds –Provide cost effective drainage solutions.
- Wildlife Habitat – Provide wildlife habitat and migration corridors.
- Sustainability - Conserve water, maintain habitat and provide adequate funding.
- Sense of Community – Develop "arroyo ownership" and "doing-the-right-thing".
- Property Value – Enhance property values along arroyo corridors.
- Economic Benefit. Provide economic benefits for the homeowner and the general public.
- Flooding. Improve safety by reducing sediment build-up leading to flooding.
- Neighbor Conflicts. Reduce conflicts from cross-lot drainage.
- Affordable. Implement a program that is affordable for the residential owner.
- Infrastructure Funds. Maximize the benefits from public funds.
- Phasing. Increase phasing opportunities of drainage infrastructure needs.
- Public Awareness. Minimize unintended consequences by maintaining dialog with the public, encourage voluntary rainwater conservation.

III. RAINWATER HARVESTING PROGRAM (RWH)

THE ART OF COLLECTING AND USING RAINWATER TO SUPPORT LIFE.

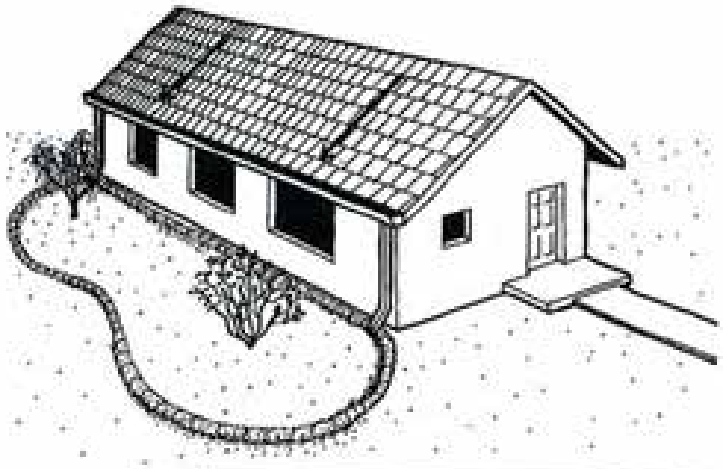
The Rainwater Harvesting Program (RWH) is the result of an exhaustive investigation of the benefits and potential issues of a RWH program for the SSCAFCA jurisdiction. This investigation is summarized in Section IV with supporting analysis and details included in the Appendices.

The investigation clearly demonstrates that RWH can reduce erosion, lessen pollutant generation, conserve water and provide other critical drainage benefits in the upland areas of the SSCAFCA jurisdiction. Therefore, rainwater harvesting is proposed as part of the overall drainage control strategy. Since conservation, stormwater quality and erosion are directly influenced by the volume of rainwater runoff, the Rainwater Harvesting Program focuses on runoff volume reduction. The collected rainwater would be used on-site for irrigation or infiltration and does not leave the site.

The Rainwater Harvesting Program is a straight forward concept with two components:

- Intercept and collect all runoff from all roof tops on new single family residential development.
- Retain on-site and use for irrigation and/or infiltration the initial 2/3 gallon/square foot (1") of this runoff.

Roof top collection is proposed rather than collection of all impervious area due to the advantages provided by the elevation of the collection point. Also, the roof top collection conforms to the State Engineer Rainwater/Snowmelt Harvesting Policy (NMOSE, 2005)*. Retention of the initial 1" of runoff was selected since increased storage capacity provides little benefit but adds substantial cost.



A Simple Passive Roof Top Collection System

*References are listed alphabetically in appendix B.

Rainwater Harvesting can be implemented using two basic concepts or techniques:

- Passive. Increase the effectiveness of rainwater when it falls using rain gardens, swales, permeable surfaces, etc. Passive RWH does not store the rainwater for future use.
- Active. Capture and store rainwater for the future using cisterns. Active RWH provides the opportunity for the reduction of irrigation water when rainfall is scarce.

Either of these techniques, or a combination, can be used to accomplish the rainwater harvesting program.

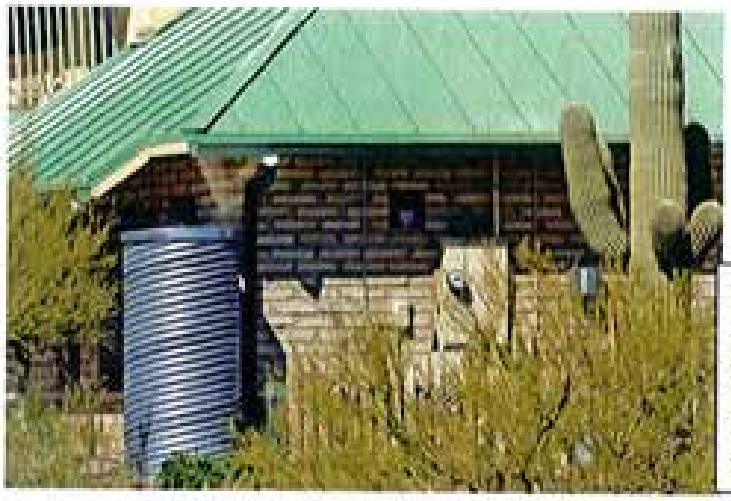
The LUMI, A Modern Rainwater Cistern: (source www.metaefficient.com)

The rainwater harvesting collection technique investigated in this analysis is frequently referred to as "impervious disconnection". Runoff from impervious surfaces is prevented from discharging off-site and this runoff is not hydraulically connected to off-site drainage facilities. This effectively "disconnects" those impervious areas reducing runoff volume, particularly for the smaller storms. The retained runoff is used on-site for irrigation and other non-potable functions. In this report, rainwater harvesting and impervious disconnection are used interchangeably.

Implementation of the rainwater harvesting program will utilize components from other successful programs in the southwest to ensure safety, maintainability and conformance with criteria. The program guidelines include the following elements:

- A roof drainage plan and water harvesting plan submitted and accepted in conjunction with the grading and drainage plan.
- A maintenance plan including a cleaning schedule.

- The rainwater system sized to intercept and hold on-site the initial 2/3 gallon per square foot of roof area. This volume may include cisterns, rain gardens or a combination of the two.
- Rain gardens, if used with fixed boundaries to identify the required volume for maintenance and verification.
- Rain garden depth less than 8" for safety.
- Rain gardens located a minimum of 10' from building foundations.
- Cisterns have locking covers, screens and/or lids.
- All spigots/outlets connected to the system marked "non-potable water".
- All piping buried a minimum of 18".
- Cistern systems with a first flush diverter, screen, sediment trap and/or filter to prevent particles entering the system.
- Above ground cisterns incorporating integral pigment to reduce algae growth.
- All system components protected from freeze damage.
- All systems include an overflow outlet or discharge point.
- All systems comply with local, state and federal requirements.



Active System, Above Ground Cistern (source tucsoncitizen.com)

- All systems constructed by a licensed contractor or other qualified individual as approved.
- All systems certified by a professional engineer or landscape architect prior to acceptance.
- Annual certification by the homeowner that the rainwater harvesting system conforms to and is operating in accordance with the accepted plan.

IV. FEASIBILITY INVESTIGATION
USING RAINWATER HARVESTING IN THE SEMI-ARID SSCAFCA AREA

An extensive technical investigation was performed to evaluate the feasibility, advantages, disadvantages and prudence of a rainwater harvesting program (RWH) for the unique situation in the SSCAFCA jurisdiction. A project team guided and performed the investigation including representatives from SSCAFCA, City of Rio Rancho, WHPacific, Huitt-Zollars and Bohannan-Huston with participation by the public This investigation provides justification for and forms the basis of the proposed SSCAFCA rainwater harvesting program. The results of this investigation are presented in the following sections and the details are included in the Appendices. References are listed in appendix B, "References." Specific references for analysis details are listed in Appendix H, H&E Analysis.

A. BACKGROUND

The SSCAFCA jurisdiction has several unique conditions as the result of topography, soil conditions and previous human activity including the Rio Rancho Estates platting in the 1960s. Some of these considerations are:

Rainwater Fence Storage

- Single family residential (SFR) building in antiquated platting areas, such as Unit 17, cause severe erosion as highlighted by the 2006 and 2010 storms.
- Risk and property damage increase due to the increased erosion and subsequent sedimentation.
- Emergency repairs and maintenance increases, diverting funds from permanent improvements.
- Unique conditions including antiquated platting, erosive soils, steep slopes and development combine to exacerbate the problem.
- One objective is to keep a naturalistic arroyo system with quality of life amenities minimizing the use of concrete channels to solve erosion problems.
- Watershed based stormwater quality NPDES Permit requirements are anticipated in the next permit cycle. RHW has been shown to help improve water quality on a watershed basis and conforms to one aspect of the proposed permit conditions.

B. OTHER AGENCY RAINWATER HARVESTING PROGRAMS REVIEW

A review of present rainwater harvesting and similar practices in other communities was performed by Bohannan-Huston. The details are included in Appendix G, Other Agency Program Data. Sixty four community programs were reviewed summarized as follows:

• Is water harvesting required?	10 programs
• Required for residential?	9 programs
• Required for subdivision?	8 programs
• Required for Commercial?	14 programs
• Is retrofit required?	7 programs
• Is a depressed pond required?	30 programs (many flood control related)
• Pond capacity requirement?	16 programs
• Impervious disconnection?	9 programs
• Funding source?	14 programs, impact fees and utility fees
• Combined system?	12 programs (combined sanitary and drainage)
• Stormwater Utility	27 programs
• Program Start Date	First programs identified in 1992.
• Enforcement?	9 programs.
• Incentives?	23 programs (utility credits most common)

Six New Mexico rainwater harvesting programs were identified:

- Albuquerque – Water Authority rebate, voluntary with utility invoice based rebates, initiated in 1998;
- Las Cruces – Pond requirement;
- Los Ranchos de Albuquerque – Pond and impervious disconnection required,
- City of Santa Fe – Voluntary harvesting as conservation measure;
- New Mexico Office of the State Engineer (statewide) – Voluntary rainwater harvesting for water conservation .
- Santa Fe County – Rainwater harvesting required for residential and commercial, including retrofits. The Santa Fe County requirements, from the County website, are quoted below:

"Residences 2,500 ft^2 of heated area **or less** must utilize rain barrels, cisterns, or other catchment basins. Residences 2,500 ft^2 of heated area **and greater** must install an active rainwater catchment system comprised of cisterns

- Cisterns must be buried or partially buried.
- Cisterns must hold 1.15 gallons per ft^2 of residential heated area; this figure can be adjusted based on landscaping, but not eliminated.
- Landscaping must be watered by a pump and drip irrigation system connected to cisterns."

From a funding viewpoint, Texas has several tax break and rebate programs (Texas 2005) including:

- Sales tax exemption – Texas (statewide)
- Property tax exemption – Hayes Co. TX (cost of system)
- Rebate on system cost – Austin, TX ($500), San Antonio, TX (50% of cost, limited total amount)

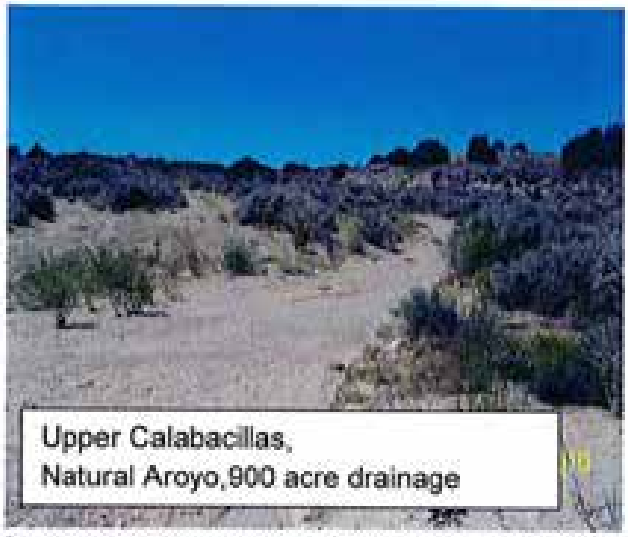
Crawl space or under deck rainwater pillow. kit (source www.aquabarrel.com)

Hundreds of rainwater resources are available including brochures, design data, guidance manuals, suppliers and contractors. For example, a web search for the specific phrase "rainwater harvesting in New Mexico" provided 636 results.

rainwater cistern at Columbia Credit Union in Vancouver (source technoccult.net)

This review demonstrates that rainwater harvesting has proven to be a viable method of drainage management for other agencies and communities. The example ordinances, guidance manuals and supplemental data gathered from this review form the basis of the proposed SSCAFCA rainwater harvesting program.

C. HYDROLOGY & EROSION INVESTIGATION



Upper Calabacillas,
Natural Aroyo,900 acre drainage

Can rainwater harvesting be used to effectively reduce runoff volume and arroyo erosion?

Rainwater Harvesting (RWH) is widely recognized as a water conservation and stormwater quality technique. For example, several RWH programs in New Mexico, Arizona and Texas focus on conserving potable water. The New Mexico State Engineer publication "ROOF RELIANT LANDSCAPING™, Rainwater Harvesting with Cistern Systems in New Mexico" (NMOSE, 2005) is an excellent example of a conservation focused program. Numerous RWH programs where rainfall is more frequent focus on stormwater runoff quality. For example, the "URBAN STORM DRAINAGE, Best Management Practices (UDFCD, 2010) is focused on reducing pollutant runoff. However, erosion control in sand bed arroyos is not a major component of these programs. Since erosion is a major SSCAFCA concern, a detailed investigation was conducted to determine the RWH impact on erosion. The "Hydrology and Erosion Analysis" with the analysis details is included in Appendix H.

Existing Condition, Barranca Arroyo

Arroyos developed from erosion long before the influence of man. However, human impacts accelerate the erosion and degradation of the arroyo system. The investigation found that more than 80% of the total arroyo erosion from developed property runoff is attributable to human

Black Arroyo South of Southern Blvd.
Developed Arroyo, 300 acre drainage

influences. If this erosion can be reduced with rainwater harvesting, safety will be improved and public costs for maintenance and emergency repairs can be better utilized for flood control.

The erosion volume, in addition to being closely tied to rainwater runoff volume, is a function of erosive factors such as soil type, slope, rainfall intensity, land uses, etc. This analysis is based on typical conditions in the semi-arid upland areas of the SSCAFCA jurisdiction which are very erosive. The results of an erosion analysis in other areas such as the valley or Albuquerque east mesa may be different.

A team consisting of representatives from SSCAFCA, Rio Rancho, WHPacific, Bohannan-Huston and Huitt-Zollars plus citizen input investigated the feasibility and practicality of using RWH to address erosion and other drainage issues. The analysis is based on typical 1/2 acre residential lots in a hypothetical 21-acre block with 40 lots. Hydrology, erosion, flood control, water conservation and stormwater quality impacts of RWH were investigated. The typical lot assumed for the analysis consists of 3,500 square feet of roof area and 2,380 SF of driveway, patio, etc. and the 15,900 SF remainder is a combination of landscaping and native vegetation. The roadway is considered to be paved with dirt bar ditches. Standard SSCAFCA analytical procedures were utilized. The results were compared to other studies and programs to verify reasonableness.

1. <u>Development Impact on Rainwater Runoff, Erosion and Frequency of Runoff Events:</u>

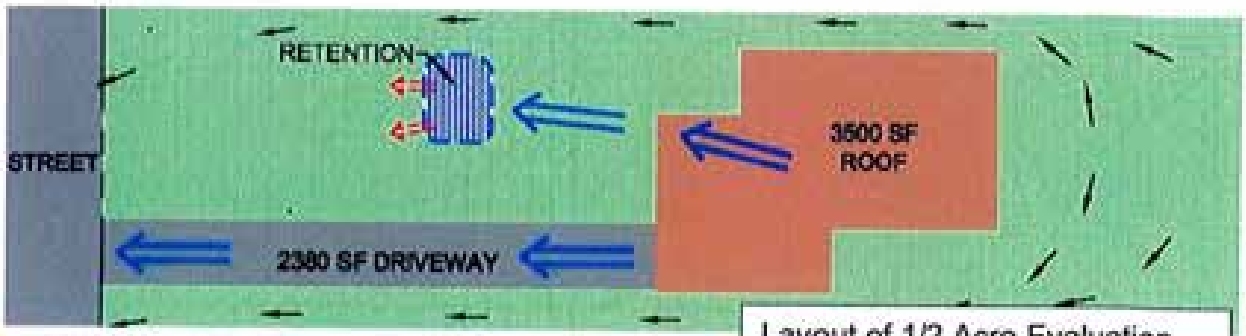
Three development conditions without RWH were considered to establish the current conditions without runoff source control:

- <u>Predevelopment</u> – Open space rangeland prior to the platting of Rio Rancho Estates. There is no impervious area in this model. This is the basis of comparison for determining the impact of development and to evaluate the effectiveness of RWH. Also, this is the condition used by the State Engineer to evaluate water rights and by EPA to evaluate water quality improvements.

- Existing – Rio Rancho Estates platted but vacant single family residential (SFR) platting with graded roads and human impacts. This model has 5% impervious area.
- Developed – All SFR lots are built-out. This is the "do nothing" hydrology model with 27% impervious area.

The impact of development is significant. The preceding photographs comparing the upper Calabacillas Arroyo with minimal human activity to the Black Arroyo with runoff from a developed area illustrate the on-going erosion issue due to upstream development. The investigation identified the following impacts due to SFR development:

- The annual stormwater runoff volume is about 7 times greater than the predevelopment volume.
- The annual erosion volume, the amount of soil material eroded from the roadside ditch in an average year, is about 8 times greater than the predevelopment erosion.
- The frequency of runoff events increases by a factor of 10, from one every two years to over 5 runoff events per year.
- Peak flood control flow based on 1% probability in any given year (100-year storm) doubles.



Layout of 1/2 Acre Evaluation Example

2. Rainwater Harvesting Evaluation:

Four Rainwater Harvesting scenarios were investigated.

- Scenario 'A'. Capture roof runoff only, retain and use on-site the initial 1" of runoff (2/3 gal/SF) (2,200 gallons for a 1/2 acre SFR lot). This is the recommended alternate as discussed in the following.
- Scenario 'B'. Capture roof runoff only, retain all runoff up to the 100-year event, 2.4" of runoff (1.5 gal/sf, 5,200 gallons for 1/2 acre SFR lot).
- Scenario 'C'. Capture runoff from all the impervious area (roof, driveway, patio, hardscape), retain and use on-site the initial 1" (2/3 gal/sf, 3,700 gallons for 1/2 acre SFR lot).

- Scenario 'D'. Capture runoff from all impervious area (roof, driveway, patio, hardscape), retain and use on-site all runoff up to the 100-year event, 2.4" (1.5 gal/sf, 8,800 gallons for 1/2 acre lot).

3. Rainwater Harvesting Investigation Results.

The results of this investigation are summarized on the two graphs on the following page and on the bar chart on Figure RWH1 at the end of the text. The general conclusions are:

- Collecting roof top runoff and using this rainwater on-site reduces the average annual stormwater runoff volume by about 50%.
- Collecting roof top runoff and using this rainwater on-site reduces the average annual erosion volume by about 30%.
- Retaining roof runoff volume up to the 100-year event (2.4") is only 10% more effective than retaining just the first 1" of runoff, even though the required storage volume increases by a factor of 2.4.
- Capturing all of the impervious area is about 30% more effective than capturing the roof runoff only.
- The average annual number of runoff events decreases from over 5 times per year for developed "do nothing" SFR development to about twice per year with RWH.
- Runoff volume, erosion volume and frequency of runoff events are greater than the predevelopment and the existing volumes and rates for all RWH scenarios.

a. Erosion

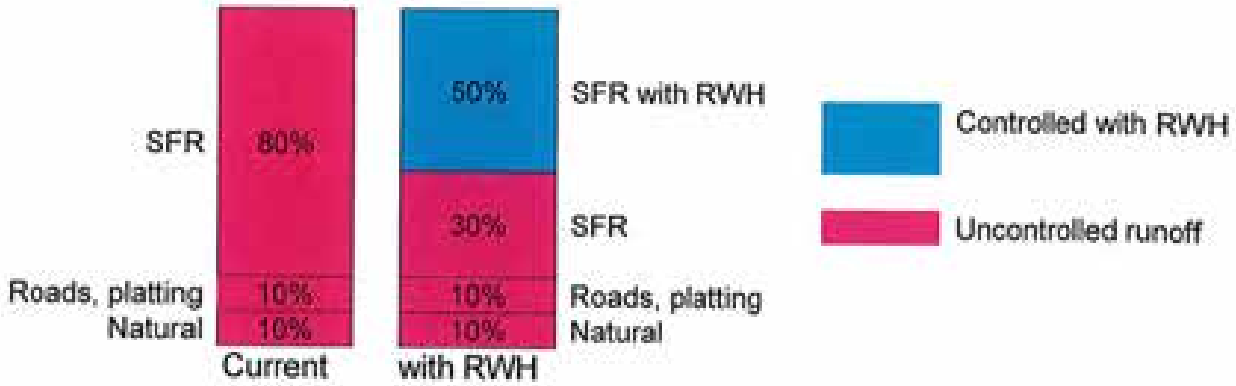
As shown in the graph below and on the bar chart on Figure RWH1 at the end of the text, the runoff from predevelopment conditions generates only about 10% as much erosion as fully developed SFR areas. The graded roads and increased human activity resulting from the platting of Rio Rancho Estates increases the erosion by about 15% of the total developed erosion with the remaining 75% of the erosion due to SFR development. The Rainwater Harvesting Program with roof top collection can reduce the average annual erosion by approximately 30%, but does not totally eliminate the impacts of SFR development. One result of the investigation is that the erosion computations are very sensitive to the assumptions used with results varying between 15% to over 50%. The 30% reduction is used as a nominal value for comparison purposes.

Details of the investigation were presented as a stand alone report included in Appendix H, Hydrology and Erosion Analysis.

Estimated Source Of Arroyo Erosion From Developed Runoff

b. Stormwater Runoff

The stormwater runoff volume follows a pattern similar to the erosion with about 20% of the total average annual runoff attributable to natural conditions and existing roads and vacant platting. The average annual runoff volume reduction with roof top rainwater harvesting is approximately 50% as illustrated on the following graph.



Estimated Source Of Stormwater Runoff Volume From Development

D. WATER CONSERVATION

1. References

Water conservation is the primary purpose of many of the rainwater harvesting programs in the southwest. Several good references for programs that focus on water conservation include:

- Roof-Reliant Landscaping™, Rainwater Harvesting with Cistern Systems in New Mexico prepared by the Office of the State Engineer (NMOSE, 2005),
- Santa Fe County Water Harvesting Guidelines (Santa Fe, 2003),
- The Texas Manual on Rainwater Harvesting (Texas, 2005).
- Stormwater as a Resource, Santa Fe, (Morgan and Trevathan),
- Sustainability Of Semi-Arid Hydrology And Riparian Habitat, (www.sahra.arizona.edu),
- Rainwater Harvesting, Supply from the Sky, City of Albuquerque (Albuquerque, 1995)
- Rainwater Harvesting: System Planning, Texas, New Mexico & Arizona (Texas A&M, 2010).
- Harvest the Rain, How to Enrich Your Life by Seeing Every Storm as a Resource (Downey, 2010)

These documents, as well as many more southwest based rainwater harvesting publications, are listed in the References Appendix in this report.

Many rainwater harvesting programs in more moderate or humid climates utilize rainwater harvesting primarily as a stormwater quality BMP. Examples include Denver, CO (UDFCD, 2010) and Maryland (Maryland, 2000).

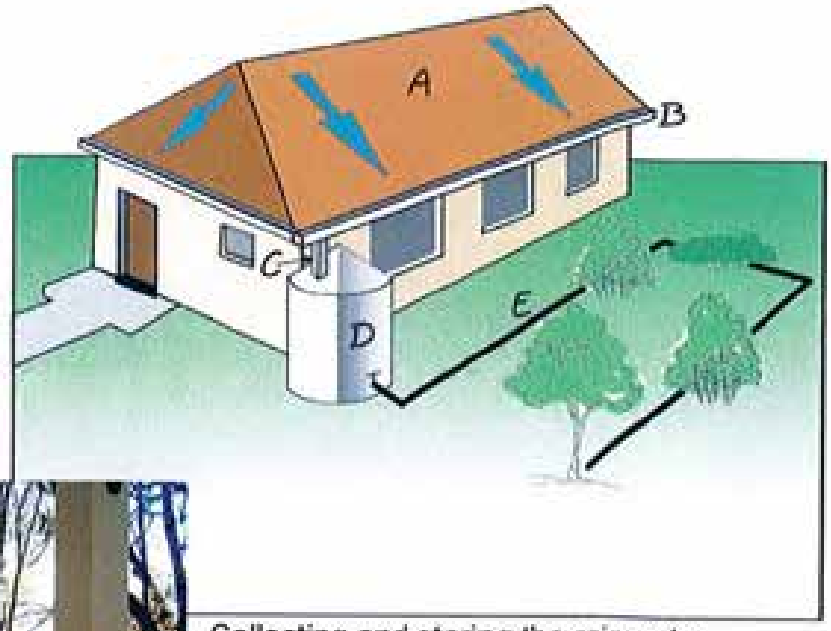
2. Passive and Active Systems.

Rainwater Harvesting can put rainwater to use on-site and therefore conserve potable and/or ground water in two fundamentally different ways, passive systems and active systems. Both are embraced by the proposed rainwater harvesting program.

a. Passive Rainwater Harvesting Systems.

Passive techniques are the use of on-site surface and shallow drainage features to catch or slow the runoff and allow the stormwater to soak into the soil for plant use or as infiltration. This is a common landscaping or permaculture technique using "micro catchment" basins, swales, tree wells, permeable pavement, infiltration basins, bio-retention and similar facilities (Downey, 2010). Permaculture, as defined in Wikipedia, is sustainable land use design based on ecological and biological principles, often using patterns that occur in nature to maximise effect and minimise work. Permaculture aims to create stable, productive systems that provide for human needs, harmoniously

integrating the land with its inhabitants. The ecological processes of plants, animals, their nutrient cycles, climatic factors and weather cycles are all part of the picture. Inhabitants' needs are provided for using proven technologies for food, energy, shelter and infrastructure. Elements in a system are viewed in relationship to other elements, where the outputs of one element become the inputs of another. Within a Permaculture system, work is minimised, "wastes" become resources, productivity and yields increase, and environments are restored. Permaculture principles can be applied to any environment, at any scale from dense urban settlements to individual homes, from farms to entire regions.



b. Active Rainwater Harvesting Systems.

Collecting and storing the rainwater in cisterns for future use is another method that potentially provides a more effective use of the rainfall over a longer period. This is a more structured approach and provides a more effective use of the rainwater (NMOSE 2005, Texas, 2005).

The Rainwater Harvesting Program promotes the collection of the rainwater and storing it for future use for irrigation. Three resources based on local conditions to evaluate the effectiveness of rainwater harvesting in reducing the use of potable water for irrigation are the City of Albuquerque Rainwater Harvesting, Supply from the Sky (COA, 1995), Roof-Reliant Landscaping™ (NMOSE, 2005) and an online calculator available from the Texas AgriLife Extension (Texas A&M, 2010).

3. Water Balance

Water balance is the concept of balancing supply with demand. The amount of rainwater available over a time period including rainfall and stored water is the supply. The demand is the irrigation required over that same period plus any leakage or losses. The difference is the amount of potable water needed. Typically, rainwater harvesting water balances are based on monthly averages. Also, the average rainfall amount is skewed in the southwest due to infrequent but large storms. For example, in Albuquerque, the average annual precipitation is about 8.6". So a single 2" storm has a major impact on the annual rainfall available for harvesting. A "normal" rainfall depth is used for the rainwater harvesting calculations. A depth of about 80% of the average amount is recommended, which for the SSCAFCA jurisdiction is assumed to be approximately 7.8" (NMOSE, 2005).

Two different models were used to estimate the amount of water that can be conserved using active rainwater harvesting techniques.

- Online Calculator (Texas A&M, 2010)
- Roof Reliant Landscaping (RRL) (NMOSE, 2005)

Several different examples, all based on a 1/2 acre SFR developed lot, were evaluated. The details of this investigation are included in the Appendix C, Conservation. The results are:

a. Online Calculator Methodology.

Sample water balance calculations were developed using the online calculator at http://rainwaterharvesting.tamu.edu/onlinecalculator/NM. This calculator was developed as part of a cooperative effort with NMSU, University of Arizona, Texas A&M and others. The following assumptions were used with the online calculator to provide a water balance estimate:

- Rainfall for a "normal" year of 7.8"
- Irrigation demand for two different types of plant communities;
  - Low Use – Blue Grama Grass, Desert Willow (native sand-scrub mesa habitat)
  - Medium – Buffalo Grass, Bermuda Grass
- Catchment runoff coefficient for roofs = 0.9 (90% of the rainfall runs off).
- 100% efficient irrigation system.
- No additional water allocated for first year plant establishment.
- The first year and second year cumulative storage and the supplemental water use required to balance demand are computed assuming the cistern is empty on January 1st of the first year.

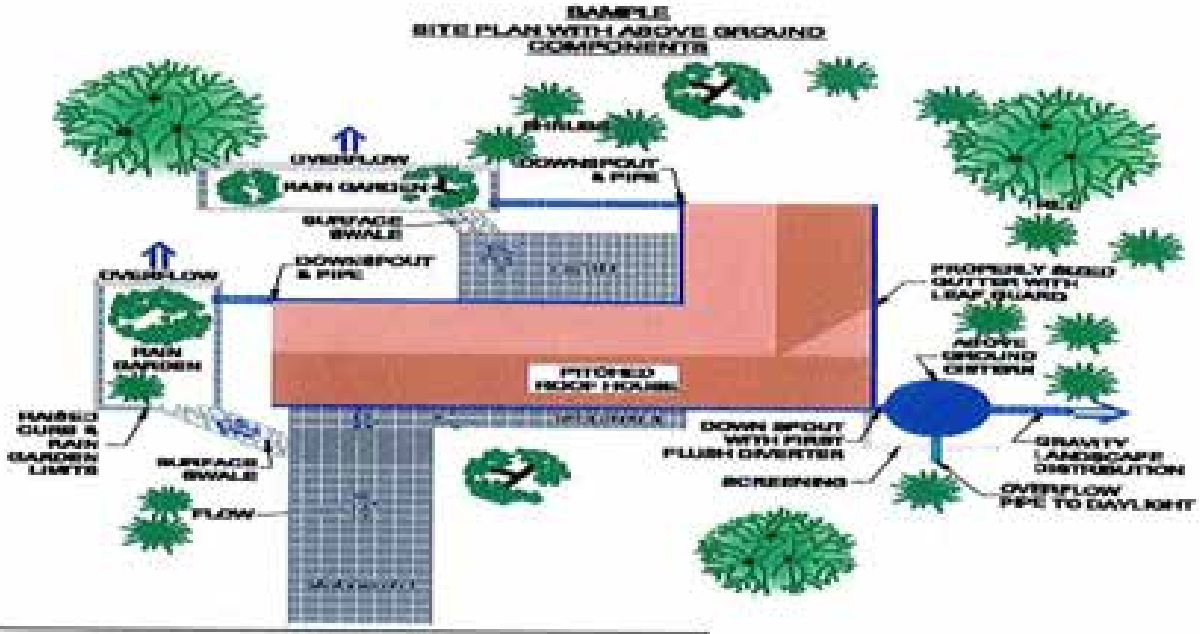
The following examples demonstrate the potential water conservation value of the Rainwater Harvesting program. The printouts from the online calculator are included in Appendix C, Conservation. Based on the assumptions above, the following combinations of roof area and landscape area can be maintained without supplemental watering:

- 2,500 SF roof area, 1,700 gallon cistern
  - low water use plantings, landscape area = 2,300 SF
  - medium water use plantings, landscape area = 900 SF
- 3,500 SF roof area, 2,200 gallon cistern (This is the baseline 1/2 acre SFR site)
  - Low water use plantings, landscape area = 3,100 SF
  - Medium water use plantings, landscape area = 1,200 SF

Based on these same assumptions and using the online calculator, the supplemental water demand for the same landscape area without RWH is:

Low water use plantings, 4.7 gallons/SF of landscape area
(14,720 gallons for 3,100 SF of landscape)

Medium water use plantings, 11.9 gallons/SF of landscape area
(14,280 gallons for 1,200 SF landscaping)



Sample Site Layout with a Combination of Cistern and Rain Garden Rainwater Harvesting

b. Roof Reliant Landscaping ™ Methodology

A water balance estimate was also made using the data provided in the State Engineer Roof Reliant Landscaping™ Manual (NMOSE, 2005). The spreadsheets for this analysis are in Appendix C, Conservation. Using the same assumptions listed above, the following combinations of roof area and landscape area are estimated without supplemental watering:

- 2,500 SF roof area, 1,700 gallon cistern
  - low water use plantings, landscape area = 1,750 SF
  - medium water use plantings, landscape area = 700 SF
- 3,500 SF roof area, 2,200 gallon cistern (This is the baseline 1/2 acre SFR site)
  - Low water use plantings, landscape area = 2,400 SF
  - Medium water use plantings, landscape area = 1,000 SF

Based on these same assumptions and using the RRL methodology, the supplemental water demand for the same landscape area without RWH is:

Low water use plantings, 5.8 gallons/SF of landscape area
(13,920 gallons for 2,400 SF of landscape)

Medium water use plantings, 14.38 gallons/SF of landscape area
(14,380 gallons for 1,000 SF landscaping)

Xeric Landscaping Plants

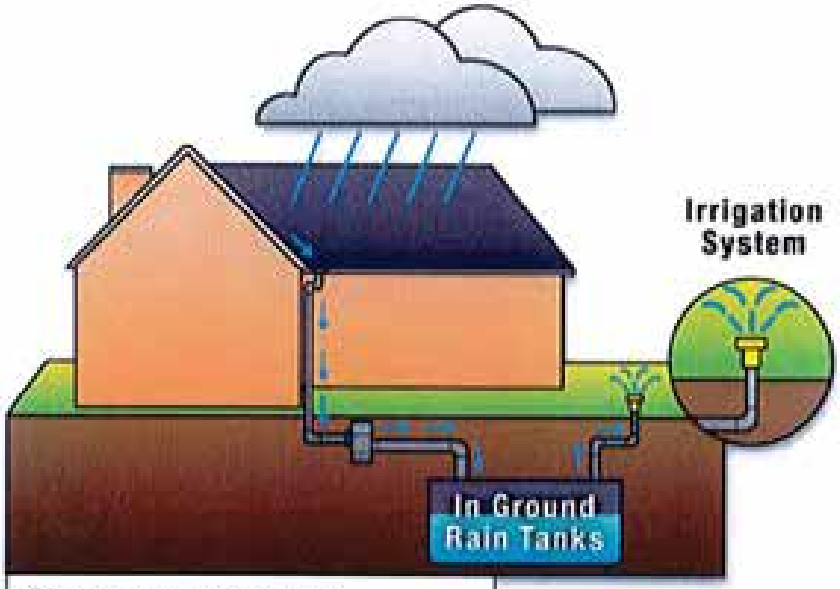
c. Potential Savings

Based on these estimates, rainwater harvesting can save approximately 14,000 gallons of irrigation water per year for a 3,500 square foot roof area. The Rio Rancho monthly potable water rates for a 5/8" meter are $7.35 base rate plus $3.00 water rights fee plus $3.39/1000gallon (www.ci.rio-rancho.nm.us). This is a potential savings to the homeowner of $47 per year. This is not considered adequate to pay for the rainwater harvesting system based on water use cost only.

d. Conservation Conclusions

The following conclusions are supported by this analysis:

- For the baseline 1/2 acre SFR site with 3,500 square feet of roof capture and a 2,200 gallon cistern, approximately 14,000 gallon per year of potable water can be conserved.
- Numerous combinations of catchment area, active rainwater harvesting cistern size and reasonable landscape area result in a break even water use without supplemental irrigation water for a typical rainfall year. Using the rule of thumb that 1/2 of the water use in suburban areas is for irrigation, rainwater harvesting could save about half of the potable water use and associated groundwater depletion.
- For the baseline 1/2 acre SFR site with 3,500 square feet of roof capture and 2,200 gallons of storage, a landscape area of about 3,000 square feet can be maintained with a break even water balance for the typical year. This is a plot of 40' by 70', or a little over 1/16 acre.
- Increasing the storage volume does not significantly decrease the demand for supplemental water for a given landscape area since the supply is fixed.
- Using medium water use plantings dramatically increases the water use, regardless of the storage volume.
- A break even water balance can be achieved even with medium water use plants by significantly reducing the landscape area.
- With a reduced impervious area representative of a smaller house, a reasonably sized landscape area can be supported at a break even water balance.



Simple Active System Schematic (source propertycreationsinc.com)

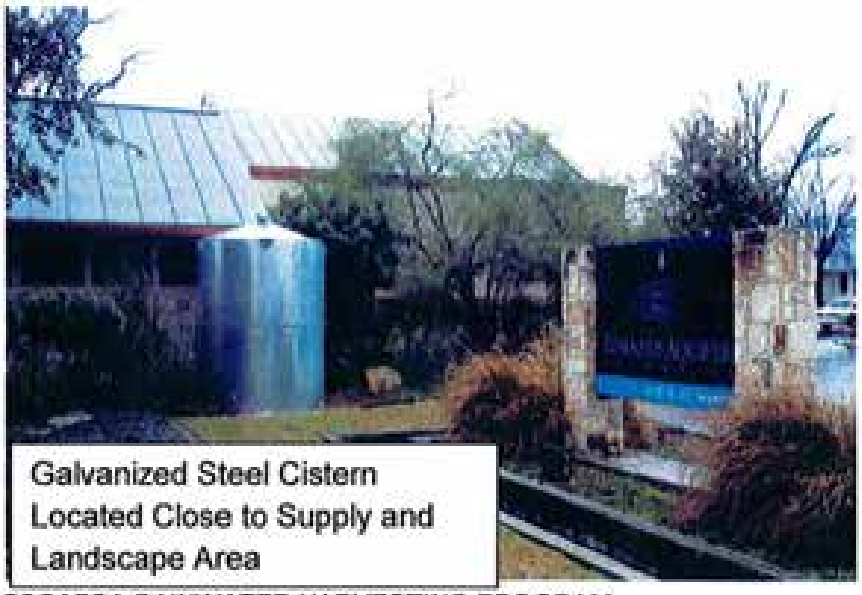
E. STORMWATER QUALITY

Essentially all of the SSCAFCA jurisdiction drains to the Rio Grande and pollutants that are picked up by stormwater runoff are discharged to the river. This area drains to the Rio Grande reach from the Alameda Bridge to the US 550 bridge. The designated use for this reach is Marginal Warmwater Aquatic Life and Secondary Contact. This reach does not meet minimum water quality standards for this use (NMENV, 2010). Probable Causes of Impairment are listed as E. coli, Dissolved Oxygen and PCBs in Fish Tissue. For the downstream reach from the Isleta Pueblo to the Alameda Bridge, the same impairments are listed with water temperature as an added pollutant.

Discharge of stormwater into the Rio Grande is permitted by the EPA National Pollutant Discharge Elimination System (NPDES) (a good source of general NPDES information is the EPA website http://cfpub1.epa.gov/npdes). SSCAFCA currently has a NPDES permit which is in the process of being updated (MS4, 2010). At the time of this report, a draft permit is being developed as a watershed based permit including all communities draining to the middle Rio Grande. Since the river does not meet water quality standards, the permit may require reduction of discharge of pollutants to the Rio Grande below current levels.

Reduction of pollutants can be accomplished by controlling the source of the pollution and by "end of pipe" or regional treatment facilities.

Due to the volume of stormwater runoff that comes all at once, the "end of pipe" treatment facilities are large and very expensive, although they can be combined with flood control facilities in some instances. Additionally, treatment of some pollutants, such as bacteria, are either infeasible or not prudent. Therefore, reduction of pollutants at the source is a practical method for improving stormwater quality and may be necessary for adequate pollutant control.



Galvanized Steel Cistern Located Close to Supply and Landscape Area

Pollution source control is accomplished by a combination of education, such as anti-litter and pet waste pickup programs and by on-site pollutant runoff reduction. The rainwater harvesting program retains the initial 1" portion of the roof runoff and thus eliminates the pollution from this stormwater source.

However, runoff from other impervious areas such as driveways, patios, landscape areas and roof runoff greater than 1" will continue to drain directly to downstream conveyance and carry pollutants to the Rio Grande.

1. Stormwater Quality Treatment Metrics

Several measures are used to design and evaluate water quality techniques. Stormwater quality source control metrics include stormwater quality treatment volume, the percent of rainfall treated, the percent of runoff events treated, etc. The criteria for water quality source control varies by community and by location. Comparison of the rainwater harvesting program with some of these criteria follows.

a. SSCAFCA Stormwater Quality Treatment Volume (SWQV)

The SSCAFCA DPM recommends that all development address stormwater quality, although single family residential (SFR) development is not required to include stormwater quality controls. The DPM defines the "stormwater quality storm event" as 0.6" of precipitation within a 6-hour period. The "stormwater quality treatment volume" for developments smaller than 40 acres is tabulated in the DPM as a percent of impervious area.

For a developed 1/2 acre SFR site, the DPM defines the impervious area as 27% and the resultant SWQV is 0.12". This equates to 218 cubic feet or 1631 gallons for a 1/2 acre SFR site. For the 1/2 acre example, the 27% impervious area is 5,880 SF and the roof area is assumed to be 3,500 SF. Rainwater harvesting captures all roof runoff up to 1", thus all of the roof runoff from the stormwater quality storm event of 0.6" will be captured and retained on-site. This is equivalent to 175 cubic feet. Thus capturing the roof runoff treats approximately 80% (175/218) of the SWQV as defined in the DPM. Capture of additional area would be required to meet the SWQV.

b. Average Annual Treatment Volume

Treatment of 80% of the runoff volume is a common stormwater quality treatment criteria (Maryland, 2000).

The Hydrology and Erosion Analysis (H&E Analysis, included in this report as Appendix H) identified that the rainwater harvesting program reduces the average annual runoff volume from 1.14" to 0.52" for the example 1/2 acre site. This reduction equates to a 45% stormwater quality treatment volume on an annual basis. Additional treatment, either on-site or in regional facilities would be required to meet the 80% requirement.

c. Draft Albuquerque MS4 NPDES Permit

The draft renewal permit for the Albuquerque MS4 Permit (MS4, 2010) includes requirements that may be similar to those incorporated into future SSCAFCA permits.

One requirement is for post-construction stormwater management to conform to the following criteria:

"The program shall address post-construction stormwater management and include the following elements in the Storm Water Management Plan and comply with the schedules contained in Table I.B:

iv. Implementation and enforcement, via ordinance and/or other enforceable mechanism(s), of site design standards that prevent an increase in the one-hundred-year (100-yr), two-hour (2-hr) peak runoff, a change in the time of the peak, or an increase in the total runoff from its pre-development values to ensure the hydrology associated with new development and redevelopment sites mimic the pre-development hydrology of the previously undeveloped site. Management of runoff volume may be achieved by canopy interception, soil amendments, rainfall harvesting, engineered infiltration, extended filtration, other appropriate techniques, and any combination of these practices. Pre-development runoff values may be achieved through on-site utilization of practices including dry swales, bioretention, rain tanks and cisterns, soil amendments, roof top disconnections, permeable pavement, porous concrete, permeable pavers, reforestation, grass channels, green roofs or other green infrastructure practices as appropriate."

The H&E Analysis used the 6-hour storm duration and the AHYMO program for the hydrology analysis. The 100-yr rainfall depth is 2.37" with approximately 80% of the rainfall occurring during the peak hour. The H&E analysis identified the following predevelopment and post-development rates and volumes for the 100-year, 6-hour storm event:

Condition	Peak Runoff Rate (cfs/ac)	Runoff Volume (inches)
Predevelopment	1.31 cfs/ac	0.66"
Developed	2.50 cfs/ac	1.23"
Rainwater Harvesting	2.27 cfs/ac	1.09"

With rainwater harvesting, the peak 100-year discharge rate and runoff volume are approximately 1.7 times the predevelopment rate and volume. The 100-year discharge rate and volume with rainwater harvesting are approximately 10% less than developed conditions without runoff control. Since the rainwater harvesting program focuses on reducing the annual volume rather than the runoff from infrequent large events, it is expected that the 100-year event with rainwater harvesting will not mimic predevelopment conditions. This is consistent with the condition that the rainwater harvesting program does not provide flood control.

Also, this points out that mimicking the single 100-year event could result in a program or system that would control the annual average runoff to less than the predevelopment condition.

d. Mimic Average Annual Predevelopment Conditions

Another measure of stormwater quality treatment is to conform to one of the Low Impact Development (LID) goals of mimicking predevelopment conditions (Guo, et al, 2010). For the 1/2 acre SFR example, the average annual runoff volume increases from 0.15" for predevelopment conditions to 1.15" for uncontrolled SFR runoff which is reduced to 0.52" with rainwater harvesting. Thus on an annual basis, the runoff volume with rainwater harvesting is approximately 3.5 times the predevelopment volume, although the runoff is reduced to about half of the developed "do-nothing" volume.

Debris Pollutant Collection, Bear Canyon Arroyo

e. Number of Runoff Events

Small frequent runoff events can contribute disproportionally to the total annual pollutant loading. One criteria using frequency as a measure is to treat 80% of the runoff events as defined in the "Effectiveness of Urban Stormwater BMPs in Semi-Arid Climates" (Urbonas, 2003).

> "Watershed-wide use of BMPs that significantly reduce runoff rates and control runoff volumes from the majority of most frequently occurring smaller storms (i.e., 80% of runoff events) can reduce the impact on receiving waters and their biota. Effective BMPs, in addition to controlling runoff volumes and rates of runoff, need to remove TSS particles less than 60 µm in size from stormwater runoff to the maximum extent practicable, should be integrated into the urban landscape to the maximum extent possible and be readily accessible and visible for maintenance."

For the average rainfall year, there are approximately 39 storms with rainfall greater than 0.05". The Hydrology and Erosion Analysis (Appendix H) identified that a developed 1/2 acre SFR site produces about 5 storms/year with runoff greater than 0.05". With rainwater harvesting, the storms with greater than 0.05" runoff are reduced to approximately 2 storms/year, or a treatment of 60% of the runoff events. Thus rainwater harvesting with rooftop collection provides significant reduction in the number of runoff events but does not satisfy the recommended 80% criteria.

Above Ground Cistern with Pump (source watertankspumpsandirrigation.com)

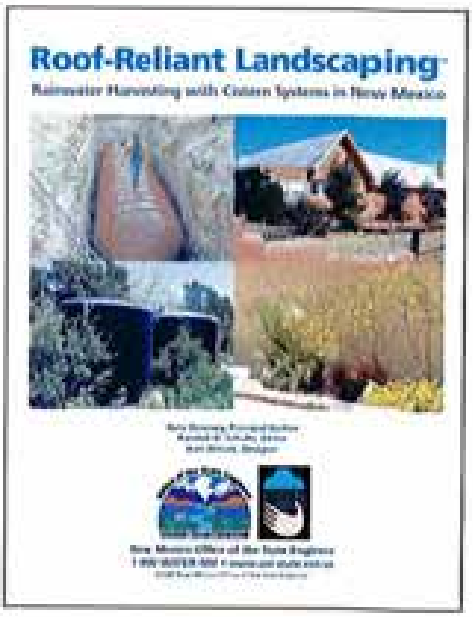
2. Stormwater Quality Conclusions

In conclusion, rainwater harvesting provides treatment of 50% to 60% of the stormwater volume and frequency and is a significant improvement over developed runoff without controls. However, rainwater harvesting with roof only collection does not meet generally accepted stormwater quality treatment goals. Increased impervious area collection, secondary landscape retention or infiltration, end-of-pipe facilities and regional stormwater flood control detention facilities all could provide additional stormwater quality treatment as elements of an integrated stormwater management program.

F. WATER RIGHTS

The use of rainwater and the possible impairment of the water rights of downstream users are of particular concern in the semi-arid southwest. The New Mexico Office of the State Engineer (NMOSE) has addressed the issues of water conservation and rainwater harvesting in the following policies.

The NMOSE official policy on rainwater harvesting is published in a NMOSE document titled "Water Conservation – Policy Development" and in the "Roof-Reliant Landscaping™" manual. These policies are reproduced below and are available from the NMOSE web site, www.ose.state.nm.us.



"NEW MEXICO OFFICE OF THE STATE ENGINEER
WATER USE AND COONSERVATION
Water Conservation - Policy Development
The New Mexico Office of the State Engineer encourages water conservation in all water use sectors through the educational efforts of its Water Conservation Program. The agency is also establishing water conservation policy guidelines for water rights applicants.
New Mexico law states that the state engineer must consider water conservation when reviewing an application for water rights. Water right permits that are issued include a water conservation condition stating that the permittee "shall utilize the highest and best technology available to ensure conservation of water to the maximum extent practical."
OSE policy on specific water conservation requirements for water right applicants is still evolving. However, there are several sources of OSE assistance to help water right applicants, and others as well, in preparing water conservation plans and programs.
A water conservation guide for industrial, commercial and institutional water users and a guide for municipal water suppliers prepared by OSE are available free of charge. Also available are draft guidelines on how to prepare a water conservation plan prepared specifically for municipal and industrial water right applicants.
To request these and other assistance documents, call 1-800-WATERNM or e-mail waternm@ose.state.nm.us. "

"NEW MEXICO OFFICE OF THE STATE ENGINEER
RAINWATER/SNOWMELT HARVESTING POLICY
The New Mexico Office of the State Engineer supports the wise and efficient use of the state's water resources; and, therefore, encourages the harvesting, collection and use of

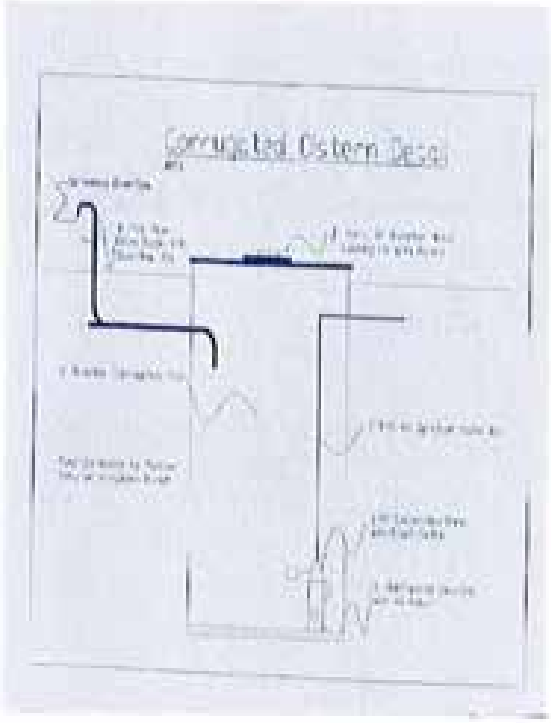
rainwater from residential and commercial roof surfaces for on-site landscape irrigation and other on-site domestic uses.
The collection of water harvested in this manner should not reduce the amount of runoff that would have occurred from the site in its natural, pre-development state. Harvested rainwater may not be appropriated for any other uses.
11/24/04, Source: www.ose.state.nm.us/wucp_policy.html"

The Rainwater Harvesting Program retains the initial 1" of the runoff volume from roof top areas on new SFR developments. The average annual predevelopment stormwater runoff is approximately 0.15". Stormwater runoff from a developed SFR site without control is approximately 1.14". With roof top harvesting, the average annual runoff is about 0.52" or approximately 3.5 times the runoff volume from predevelopment conditions. Thus, the Rainwater Harvesting Program with roof top capture and 1" retention satisfies the NMOSE Rainwater/Snowmelt Harvesting Policy.

G. NON-POTABLE WATER USE

Some programs allow or promote the treatment and use of collected rainwater for drinking and other potable water uses. These typically are areas without a ready source of water, such as island areas (Hawaii, 2010), or arid climates (Texas, 2005).

The collected rainwater for the SSCAFCA Rainwater Program is intended for non-drinking water uses only. Labeling of all spigots and other access locations to the collected rainwater would be required to be labeled appropriately. The use of the rainwater for irrigation and/or infiltration does not require treatment to drinking water standards.



Direct connection potable water supply systems to irrigation systems is common practice with backflow prevention devices required. Such connections may also be an integral component of some RWH systems, such as buried tanks and/or systems with pumps. Connections to the irrigation system from potable water supplies when the cistern is empty will require a means to prevent contamination of the drinking water supply, such as backflow preventers.

H. COST CONSIDERATIONS

1. Cost Data from Other Sources

Limited published data regarding system costs were found during the literature survey. The data that was recovered varies significantly based on type, size and complexity of the system. The data from these documents and the source of the data is included in Appendix E, Cost Data. In general, the result of reviewing the cost data sources are:

- Cistern tank costs range from $0.15/gal to over $2/gal. (Texas, 2005; rainwatertechnology.org; Hawaii, 2010; rainharvest.com).
  - Concrete and ferrocement tanks are the least expensive at $0.15/gal to $1.25/gal, may be constructed on site but are heavy to transport and place if precast.
  - Polyethylene and polypropylene tanks range from $0.35/gallon to $1.29/gallon, are very popular and are easy to transport and place. .
  - Galvanized steel tanks range from $0.50/gal to $1.61/gal and are frequently used for the larger sizes.
  - Wooden tanks are the most costly but may be incorporated into the site aesthetics easier than other tanks.
  - Above ground swimming pools are the least costly at approximately $0.20/gallon but are basically temporary storage and are not recommended.
  - Fiberglass tanks cost between $0.45/gal. to $2.00/gal. Minimal use is reported in the literature.
- Rain Garden costs, constructed as bioretention cells, range between $0.25/gal to over $1.00/gal (Maryland, 2000, Prince George's, 2007; UCR, 2006).
- Supplier data for package above ground cistern systems with pump and appurtenances range from $1.28/gal. to $1.71/gal. with an underground system cost of $2.10/gal. (Rainmaster 1700 IG, 2011; RMS, 2011)
- Minimal maintenance cost data was found in the literature. An annualized median maintenance cost of $9.00/household was estimated for "Water Sensitive Urban Design" in an Australian subdivision (WUSD, 2003).

2. Cost Estimates

a. Example Grading and Drainage Plans with Rainwater Harvesting Plans

Example site Grading and Drainage Plans and Rainwater Harvesting Plans were developed by Huitt-Zollars for a typical SFR lot in Rio Rancho conforming to current

criteria for Grade and Drain Plans and the proposed root-top rainwater harvesting plan. The examples included detailed site grading for several conditions to evaluate the impact of site constraints. These examples were for a typical 80' by 274' 1/2 acre lot. Note that these examples were developed to evaluate the feasibility of placing the rainwater harvesting facilities on the lot and may not satisfy future design standards to be defined in the Guidance Manual. Cost estimates were developed for each of these examples based on typical contractor prices. These examples are included in Appendix F, Grade and Drain Examples and are summarized below:

i. Example 1 – Site below roadway elevation with off-site flow through the back of the lot. Storm drain piping of roof runoff to a below ground 2,850 gallon corrugated metal cistern.
   Estimated cost - $16,460 = $5.78/gallon = $3.87/SF roof area
ii. Example 2 – Site below roadway elevation with no off-site discharge onto the site. Surface drainage with stabilized swales of roof runoff to an above ground rain garden with 2,850 gallon capacity at the back of the lot.
   Estimated cost - $4,216 = $1.48/gallon = $.99/SF roof area
iii. Example 3 – Site above roadway elevation with no off-site discharge onto the site. Surface drainage with stabilized swales of roof runoff to a below ground 2,850 gallon corrugated metal cistern.
   Estimated cost - $6,690 = $2.37/gallon=- $1.57/SF roof area
iv. Example 4 – Site below roadway elevation with off-site discharge through the back of the site. Storm drain piping of roof runoff to a below ground 3,370 gallon precast concrete cistern (septic tank).
   Estimated cost - $16,600 = $4.93/gallon = $3.30/SF roof area
v. Example 5 – Site below roadway elevation with no off-site discharge onto the site. Surface drainage with stabilized swales of roof runoff to an above ground rain garden with 3,370 gallon capacity at the back of the lot.
   Estimated cost - $5,020 = $1.49/gallon = $1.00/SF roof area
vi. Example 6 – Site above roadway elevation with no off-site discharge onto the site. Roof runoff drains directly to 5 above ground precast concrete cisterns with total capacity of 3,370 gallons, one at each downspout location.
   Estimated cost - $6,420 = $1.91/gallon = $1.28/SF Roof Area

b. <u>Generic System Cost Examples</u>

i. Above ground cistern - Above ground cistern with gravity or low head irrigation system.
   A simple above ground cistern storage with gravity irrigation following the guidelines in the Santa Fe County requirements (Santa Fe, 2003) and

NMOSE Roof-Reliant Landscaping™ (NMOSE, 2005) guidelines is estimated to cost approximately $2,200 ($0.92/gallon or $0.62/SF roof area) for a 3,500SF roof area. This system includes:

- two 1,200 gallon polyethylene or polypropylene ground mounted tanks with UV inhibitor to reduce algae growth and deterioration ($0.67/gal. median tank estimate = $1,600)
- two downspout first flush diverters and connections to reduce roof contaminants from entering the cistern ($400) and
- gravel mounting pads ($200).
- If a pump is added to boost the pressure for irrigation, an additional cost of $500 to $1,000 is estimated.

ii. Package systems - Supplier quotes were obtained for two package systems.

- 1,100 gallon cistern with garden hose pump for residential use, $1,411 + shipping @ $300 = $1,711 or $1.55/gallon or $1.04/SF.
- 2,500 gallon cistern with suction pump for residential or commercial uses, $4,287 + shipping @ $500 = $4,787 or $1.92/gallon or $1.28/SF.

Low Cost, Developing Country Basic System (www.rainwatertechnology.org)

Waterwall Fatboy™ 650 gal. Tank www.waterwalltanks.com, www.loomistank.com

iii. Simple Rain Garden(s)

Roof discharge to a rain garden comprised of typical vegetable and/or flower bed(s) can be connected to roof runoff by direct downspout discharge, by piping and/or by surface swales. A hardened boundary is proposed as a required component of rain gardens to define the retention volume area for maintenance and certification. The added cost above ordinary landscape cost is just the curb boundary and possibly an extension of the gutter downspout.

Rain Garden with Hardened Boundary

Underdrains and other typical bioretention cell components are not expected to be needed for this semi-arid climate for at-grade gardens. A concrete cutoff curb for two 1,100 gallon 10' x 30' x 6" gardens = 160' @ $20/ft = $3,200 = $1.45/gal = $0.98/SF of roof area ($3,430 for 3,500 SF roof). A maximum depth of 8" is proposed for the design criteria for safety and to allow infiltration/drainage before mosquitoes can breed.

A do-it-yourself system with cheaper edge material, such as railroad ties, could be much less expensive, depending on the price of materials.

iv. Underground Cistern with Pump Irrigation System

These systems consist of an underground cistern and associated pumping system for irrigation use. The advantages over an above ground system include the ability to use the surface for other uses, lack of UV deterioration considerations, lack of freeze/thaw issues and aesthetics. The primary disadvantage is cost. A package system including a 1,700 gallon cistern, pump, fittings, etc. is listed at $3,600. Installation would include shipping ($300), excavation and backfill ($400) and electrical and miscellaneous($500) for a total cost of about $4,800 or $2.82/gallon. This equates to $1.90/SF or $6,650 for the example 3,500 SF roof area.

v. Underground Modular Storage

Numerous manufacturers make plastic modular units for underground installation with high void ratios which stack to provide structural support. These can be designed to provide different loadings, up to highway truck loads and can be used under driveways and other surface uses. Impermeable plastic membranes are used to hold rainwater for pumping to an irrigation system. In lieu of using the rainwater for irrigation, a system using a permeable fabric can be designed to allow the collected water to infiltrate. A typical system includes excavation, membrane fabric, the modules, pumps, controls, backfill and surfacing. A typical cost for an installed system is in the range of $2.50/gallon ($1.68/SF) based on supplier estimated cost.

90,000 gallon modular underground cistern w/ roof runoff collection for irrigation use.

vi. Swimming Pool Cisterns

Rainwater harvesting cisterns using above ground plastic swimming pools have been used because of low costs. These are "backyard pools" available at discount stores and are about half as expensive as polyethylene or metal tanks, although they don't last nearly as long (Hawaii, 2010). When used for drinking water storage, they are covered to prevent mosquito problems and to avoid contamination. As long term storage for irrigation use, they would not require covering, but mosquito control as well as algae and other maintenance issues would need to be addressed. Due to these factors, use of above ground swimming pool cisterns is not recommended.

3. Maintenance Considerations

The rainwater harvesting system is comprised of three primary components that require maintenance:

a. Collection – This consists of the roof area, gutters, downspouts, and canales. Maintenance of these components is considered to be a routine homeowner maintenance activity and is not included as an additional cost for the rainwater harvesting program.
b. Landscape – These components are considered to be routine homeowner activities and are not included as an addition cost in the maintenance effort related to rainwater harvesting.
c. Rainwater harvesting elements - Components such as cisterns, piping, distribution swales, etc. will require on-going maintenance, depending on the complexity of the system.
   Also, the proposed program requires submittal and acceptance of a rainwater harvesting maintenance schedule and/or plan as part of the Rainwater Harvesting Plan.
   Some potential activities include:
   - Passive systems using rain gardens with foxes borders will require essentially no additional maintenance.
   - Active systems with above ground tanks, first flush diverters, leaf guards, vermin screens, etc. will require periodic cleaning and operational verification. Sediment may build up over time in cisterns and need to be removed, perhaps annually (e.g. similar to rain barrels). If this effort is assumed to require 6 hours per year, this is $300/yr at $50/hour.
   - For systems with pumps, with or without controls, the maintenance effort and cost will be greater than systems without pumps. If this effort is assumed to be 1 hours per month at $50/hr with a $200/yr sinking fund for equipment replacement based on a $1000 pump system with a 5 year life, this is approximately $800/year.

4. Cost Summary

Based on the data investigated, rainwater harvesting system costs are projected to vary from less than $1,000/SFR to about $7,000/SFR cost could be in excess of $10,000/SFR for extensive or complex systems. Maintenance varies from essentially no additional cost to over $800/year, again depending on the complexity of the system.

To obtain the most water conservation, an active system with a cistern is needed. Costs for cistern systems are in the range of $0.60/SF to $2/SF. Thus for a 2,000 square foot roof area, the cost could be $1,200 to $4,000. For the 3,500SF roof area example, the cost range would be $2,100 to $7,000.

V. BENEFITS AND ISSUES

RAINWATER HARVESTING ADDS COMMUNITY VALUE

Potential benefits and issues of implementing the recommended roof top rainwater harvesting program are summarized below:

- Water Conservation:

  Benefits. Up to 50% potable water savings potential. Sustainability is improved. For example, about 3,000 square feet of xeric waterwise landscaping can be irrigated with an active rainwater harvesting system in a normal 7.8" rainfall year with 3,500 square foot roof top collection and a 2,200 gallon cistern. By conserving water, it is anticipated that there will be less cost for public water rights.

  Issues. An active RWH system with cistern storage is required to maximize conservation. The potential reduction in the City water bill probably will not cover the cost of the system.
- Stormwater Quality:

  Benefits. There is limited runoff for rain events with less than 0.7", approximately 75% of all rainfall. This volume does not transport pollutants to the Rio Grande and partially satisfies one major NPDES Stormwater Discharge Permit component. Since very expensive "end-of-pipe" treatment facilities are reduced, this is a major long term cost savings.

  Issues. The runoff that does occur will still pick up pollutants and ultimately some treatment may be required, although at a reduced scale.
- Erosion:

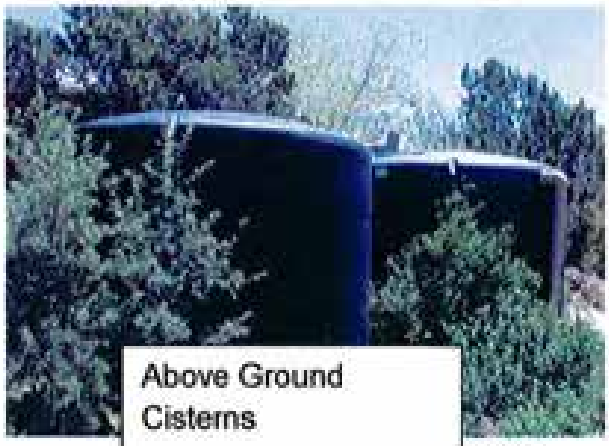
  Benefits. RWH reduces erosion from developed properties by about 30%.

  Issues. This is the long term average annual erosion, not erosion from one large infrequent event.
- Stormwater Runoff Volume:

  Benefits. Runoff volume is reduced by about 30%. While downstream conveyance arroyos and channels are designed to convey the peak flow rate, dams and detention ponds are sensitive to the volume passing through the facility. Decreased volume may decrease the size of detention facilities in some situations.

  Issues. None identified.
- Flood Control:

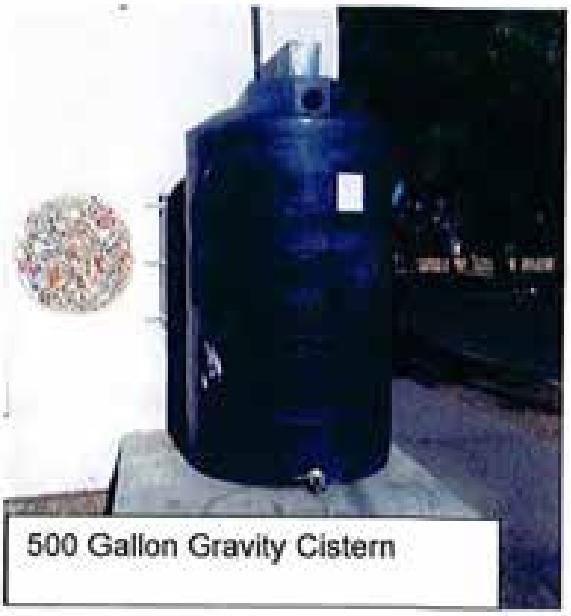
  Benefits. The 1% probability storm peak runoff rate (Q100) is reduced by about



Above Ground Cisterns

10%, if the retention facility is empty at the start of the storm.

Issues. Use of RWH for flood control is dependent on available retention volume at the time of the large event. Given that the intent is to use the rainwater for later use and the minimal impact, dependence on rainwater harvesting for flood control is not recommended.



500 Gallon Gravity Cistern

- Water Rights:

  Benefits. The State Engineer rainwater and snowmelt harvesting policy encourages the harvesting and collection and use of rainwater from residential and commercial roof surfaces for on-site landscape irrigation and other on-site domestic uses (Roof Reliant Landscaping™, www.ose.state.nm.us). The proposed program conforms to this policy. The average annual stormwater runoff with rainwater harvesting is approximately 3.5 times the predevelopment volume.

  The NMOSE Rainwater/Snowmelt Harvesting Policy is quoted below:

  > "STATE ENGINEER RAINWATER/SNOWMELT HARVESTING POLICY
  > The New Mexico Office of the State Engineer supports the wise and efficient use of the state's water resources and, therefore, encourages the harvesting, collection and use of rainwater from residential and commercial roof surfaces for on-site landscape irrigation and other on-site domestic uses.
  > The collection of water harvested in this manner should not reduce the amount of runoff that would have occurred from the site in its natural, pre-development state.
  > Harvested rainwater may not be appropriated for any other uses.
  > www.ose.state.nm.us "

  Issues. None identified.

- Costs:

  Benefits. Significant public funds are expended for emergency actions/repairs and maintenance due to erosion. RWH will reduce the need for these on-going expenses allowing better use of public funds for flood control and other drainage improvements.

  Issues. The estimated cost of a typical SFR rainwater harvesting system ranges from less than $1,000 to over $5,000. Typical costs for 3,500 SF roof area for the different types of systems are:

  Raingardens - $1,000
  Above ground cisterns – $3,500

Buried cisterns w/ pumps - $6,650

Investigation of a rebate program, perhaps based on reduction of the drainage impact fee, is recommended. Rebates are included in many other rainwater harvesting programs for conservation and for stormwater quality.

- Risk and Safety:

  Benefits. Public health, safety and welfare will be improved due to less frequent runoff events, less erosion and less pollution in the stormwater. Also, sustainability is improved reducing the long term impacts on water supplies.

  Issues. Major events with large flows will still present risk. Implementation of RWH methods will utilize standards developed in other programs in the southwest to ensure safety such as locking covers on cisterns, shallow rain gardens, mosquito control, etc.

- Quality of Life:

  Benefits. Less erosion = more habitat, more multiuse and improved sustainability. Everyone participates, fostering a sense of community and of being part of the solution by "doing the right thing".

  Issues. RWH will require on-site maintenance by the homeowner. Some may consider this to be a burden.

- Future Actions:

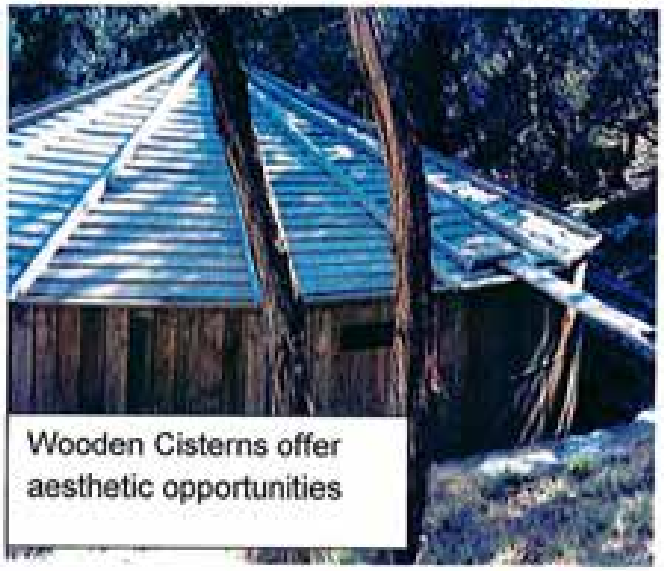
  Although the proposed RWH program reduces erosion, provides significant stormwater quality benefit and the opportunity for water conservation; erosion will continue to be an issue and further water quality and conservation improvements may be needed. Ideally, the developed runoff would mimic the predevelopment runoff in volume, frequency and rate. The RWH program does not meet this goal, even if expanded from roof only to all impervious area collection. A combination of implementation techniques will be required to mimic predevelopment hydrology.

  Future actions may include addressing roadways and streets, existing development, non-residential properties, platted but vacant SFR areas, etc.

VI. RECOMMENDED RAINWATER HARVESTING PROGRAM

The recommended rainwater harvesting program consists of the following:

- Joint Implementation of the roof-top rainwater harvesting plan by SSCAFCA, City of Rio Rancho, Sandoval Co., Town of Bernalillo and Village of Corrales.
- Develop agency agreements, policies, ordinances, procedures and administrative processes.
- Develop a "how to" Guidance Manual with safety criteria, design standards, guidelines, examples and references.
- Require all new single family residential (SFR) construction in previously platted areas in the SSCAFCA jurisdiction to incorporate the rainwater harvesting program. SFR is the primary source of uncontrolled increased stormwater runoff volume and erosion. To meet conservation, erosion and stormwater quality objectives, the program would be mandatory for all new SFR.
- Develop a voluntary program for existing development. Promote volunteer rainwater harvesting on existing SFR by providing technical assistance, pilot projects, examples, standards, education, etc.
- Investigate a cost share or rebate program. Costs estimates range from less than $1,000 to over $5,000 for a typical 3,500 SF roof area SFR site. Consider a rebate program, maybe in conjunction with drainage impact fees.
- Capture rainwater runoff from all roof areas. Capturing the roof area conforms to the State Engineer rainwater harvesting policy, is easy to do and maintain, is cost effective and has an immediate impact.
- Retain and use on-site the initial 2/3 gallon per square foot (equivalent to 1" of runoff) of roof area runoff. Increasing the storage volume to include all runoff, regardless of the size of the storm, requires a 240% cistern increase, but is only 20% more effective in reducing the average annual runoff.



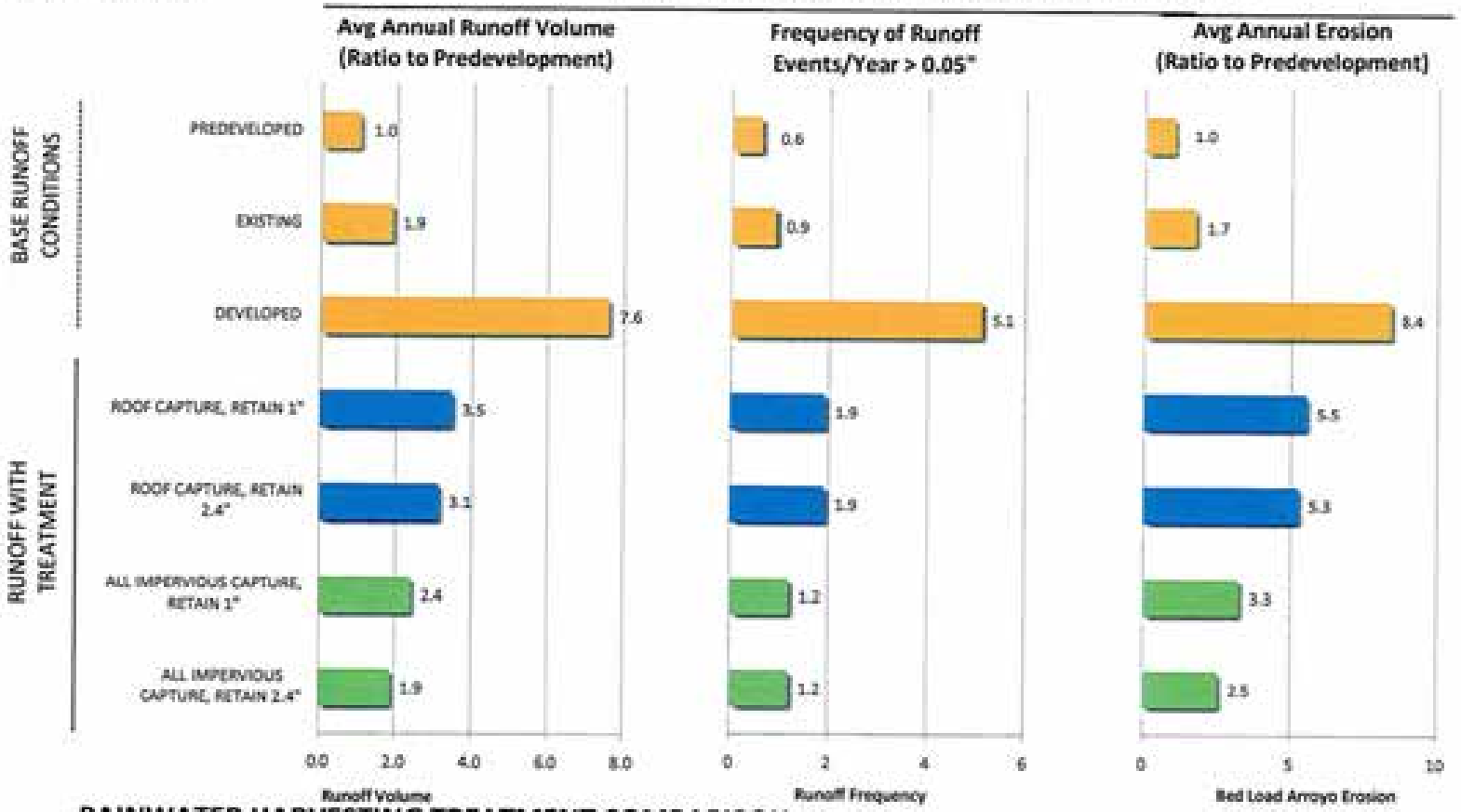
Wooden Cisterns offer aesthetic opportunities

- Provide retention facilities with verifiable capacity such as cisterns, rain gardens with fixed boundaries, engineered infiltration beds, etc.
- Flood control is not recommended. If the cistern is empty, the peak flow rate is reduced by about 10%. Cisterns, infiltration facilities, rain gardens, etc. cannot be assured of being empty at the time of the severe storm event. In fact, if conservation is to be attained some stormwater in storage is likely. For example, for the baseline model for a normal rainfall year (7.8"), the cistern would be about 20% full in July & August. In wet years, probably more.
- Administration of the program includes:
  - A Grade & Drain Plan incorporating the Rainwater Harvesting Plan and a maintenance schedule for all new SFR.
  - Engineer or landscape architect certification that construction conforms to the Rainwater Harvesting Plan.
  - To maintain the effectiveness of the RWH program, an annual mail-out for homeowner certification that the rainwater harvesting system has been inspected and maintained and is operating as originally designed.
  - Occasional verification inspections accomplished by the appropriate agency (i.e. SSCAFCA, City, etc.).

Future implementation would consider roads and streets, planned communities and non-residential development.

FIGURE RWH 1

RUNOFF, FREQUENCY AND SEDIMENT VOLUME



RAINWATER HARVESTING TREATMENT COMPARISON

APPENDIX A

GLOSSARY

RAINWATER HARVESTING

Sustainable Drainage Management for SSCAFCA,
Sandoval County, City of Rio Rancho, Town of Bernalillo
and Village of Corrales

GLOSSARY

NOTE. The following definitions have been developed specifically for use with this report and are not intended to be generalized to other uses

BEST MANAGEMENT PRACTICE (BMP): A technique, process, activity, or structure used to reduce pollutant discharges in stormwater. BMPs include source control practices (non-structural BMPs) and engineered structures designed to treat runoff.

BIORETENTION: A method of stormwater quality treatment that relies on soils and vegetation for reduction of the quantity (volume) of stormwater runoff and removal/retention of stormwater pollutants. Bioretention facilities reduce runoff volume discharged downstream by infiltration and evapotranspiration. Bioretention facilities may be designed for infiltration to subsoils or with underdrains, depending on site-specific conditions. Pollutant removal processes include filtration, biological uptake, sorption and sedimentation (in the temporary surface pool during an event). Bioretention facilities are also known as rain gardens and porous landscape detention.

CANOPY INTERCEPTION: The interception of precipitation, by leaves and branches of trees and vegetation that does not reach the soil.

CISTERN. A water tank used to store harvested stormwater

CWA: Clean Water Act (formerly referred to as the Federal Water Pollution Control Act or Federal Water Pollution Control Act Amendments of 1972) Pub L. 92-500, as amended Pub. L. 95-217, Pub L. 95-576, Pub. L. 96-483 and Pub. L. 97-117, 33 U.S.C. 1251 et.seq.

DIRECTLY CONNECTED IMPERVIOUS AREA (DCIA): The portion of impervious area with a direct hydraulic connection to the municipal separate storm sewer system or a waterbody via continuous paved surfaces, gutters, pipes, and other impervious features Direct connected impervious area typically does not include isolated impervious areas with an indirect hydraulic connection to the municipal separate storm sewer system (e.g. swale or detention basin) or that otherwise drain to a pervious area.

DISTRIBUTED CONTROLS: Use of multiple BMPs distributed throughout a development site to control and treat stormwater close to it source, as opposed to

routing flows to a larger, centralized stormwater facility. Use of distributed stormwater controls is key component of Low Impact Development.

ENGINEERED INFILTRATION: An underground device or system designed to accept stormwater and slowly exfiltrates it into the underlying soil. This device or system is designed based on soil tests that define the exfiltration rate.

EVAPOTRANSPIRATION: The sum of evaporation and transpiration of water from the earth's surface to the atmosphere. It includes evaporation of liquid or solid water plus the transpiration of plants.

EXTENDED FILTRATION: A structural stormwater practice which filters stormwater runoff through vegetation and engineered soil media. A portion of the stormwater runoff drains into an underdrain system which slowly releases it after the storm is over.

GREEN INFRASTRUCTURE: An array of products, technologies, and practices that use natural systems – or engineered systems that mimic natural processes – to enhance overall environmental quality and provide utility services. As a general principal, Green Infrastructure techniques use soils and vegetation to infiltrate, evapotranspirate, and/or recycle stormwater runoff. When used as components of a stormwater management system, Green Infrastructure practices such as green roofs, porous pavement, rain gardens, and vegetated swales can produce a variety of environmental benefits. In addition to effectively retaining and infiltrating rainfall, these technologies can simultaneously help filter air pollutants, reduce energy demands, mitigate urban heat islands, and sequester carbon while also providing communities with aesthetic and natural resource benefits.

GREEN ROOF: An engineered vegetated roof that can be used to retain and/or detain and treat precipitation. Green roofs require an engineered structure that can support soils, vegetation and loads associated with rainfall, stored water, snow, people and equipment. Key components include a waterproof membrane, root barrier, drainage layer, soil/growing medium, irrigation system and plants.

HYDROMODIFICATION: The alteration of the natural flow of water through a landscape, and often takes the form of channel straightening, widening, deepening, or relocating existing, natural stream channels. It also can involve excavation of borrow pits or canals, building of levees, streambank erosion, or other conditions or practices that change the depth, width or location of waterways. Hydromodification usually results in water quality and habitat impacts.

ILLICIT DISCHARGE: Any discharge to a municipal separate storm sewer that is not composed entirely of stormwater except discharges pursuant to a NPDES permit (other than the NPDES permit for discharges from the municipal separate storm sewer) and discharges resulting from fire fighting activities.

APPENDIX B

REFERENCES

RAINWATER HARVESTING

Sustainable Drainage Management for SSCAFCA, Sandoval County, City of Rio Rancho, Town of Bernalillo and Village of Corrales

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IMPERVIOUS DISCONNECTION. Runoff from impervious surfaces is prevented from discharging to and is not hydraulically connected to off-site locations. In these guidelines, impervious disconnection is the same thing as rainwater harvesting.

IMPERVIOUS SURFACE. The portion of a parcel that has a covering which does not permit or severely restricts water to percolate into the natural soil. Impervious surface includes, but is not be limited to, buildings, roofs, all driveways and parking areas (whether paved or not), dense graded gravel material, sidewalks, patios, tennis and basketball courts, covered and uncovered decks, porches, patio blocks, paver bricks, hard landscape materials (hardscape) and other structures where the majority of water runs off the surface rather than being absorbed into natural soils underneath. Surfaces that are specifically designed, constructed and maintained to percolate or infiltrate water into the natural soils underneath are not considered impervious surfaces.

INFILTRATION. Movement of water from the surface to below ground through soil pore spaces.

LOW IMPACT DEVELOPMENT (LID): LID is an overall land planning and engineering design approach to managing stormwater runoff. LID emphasizes conservation and use of on-site natural features to protect water quality. This approach implements engineered small-scale hydrologic controls to mimic the pre-development hydrologic regime of watersheds through infiltrating, filtering, storing, evaporating, and detaining runoff close to its source. The term Green Infrastructure (GI) may also be used.

MICROBASIN. A small relatively shallow basin used to capture, store and utilize stormwater.

MICROCLIMATE. Localized conditions of moisture, sun, wind, etc.

MUNICIPAL SEPARATE STORM SEWER SYSTEM (MS4): A publicly owned conveyance or system of conveyances that discharges to waters of the U.S. and is designed or used for collecting or conveying stormwater, is not a combined sewer, and is not part of a publicly owned treatment works (POTW). All separate storm sewers that are defined as "large" or "medium" or "small" municipal separate storm sewer systems pursuant to paragraphs 40 CFR §122.26(b)(4), (b)(7), and (b)(16), or designated under paragraph 40 CFR §122.26(a)(1)(v).

MS4 PERMIT: A state or federal stormwater discharge permit to regulate discharges from municipal separate storm sewers (MS4s) for compliance with Clean Water Act regulations.

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES): The national program under Section 402 of the Clean Water Act for regulation of discharges of pollutants from point sources to waters of the U.S.

NON-POINT SOURCE (NPS) POLLUTION: Pollution that occurs when rainwater, snowmelt, or irrigation transports pollutants from diffuse sources across land surfaces into waterbodies. Nonpoint source pollution is contrasted with point source pollution in that it is not discharged from single discharge points such as wastewater treatment plants.

OVERFLOW DEVICE. Component of a water harvesting structure that allows excess stormwater to flow out of the structure without damaging the structure.

RAINWATER. Liquid precipitation falling from the sky before it has hit a solid surface.

RAINWATER HARVESTING. The collection, conveyance, and storage of rainwater. The scope, method, technologies, system complexity, purpose, and end uses vary from rain barrels for garden irrigation in urban areas, to large-scale collection of rainwater for all domestic uses.

REVISED UNIVERSAL SOIL LOSS EQUATION (RUSLE): An erosion prediction method originally developed for agricultural land use that can also be used for estimating erosion potential on construction sites and adjusting BMPs to reduce the estimated erosion. Factors included in this equation include rainfall-runoff erosivity, soil erodibility, slope length and steepness, surface cover management, and erosion control practice implementation.

SOIL AMENDMENT: Adding components to in-situ or native soils to increase the spacing between soil particles so that the soil can absorb and hold more moisture. The amendment of soils changes various other physical, chemical and biological characteristics so that the soils become more effective in maintaining water quality.

SOURCE CONTROLS: A variety of practices implemented to minimize runoff by controlling stormwater where it originates and/or accumulates

STORMWATER. Rainwater becomes stormwater once it has landed on a surface.

SWALE. A curvilinear depression in the land surface that collects, stores and utilizes stormwater.

TOTAL MAXIMUM DAILY LOAD (TMDL): A calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. A TMDL is the sum of individual wasteload allocations for point sources (WLA), load allocations for non-point sources and natural background (LA), and must consider seasonal variation and include a margin of safety. The TMDL comes in the form of a technical document or plan.

UDFCD: Urban Drainage and Flood Control District. (Denver and Colorado vicinity)

WATER QUALITY CAPTURE VOLUME (WQCV, as defined by UDCFD): The quantity of stormwater runoff that must be treated in stormwater quality BMPs. This volume is equivalent to the runoff from an 80th percentile storm, meaning that 80 percent of the most frequently occurring storms are fully captured and treated and larger events are partially treated.

WATERSHED. a term commonly used to describe a catchment area within which all stormwater drains toward a common collection point.

WETLANDS: Those areas that are inundated or saturated by surface or ground water at a frequency and duration to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

XERISCAPE. Landscaping that saves water by using water conserving designs, drought tolerant plants, native plants, water harvesting techniques, reduced turf areas, appropriate irrigation methods, soil improvements and mulching, and proper maintenance practices.

303(D) LIST: Section 303(d) of federal Clean Water Act requires states to list those waterbodies that are not attaining water quality standards, including designated uses, and identify relative priorities among the impaired waterbodies. Once a stream is listed on the state 303(d) list, a Total Maximum Daily Load (TMDL) is typically required to assign allowable pollutant loads to various sources to enable the waterbody to attain designated uses in the future.

404 PERMIT: A federal discharge permit authorized under Section 404 of the Clean Water Act, which regulates the discharge of dredged, excavated, or fill material into wetlands, streams, rivers, and other Waters of the U.S. The U.S. Army Corps of Engineers is the federal agency authorized to issue Section 404 Permits for certain activities conducted in wetlands or other U.S. waters. When working in or around waterways or wetlands, 404 Permits are often required.

APPENDIX C

CONSERVATION

RAINWATER HARVESTING
APPENDIX C
WATER CONSERVATION

An estimate of the amount of potable water that could be saved with the Rainwater Harvesting Program was investigated.

1. References

Water conservation is the primary purpose of many of the rainwater harvesting programs in the southwest. Several good references for programs that focus on water conservation include:

- Roof-Reliant Landscaping™, Rainwater Harvesting with Cistern Systems in New Mexico prepared by the Office of the State Engineer (NMOSE, 2005),
- Santa Fe County Water Harvesting Guidelines (Santa Fe, 2003),
- The Texas Manual on Rainwater Harvesting (Texas, 2005).
- Stormwater as a Resource, Santa Fe, (Morgan and Trevathan),
- Sustainability Of Semi-Arid Hydrology And Riparian Habitat, (www.sahra.arizona.edu),
- Rainwater Harvesting, Supply from the Sky, City of Albuquerque (Albuquerque, 1995)
- Rainwater Harvesting: System Planning, Texas, New Mexico & Arizona (Texas A&M, 2010).
- Harvest the Rain, How to Enrich Your Life by Seeing Every Storm as a Resource (Downey, 2010)

These documents, as well as many more southwest based rainwater harvesting publications, are listed in the References Appendix.

2. Passive and Active Systems.

Rainwater Harvesting can put rainwater to use on-site and therefore conserve potable and/or ground water in two fundamentally different ways, passive systems and active systems. Both are embraced by the proposed rainwater harvesting program.

1. Passive Rainwater Harvesting Systems.

Passive techniques are the use of on-site surface and shallow drainage features to catch or slow the runoff and allow the stormwater to soak into the soil for plant use or as infiltration. This is a common landscaping or permaculture technique using "micro catchment" basins, swales, tree wells, permeable pavement, infiltration basins, bioretention and similar facilities (Downey, 2010).Permaculture, as defined in

Wikipedia, is: "Permaculture is sustainable land use design. This is based on ecological and biological principles, often using patterns that occur in nature to maximise effect and minimise work. Permaculture aims to create stable, productive systems that provide for human needs, harmoniously integrating the land with its inhabitants. The ecological processes of plants, animals, their nutrient cycles, climatic factors and weather cycles are all part of the picture. Inhabitants' needs are provided for using proven technologies for food, energy, shelter and infrastructure. Elements in a system are viewed in relationship to other elements, where the outputs of one element become the inputs of another. Within a Permaculture system, work is minimised, "wastes" become resources, productivity and yields increase, and environments are restored. Permaculture principles can be applied to any environment, at any scale from dense urban settlements to individual homes, from farms to entire regions."

2. Active Rainwater Harvesting Systems.

Collecting and storing the rainwater in cisterns for future use is another method that potentially provides a more effective use of the rainfall over a longer period. This is a more structured approach and provides a more effective use of the rainwater (NMOSE 2005, Texas, 2005).

The Rainwater Harvesting Program promotes the collection of the rainwater and storing it for future use for irrigation. Two resources based on local conditions were used to evaluate the effectiveness of rainwater harvesting in reducing the use of potable water for irrigation. These are Roof-Reliant Landscaping™ (NMOSE, 2005) and an online calculator available from the Texas AgriLife Extension (Texas A&M, 2010).

3. Water Balance

Water balance is the concept of balancing supply with demand. The amount of rainwater available over a time period including rainfall and stored water is the supply. The demand is the irrigation required over that same period plus any leakage or losses. The difference is the amount of potable water needed. Typically, rainwater harvesting water balances are based on monthly averages. Also, the average rainfall amount is skewed in the southwest due to infrequent but large storms. For example, in Albuquerque, the average annual precipitation is about 8.6". So a single 2" storm has a major impact on the annual rainfall available for harvesting. A "normal" rainfall depth is used for the rainwater harvesting calculations. A depth of about 80% of the average amount is recommended, which for the SSCAFCA jurisdiction is approximately 7.8" (NMOSE, 2005).

Two different models were used to estimate the amount of water that can be conserved using active rainwater harvesting techniques.

- Online Calculator (Texas A&M, 2010)
- Roof Reliant Landscaping (RRL) (NMOSE, 2005)

The following examples based on a 1/2 acre SFR developed lot are included in this evaluation to determine water balance and potential supplemental water use:

a. Online Calculator. Sample water balance calculations were developed using the online calculator at http://rainwaterharvesting.tamu.edu/onlinecalculator/NM. This calculator was developed as part of a cooperative effort with NMSU, University of Arizona, Texas A&M and others.

   A. Roof top collection (3,500 square feet), 2,200 gallon (1") cistern, 5,000 SF landscape, low water use plantings.
   B. Roof top collection (3,500 square feet), 5,200 gallon (2.4") cistern, 5,000 square foot irrigated area, low water use plantings.
   C. Baseline model. All impervious collection (5,880 square feet), 3,700 gallon cistern (1"), 5,000 square foot irrigated area, low water use plantings
   D. All impervious collection (5,880 square feet), 8,800 gallon cistern (2.4"), 5,000 square foot irrigated area, low water use plantings
   E. All impervious collection (5,880 square feet), 8,800 gallon cistern (2.4"), 6,000 square foot irrigated area, low water use plantings to determine the increase in irrigation area for the larger cistern.
   F. All impervious collection (5,880 square feet), 3,700 gallon cistern (1"), 2,100 square foot irrigated area, medium water use plantings to investigate the impact of medium water use plants.
   G. All impervious collection (5,880 square feet), 3,700 gallon cistern (1"), 1,400 square foot irrigated area, high water use plantings to investigate the impact of high water use.
   H. Small house model, 2,000 square foot impervious collection, 1,250 gallon cistern (1"), 1,800 square foot irrigated area, low water use plantings to investigate the impact of smaller footprint.
   I. All impervious collection (5,880 square feet), 3,700 gallon cistern (1"), 5,000 square foot irrigated area, medium water use plantings.
   J. All impervious collection (5,880 square feet), 3,700 gallon cistern (1"), 5,000 square foot irrigated area, high water use plantings
   K. Roof top collection (3,500 square feet), 2,200 gallon cistern (1"), 3,100 square foot irrigated area, low water use plantings.
   L. Roof top collection (3,500 square feet), 2,200 gallon cistern (1"), 2,300 square foot irrigated area, medium water use plantings.

The online calculator provides a water balance calculation using the following assumptions:

- Monthly City of Albuquerque rainfall data for a "normal" year of 7.8"
- Irrigation demand for three different types of plant communities,
  - Low Use – Blue Grama, Desert Willow (native sand-scrub mesa-habitat)
  - Medium – Buffalo Grass, Bermuda Grass
  - High – St. Augustine, Fescue
- Catchment runoff coefficient for roof = 0.9, (90% of the rainfall runs off)
- 100% efficient irrigation system.
- No additional water allocated for plant establishment
- The first year and second year cumulative storage and the supplemental water use required to balance demand are computed assuming the cistern is empty on January of the first year.
- Catchment area, storage volume and landscape area are variables

Using this calculator, the following examples demonstrate the potential conservation value of the Rainwater Harvesting program.

WATER CONSERVATION EXAMPLES
Online Calculator

Example	A Roof @ 1".	B. Roof @ 2.4"	C. All, 1'	D. All, 2.4'
Variable				
Catchment	3,500 sf	3,500	5,880	5,880
Water Use Plant Type	Low – Blue Grama, Desert Willow	Low – Blue Grama, Desert Willow	Low – Blue Grama, Desert Willow	Low – Blue Grama, Desert Willow
Available Storage	2,200 gallons	5,200 gallons	3,700 gallons	8,800 gallons
Landscape Area (sf)	5,000 sf	5,000 sf	5,000 sf	5,000 sf
Rainfall	7.8 inches	7.8 inches	7.8 inches	7.8 inches
Supplemental Water Yr. 1	7,800 gallons	7,800 gallons	427 gallons	427 gallons
Supplemental Water Yr. 2	6,740 gallons	6,740 gallons	-0- gallons	0- gallons

	E Alt @ 2.4	F. All @ 1"	G All. 1"	H. Small, 1"
Catchment	5,880 sf	5,880 sf	5,880 sf	2,300 sf
Water Use Plant Type	Low – Blue Grama, Desert Willow	Med Buffalo & Bermuda Grass	High - St Augustine, Fescue	Low – Blue Grama, Desert Willow
Available Storage	8,800 gallons	3,700 gallons	3,700 gallons	1,250 gallons (1")
Landscape Area (sf)	6,000 sf	2 100 sf	1,400 sf	1 800 sf
Rainfall	7.8 inches	7 8 inches	7.8 inches	7.8 inches
Supplemental Water Yr. 1	3,335 gallons	1154 gallons	1154 gallons	370 gallons
Supplemental Water Yr. 2	320 gallons	-0- gallons	-0- gallons	-0- gallons

	I All @ 1",	J. All @ 1"	K Roof @ 1".	L Roof @ 1".
Catchment	5,880 sf	5,880 sf	3,500 sf	3,500 sf
Water Use Plant Type	Med – Buffalo & Bermuda Grass	High – St Augustine, Fescue	Low – Blue Grama, Desert Willow	Med – Blue Grama, Desert Willow
Available Storage	3,700 gallons	3,700 gallons	2,200 gallons	2,200 gallons
Landscape Area (sf)	5,000 sf	5,000 sf	3,100 sf	2,300 sf
Rainfall	7.8 inches	7.8 inches	7.8 inches	7.8 inches
Supplemental Water Yr 1	31,820 gallons	61,000 gallons	500 gallons	605 gallons
Supplemental Water Yr 2	30,790 gallons	60,500 gallons	-0- gallons	0- gallons

b. Roof Reliant Landscaping™ (RRL).
Sample water balance calculations were developed using the data and methodology in the Roof Reliant Landscaping manual prepared by the NM Office of the State Engineer.

Z Roof top collection (3,500 square feet), 2,200 gallon (1") cistern, 2,400 SF landscape, low water use plantings.
Y All impervious collection (5,880 square feet), 3,700 gallon (1") cistern, 5,000 square foot irrigated area, low water use plantings.
X All impervious collection (5,880 square feet), 8,800 gallon cistern (2.4"), 5,000 square foot irrigated area, low water use plantings
W Small house model, 2,000 square foot impervious collection, 1,250 gallon cistern (1"), 1,400 square foot irrigated area, low water use plantings
V Small house model, 2,000 square foot impervious collection, 1,250 gallon cistern (1"), 550 square foot irrigated area, medium water use plantings.
U Roof top collection (3,500 square feet), 5,200 gallon cistern (2.4"), 2,650 square foot irrigated area, low water use plantings.
T Roof top collection (3,500 square feet), 2,200 gallon cistern (1"), 375 square foot irrigated area, high water use plantings.
S Roof top collection (3,500 square feet), 2,200 gallon cistern (1"), 950 square foot irrigated area, medium water use plantings
R Roof top collection (3,500 square feet), no cistern, 2,400 square foot irrigated area, low water use plantings.

The RRL method to estimate the water balance uses the following assumptions:

- Monthly City of Albuquerque rainfall data for a "normal" year of 7.83 "
- Irrigation demand for three different types of plant communities;
  - Low Use – Blue Grama, Desert Willow (native sand-scrub mesa-habitat)
  - Medium – Buffalo Grass, Bermuda Grass
  - High – St. Augustine, Fescue
- Catchment runoff coefficient for roof = 0.9, (90% of the rainfall runs off).
- 100% efficient irrigation system.
- No additional water allocated for plant establishment.
- The first year and second year cumulative storage and the supplemental water use required to balance demand are computed assuming the cistern is empty on January of the first year.
- Catchment area, storage volume and landscape area are variables

Using this calculator, the following examples demonstrate the potential conservation value of the Rainwater Harvesting program.

WATER CONSERVATION EXAMPLES

Roof-Reliant Landscaping Methodology

Example Variable	Z Roof @ [illegible]	Y All @ 1"	X All 2.4"
Catchment	3,500 sf	5880	5,880
Water Use Plant Type	Low – Zone 1	Low – Zone 1	Low – Zone 1
Available Storage	2,200 gallons	3,700 gallons	5,200 gallons
Landscape Area (sf)	2,400 sf	5,000 sf	5,000 sf
Rainfall	7.8 inches	7.8 inches	7.8 inches
Supplemental Water Yr 1	986 gallons	5,961 gallons	5,961 gallons
Supplemental Water Yr 2	27 gallons	3,984 gallons	3,221 gallons

Example	W Small @ 1'	V. Small @ 1'	U Roof, 2.4'
Variable			
Catchment	2,000 sf	2,000sf	3,500
Water Use Plant Type	Low – Zone 3	Med – Zone 2	Low – Zone 1
Available Storage	1,250 gallons	1250 gallons	5,200 gallons
Landscape Area (sf)	1,400 sf	550 sf	2650 sf
Rainfall	7.8 inches	7.8 inches	7.8 inches
Supplemental Water Yr 1	665 gallons	577 gallons	1,875gallons
Supplemental Water Yr 2	113 gallons	-0- gallons	22 gallons

Example	T Roof @ 1",	S Roof @ 1"	R Roof, No Cistern
Variable			
Catchment	3,500 sf	3,500 sf	3,500 sf
Water Use Plant Type	High – Zone 3	Med – Zone 2	Low – Zone 1
Available Storage	2,200 gallons	2200 gallons	-0- gallons
Landscape Area (sf)	375 sf	950 sf	2,400 sf
Rainfall	7.8 inches	7.8 inches	7.8 inches
Supplemental Water Yr 1	849 gallons	812 gallons	2,230 gallons
Supplemental Water Yr 2	-0- gallons	-0-	2,230 gallons

4. Conclusions.

The following conclusions are supported by this analysis:

- Numerous combinations of catchment area and reasonable landscape area result in a break even water use without supplemental irrigation water for the typical rainfall year (Examples C, D, E, F, G and H). Using the rule of thumb that 1/2 of the water use in suburban areas is for irrigation, rainwater harvesting could save about half of the potable water use.
- For the baseline 1/2 acre SFR site with 5,880 square foot of impervious capture and 3,700 gallons of storage, a landscape area of 5,000 square feet can be maintained with a break even water balance for the typical year (Example C). This is a plot of 70' by 70' or about 1/8 acre.
- Increasing the storage volume does not decrease the demand for supplemental water for a given landscape area (Examples A to B and C to D)
- Increasing storage from 3,700 gallons to 8,800 gallons allows only an increase of 1000 sf of landscape area to achieve a break even water balance (Example D to E).
- Using medium water use plantings or high water use plants dramatically increases the water use, regardless of the storage volume (Examples I and J).
- break even water balance can be achieved even with medium and high water use plants by reducing the landscape area (Examples F and G).
- With a reduced impervious area representative of a smaller house, a reasonably sized landscape area can be supported at a break even water balance (Example H).

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[illegible] RAINWATER HARVESTING WATER CONSERVATION [illegible]
WATER BALANCE USING [illegible] LANDSCAPING DATA (NORMAL RAINFALL)

			EXAMPLE A: Small [illegible]					EXAMPLE B: Small w/ mod. landscape					EXAMPLE C: [illegible]				
Irrigated [illegible] Area SF			2000					2000					3500				
[illegible]			.9					0.9					.75				
Cistern Capacity (gallons)			1150					1250					5000				
Landscape Area (SF)			1400					550					2592				
Landscape Tree gal [illegible]			5.30					14.35					3.51				
MONTH	Normal Rainfall	Irrigation Requirement	Total Normal Rainfall (gallons)	Irrigation Demand (gal)	Water Surplus	Cistern Storage (gallons)	Supplemental Water (gal)	Total Normal Rainfall (gallons)	Irrigation Demand (gal)	Water Surplus	Cistern Storage (gallons)	Supplemental Water (gal)	Total Normal Rainfall (gallons)	Irrigation Demand (gal)	Water Surplus	Cistern Storage (gallons)	Supplemental Water (gal)
January	2.33	22	598	31	267	267	0	549	78	190	259	0	509	152	451	451	0
February	2.47	74	545	117	428	455	0	475	133	442	461	0	557	150	750	756	0
March	2.41	75	552	136	599	619	0	550	278	721	711	0	312	502	1244	1246	0
April	1.54	125	535	519	649	645	0	519	577	679	679	0	743	1114	979	976	0
May	1.57	201	422	463	241	241	0	512	951	299	296	0	1071	1855	122	121	0
June	1.6	302	477	1189	445	5	445	671	1525	150	0	150	1275	1971	1277	0	1272
July	2.53	352	1010	1512	420	7	230	1110	1647	177	0	177	2257	2902	607	0	155
August	1.4	321	1571	1173	155	156	0	1571	1997	154	216	0	2245	2490	144	145	0
September	2.85	154	958	744	256	255	0	754	918	273	270	0	1519	1722	19	19	0
October	.51	133	654	516	151	154	0	654	527	451	411	0	1254	1025	212	212	0
November	2.56	45	741	198	851	857	0	741	192	921	951	0	1270	174	1129	1125	0
December	2.42	29	525	97	1250	1251	0	516	94	1192	1259	0	501	163	1341	1345	0
Total	7.51	2021	8,785	8,134			655	8,785	7,903			522	15,174	15,221			1,815
January	2.33	22	545	61	1259	1257	0	545	78	1156	1259	0	506	153	2300	2309	0
February	2.17	56	525	117	1249	1252	0	422	171	1250	1250	0	555	75	2019	2019	0
March	2.40	56	552	176	1252	1252	0	550	178	1150	1170	0	312	502	1554	1501	0
April	1.54	125	539	585	1220	1277	0	519	577	1214	1216	0	742	1114	1879	2519	0
May	2.53	152	512	580	712	592	0	512	951	825	819	0	1071	1515	1975	1745	0
June	2.1	307	622	1189	324	326	0	671	1525	157	167	0	1275	1557	961	743	0
July	2.12	352	1512	1511	411	5	111	1110	1645	10	10	0	2257	1922	22	0	22
August	1.4	321	1571	1175	155	155	0	1571	1957	148	144	0	2745	2421	146	145	0
September	2.85	276	948	544	225	226	0	954	916	180	210	0	1545	1701	20	20	0
October	2.53	130	683	516	154	754	0	666	527	441	441	0	1158	1013	211	222	0
November	2.36	44	741	198	891	857	0	741	192	992	992	0	1276	174	1121	1130	0
December	2.43	24	521	97	2496	1250	0	516	94	1157	1250	0	501	151	1252	1663	0
Total	7.51	2021	8,785	8,134			113	8,785	7,905			[illegible]	15,174	15,221			25

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
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A

Albuquerque, New Mexico

User Defined Site Information			
Square Footage of Catchment Area	=	Input Value =>	3500
Coefficient for Catchment Surface	=	Roof	0.90
Plant Water Use Coefficient	=	Low (Blue Grama/Desert Will	0.2
Available Storage	=	Input Value =>	2200
Square Footage of Landscape	=	Input Value =>	5000

Albuquerque, New Mexico

Storage/Supplement Water Use (gallons)

Month	Yield	Demand	Cumulative Storage	Supplemental Water Use
Year 1				
January	765	237	529	0
February	785	399	915	0
March	942	897	960	0
April	981	1,719	221	0
May	1,197	2,853	0	1,435
June	1,276	3,969	0	2,693
July	2,571	4,467	0	1,896
August	2,983	4,006	0	1,023
September	2,002	2,754	0	752
October	1,590	1,570	20	0
November	942	579	382	0
December	962	287	1,057	0
Year 2				
January	765	237	1,586	0
February	785	399	1,972	0
March	942	897	2,017	0
April	981	1,719	1,279	0
May	1,197	2,853	0	378
June	1,276	3,969	0	2,693
July	2,571	4,467	0	1,896
August	2,983	4,006	0	1,023
September	2,002	2,754	0	752
October	1,590	1,570	20	0
November	942	579	382	0
December	962	287	1,057	0

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B

Albuquerque, New Mexico

User Defined Site Information			
Square Footage of Catchment Area	=	Input Value =>	3500
Coefficient for Catchment Surface	=	Roof	0.90
Plant Water Use Coefficient	=	Low (Blue Grama/Desert Will	0.2
Available Storage	=	Input Value =>	5200
Square Footage of Landscape	=	Input Value =>	5000

Albuquerque, New Mexico

Storage/Supplement Water Use (gallons)

Month	Yield	Demand	Cumulative Storage	Supplemental Water Use
Year 1				
January	765	237	529	0
February	785	399	915	0
March	942	897	960	0
April	981	1,719	221	0
May	1,197	2,853	0	1,435
June	1,276	3,969	0	2,693
July	2,571	4,467	0	1,896
August	2,983	4,006	0	1,023
September	2,002	2,754	0	752
October	1,590	1,570	20	0
November	942	579	382	0
December	962	287	1,057	0
Year 2				
January	765	237	1,585	0
February	785	399	1,972	0
March	942	897	2,017	0
April	981	1,719	1,279	0
May	1,197	2,853	0	378
June	1,276	3,969	0	2,693
July	2,571	4,467	0	1,896
August	2,983	4,006	0	1,023
September	2,002	2,754	0	752
October	1,590	1,570	20	0
November	942	579	382	0
December	962	287	1,057	0

7799

6742

C

Albuquerque, New Mexico

User Defined Site Information			
Square Footage of Catchment Area	*	Input Value	5500
Coefficient for Catchment Surface		0.95	0.95
Plant Water Use Coefficient	*	[illegible]	0.2
Available Storage	*	Input Value	2700
Square Footage of Landscape	*	Input Value	5000

Albuquerque, New Mexico				
Storage/Supplement Water Use (gallons)				
Month	Yield	Demand	Cumulative Storage	Supplemental Water Use
Year 1				
January	1,455	231	1,012	0
February	1,351	299	1,924	0
March	1,501	831	2,594	0
April	1,672	4,219	2,047	0
May	1,984	2,852	1,179	0
June	2,114	3,969	0	220
July	4,960	4,467	0	207
August	4,982	4,006	976	0
September	3,017	2,754	1,239	0
October	2,634	3,110	2,763	0
November	1,581	579	3,765	0
December	1,584	291	5,058	0
Year 2				
January	1,268	231	3,095	0
February	[illegible]	299	3,095	0
March	1,501	831	3,765	0
April	1,672	[illegible]	1,457	0
May	1,984	2,852	3,757	0
June	2,114	3,969	882	0
July	4,960	4,467	576	0
August	4,982	4,006	[illegible]	0
September	3,017	2,754	2,305	0
October	2,634	[illegible]	3,240	0
November	1,581	579	3,797	0
December	1,584	291	5,090	0

Albuquerque, New Mexico

User Defined Site Information			
Square Footage of Catchment Area	*	[illegible]	5800
Coefficient for Catchment Surface	*	Roof	0.95
Plant Water Use Coefficient	*	[illegible]	[illegible]
Available Storage	*	[illegible]	8500
Square Footage of Landscape	*	[illegible]	5000

Albuquerque, New Mexico

Storage/Supplement Water Use (gallons)

Month	Supply	Demand	Cumulative Storage	Supplemental Water Use
Year 1				
January	[illegible]	[illegible]	[illegible]	0
February	[illegible]	395	[illegible]	0
March	[illegible]	831	[illegible]	0
April	[illegible]	[illegible]	[illegible]	0
May	[illegible]	[illegible]	[illegible]	0
June	[illegible]	[illegible]	0	220
July	[illegible]	[illegible]	0	[illegible]
August	[illegible]	[illegible]	957	0
September	[illegible]	[illegible]	[illegible]	0
October	[illegible]	[illegible]	[illegible]	0
November	[illegible]	[illegible]	[illegible]	0
December	[illegible]	267	[illegible]	0
Year 2				
January	[illegible]	337	[illegible]	0
February	[illegible]	395	[illegible]	0
March	[illegible]	831	[illegible]	0
April	[illegible]	[illegible]	[illegible]	0
May	[illegible]	[illegible]	[illegible]	0
June	[illegible]	[illegible]	[illegible]	0
July	[illegible]	[illegible]	[illegible]	0
August	[illegible]	[illegible]	[illegible]	0
September	[illegible]	[illegible]	[illegible]	0
October	[illegible]	[illegible]	[illegible]	0
November	[illegible]	[illegible]	[illegible]	0
December	[illegible]	[illegible]	[illegible]	0

E

Albuquerque, New Mexico

User Defined Site Information			
Square Footage of Catchment Area	=	Input Value =>	5800
Coefficient for Catchment Surface	=	Roof	0.90
Plant Water Use Coefficient	=	Low (Blue Grama/Desert Will	0.2
Available Storage	=	Input Value =>	6500
Square Footage of Landscape	=	Input Value =>	6000

Albuquerque, New Mexico				
Storage/Supplement Water Use (gallons)				
Month	*Yield*	*Demand*	*Cumulative Storage*	*Supplemental Water Use*
Year 1				
January	1,268	284	984	0
February	1,301	478	1,807	0
March	1,561	1,077	2,291	0
April	1,626	2,063	1,854	0
May	1,984	3,424	413	0
June	2,114	4,762	0	2,235
July	4,260	5,360	0	1,100
August	4,943	4,807	136	0
September	3,317	3,304	149	0
October	2,634	1,884	899	0
November	1,561	695	1,765	0
December	1,594	344	3,014	0
Year 2				
January	1,268	284	3,999	0
February	1,301	478	4,821	0
March	1,561	1,077	5,305	0
April	1,626	2,063	4,868	0
May	1,984	3,424	3,428	0
June	2,114	4,762	779	0
July	4,260	5,360	0	321
August	4,943	4,807	136	0
September	3,317	3,304	149	0
October	2,634	1,884	899	0
November	1,561	695	1,765	0
December	1,594	344	3,014	0

F

Albuquerque, New Mexico

User Defined Site Information			
Square Footage of Catchment Area	=	Input Value =>	5800
Coefficient for Catchment Surface	=	Roof	0.90
Plant Water Use Coefficient	=	Medium (Buffalograss/Bermu	0.5
Available Storage	=	Input Value =>	3700
Square Footage of Landscape	=	Input Value =>	2100

Albuquerque, New Mexico				
Storage/Supplement Water Use (gallons)				
Month	*Yield*	*Demand*	*Cumulative Storage*	*Supplemental Water Use*
Year 1				
January	1,268	249	1,020	0
February	1,301	419	1,902	0
March	1,561	942	2,521	0
April	1,626	1,805	2,341	0
May	1,984	2,996	1,329	0
June	2,114	4,167	0	724
July	4,260	4,690	0	430
August	4,943	4,206	737	0
September	3,317	2,891	1,163	0
October	2,634	1,648	2,148	0
November	1,561	608	3,101	0
December	1,594	301	3,700	0
Year 2				
January	1,268	249	3,700	0
February	1,301	419	3,700	0
March	1,561	942	3,700	0
April	1,626	1,805	3,521	0
May	1,984	2,996	2,509	0
June	2,114	4,167	455	0
July	4,260	4,690	25	0
August	4,943	4,206	762	0
September	3,317	2,891	1,188	0
October	2,634	1,648	2,174	0
November	1,561	608	3,126	0
December	1,594	301	3,700	0

G

Albuquerque, New Mexico

User Defined Site Information			
Square Footage of Catchment Area	-	[illegible]	[illegible]
Coefficient for Catchment Surface	-	[illegible]	0.90
Plant Water Use Coefficient		[illegible]	0.75
Available Storage		[illegible]	[illegible]
Square Footage of Landscape	-	[illegible]	[illegible]

Albuquerque, New Mexico

Storage/Supplemental Water Use (gallons)

Month	Total	Demand	Cumulative Storage	Supplemental Water Use
Year 1				
January	[illegible]	[illegible]	[illegible]	0
February	[illegible]	[illegible]	[illegible]	0
March	[illegible]	[illegible]	[illegible]	0
April	[illegible]	[illegible]	[illegible]	0
May	[illegible]	[illegible]	[illegible]	0
June	[illegible]	[illegible]	0	[illegible]
July	[illegible]	[illegible]	0	[illegible]
August	[illegible]	[illegible]	717	0
September	[illegible]	[illegible]	[illegible]	0
October	[illegible]	[illegible]	[illegible]	0
November	[illegible]	[illegible]	[illegible]	0
December	[illegible]	[illegible]	[illegible]	0
Year 2				
January	[illegible]	[illegible]	[illegible]	0
February	[illegible]	[illegible]	[illegible]	0
March	[illegible]	[illegible]	[illegible]	0
April	[illegible]	[illegible]	[illegible]	0
May	[illegible]	[illegible]	[illegible]	0
June	[illegible]	[illegible]	[illegible]	0
July	[illegible]	[illegible]	[illegible]	0
August	[illegible]	[illegible]	[illegible]	0
September	[illegible]	[illegible]	[illegible]	0
October	[illegible]	[illegible]	[illegible]	0
November	[illegible]	[illegible]	[illegible]	0
December	[illegible]	[illegible]	[illegible]	0

H

Albuquerque, New Mexico

User Defined Site Information			
Square Footage of Catchment Area	=	Input Value =>	2000
Coefficient for Catchment Surface	=	Roof	0.90
Plant Water Use Coefficient	=	Low (Blue Grama/Desert Wil	0.2
Available Storage	=	Input Value =>	1250
Square Footage of Landscape	=	Input Value =>	1800

Albuquerque, New Mexico				
Storage/Supplement Water Use (gallons)				
Month	*Yield*	*Demand*	*Cumulative Storage*	*Supplemental Water Use*
Year 1				
January	437	85	352	0
February	449	144	657	0
March	538	323	872	0
April	561	619	814	0
May	684	1,027	471	0
June	729	1,429	0	229
July	1,469	1,608	0	139
August	1,705	1,442	262	0
September	1,144	991	415	0
October	908	565	758	0
November	538	209	1,088	0
December	549	103	1,250	0
Year 2				
January	437	85	1,250	0
February	449	144	1,250	0
March	538	323	1,250	0
April	561	619	1,192	0
May	684	1,027	849	0
June	729	1,429	149	0
July	1,469	1,608	10	0
August	1,705	1,442	272	0
September	1,144	991	425	0
October	908	565	768	0
November	538	209	1,097	0
December	549	103	1,250	0

I

Albuquerque, New Mexico

User Defined Site Information			
Square Footage of Catchment Area	=	Input Value =>	5880
Coefficient for Catchment Surface	=	Roof	0.90
Plant Water Use Coefficient	=	Medium (Buffalograss/Bermu	0.5
Available Storage	=	Input Value =>	3700
Square Footage of Landscape	=	Input Value =>	5000

Albuquerque, New Mexico				
Storage/Supplement Water Use (gallons)				
Month	*Yield*	*Demand*	*Cumulative Storage*	*Supplemental Water Use*
Year 1				
January	1,286	592	694	0
February	1,319	997	1,016	0
March	1,583	2,243	356	0
April	1,648	4,299	0	2,295
May	2,011	7,133	0	5,122
June	2,143	9,921	0	7,778
July	4,319	11,167	0	6,848
August	5,011	10,015	0	5,003
September	3,363	6,884	0	3,521
October	2,671	3,925	0	1,254
November	1,583	1,448	134	0
December	1,615	716	1,033	0
Year 2				
January	1,286	592	1,727	0
February	1,319	997	2,049	0
March	1,583	2,243	1,389	0
April	1,648	4,299	0	1,262
May	2,011	7,133	0	5,122
June	2,143	9,921	0	7,778
July	4,319	11,167	0	6,848
August	5,011	10,015	0	5,003
September	3,363	6,884	0	3,521
October	2,671	3,925	0	1,254
November	1,583	1,448	134	0
December	1,615	716	1,033	0

31,820

36,788

J

Albuquerque, New Mexico

User Defined Site Information			
Square Footage of Catchment Area	=	Input Value =>	5000
Coefficient for Catchment Surface	=	Roof	0.90
Plant Water Use Coefficient	=	High (St. Augustine/Fescue)	0.75
Available Storage	=	Input Value =>	3700
Square Footage of Landscape	=	Input Value =>	5000

Albuquerque, New Mexico				
Storage/Supplement Water Use (gallons)				
Month	*Yield*	*Demand*	*Cumulative Storage*	*Supplemental Water Use*
Year 1				
January	1,286	888	398	0
February	1,319	1,495	222	0
March	1,583	3,364	0	1,560
April	1,648	6,448	0	4,800
May	2,011	10,700	0	8,689
June	2,143	14,882	0	12,739
July	4,319	16,751	0	12,432
August	5,011	15,022	0	10,011
September	3,363	10,326	0	6,963
October	2,671	5,887	0	3,217
November	1,583	2,173	0	590
December	1,615	1,075	541	0
Year 2				
January	1,286	888	939	0
February	1,319	1,495	762	0
March	1,583	3,364	0	1,019
April	1,648	6,448	0	4,800
May	2,011	10,700	0	8,689
June	2,143	14,882	0	12,739
July	4,319	16,751	0	12,432
August	5,011	15,022	0	10,011
September	3,363	10,326	0	6,963
October	2,671	5,887	0	3,217
November	1,583	2,173	0	590
December	1,615	1,075	541	0

61,000

60,460

K

Albuquerque, New Mexico

User Defined Site Information			
Square Footage of Catchment Area	=	Input Value =>	3500
Coefficient for Catchment Surface	=	Roof	0.90
Plant Water Use Coefficient	=	Low (Blue Grama/Desert Will	0.2
Available Storage	=	Input Value =>	2200
Square Footage of Landscape	=	Input Value =>	3100

Albuquerque, New Mexico				
Storage/Supplement Water Use (gallons)				
Month	*Yield*	*Demand*	*Cumulative Storage*	*Supplemental Water Use*
Year 1				
January	765	147	619	0
February	785	247	1,156	0
March	942	556	1,542	0
April	981	1,066	1,457	0
May	1,197	1,769	885	0
June	1,276	2,460	0	300
July	2,571	2,769	0	199
August	2,983	2,484	499	0
September	2,002	1,707	794	0
October	1,590	973	1,410	0
November	942	359	1,993	0
December	962	178	2,200	0
Year 2				
January	765	147	2,200	0
February	785	247	2,200	0
March	942	556	2,200	0
April	981	1,066	2,115	0
May	1,197	1,769	1,543	0
June	1,276	2,460	358	0
July	2,571	2,769	160	0
August	2,983	2,484	659	0
September	2,002	1,707	953	0
October	1,590	973	1,570	0
November	942	359	2,152	0
December	962	178	2,200	0

Albuquerque, New Mexico

User Defined Site Information			
Square Footage of Outdoor Area		[illegible]	2500
Sprinkler Efficiency for Outdoor Surface		Rated	0.62
Plant Water Use Coefficient		Low (Low Group Coefficient)	0.2
Available Storage		Total Storage	[illegible]
Square Footage of Landscape		Total Value	2500

Albuquerque, New Mexico

Storage/Supplemental Water Use (gallons)

Month	Yield	Demand	Cumulative Storage	Supplemental Water Use
Year 1				
January	387	[illegible]	433	0
February	741	[illegible]	815	0
March	[illegible]	433	1,575	0
April	707	991	989	0
May	855	1,115	529	0
June	511	1,436	0	387
July	1,836	2,055	0	219
August	2,131	1,881	250	0
September	1,406	1,267	491	0
October	1,155	732	914	0
November	673	257	1,330	0
December	537	537	1,330	0
Year 2				
January	147	192	1,285	0
February	391	187	1,489	0
March	613	413	1,689	0
April	[illegible]	297	1,910	
May	855	1,302	[illegible]	0
June	111	1,325	738	0
July	1,194	2,033	39	0
August	[illegible]	1,941	328	0
September	1,430	[illegible]	[illegible]	0
October	1,115	177	944	0
November	673	267	1,350	0
December	687	337	1,700	0

APPENDIX D

STORMWATER QUALITY

APPENDIX E

COST DATA

[illegible] COST SUMMARY

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]
1. [illegible]	[illegible]	[illegible]	[illegible]
2. [illegible]	[illegible]	[illegible]	[illegible]
3. [illegible]	[illegible]	[illegible]	[illegible]
4. [illegible]	[illegible]	[illegible]	[illegible]
5. [illegible]	[illegible]	[illegible]	[illegible]
6. [illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]

[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

[illegible]

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

	System Type		
	Conventional System	Type of Pipe System A	Decentralized Other System
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]			
[illegible]	$38	$65	$63
[illegible]			
[illegible]	$4.00	$8.00	$9.00

Source: [illegible]

[illegible]

Type of Development	Impact Fee Per Unit
Residential Per Garden	$1,015
Residential Per Subdivision	$3,795
Residential Per Single	$5,000
Commercial Per	$10,157
Commercial Per Hotel/d	$12,555

Source: [illegible]

[illegible]

	System Type	
	Conventional System A/B	[illegible]
Pump: [illegible]	$[illegible]	$115,[illegible]
Pump: [illegible]	$11,[illegible]	$58,[illegible]
Pump: [illegible]	$111,[illegible]	$111,[illegible]
[illegible]	$711,500	$[illegible]

Source: [illegible]

[illegible]

Pipe Type	Cost Range Per Foot
[illegible]	$0.15 - $[illegible]
[illegible]	$0.10 - $[illegible]
[illegible]	$1.00
[illegible]	$0.55 - $1.[illegible]
[illegible]	$0.15 - $1.[illegible]
Wood	$1.10 - $[illegible]
Fiberglass	$0.15 - $[illegible]

Source: [illegible]

[illegible]

Pipe Type	Cost Range Per Foot
[illegible]	$ [illegible]
[illegible]	$ [illegible]
[illegible]	$ 3.55 - $ 4.10
[illegible]	$ [illegible]
[illegible]	$ [illegible] - $ [illegible]
Wood	$ [illegible] - $1.00
Fiberglass	$ [illegible] - $1.00

Source: [illegible]

[illegible]

1	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]

Southern Sandoval County Arroyo Flood Control Authority

Preliminary Engineer's Opinion of Probable Costs for On-lot Water Harvesting

EXAMPLE 1

Prepared by: HUITT-ZOLLARS

Date: NOVEMBER 2010

ITEM NO.	DESCRIPTION	UNIT PRICE	UNIT	QUAN.	AMOUNT
1	**Water Harvesting Quantities**				
2	6" DIA Drain Pipe w/ connections	$20.00	LF	365	$ 7,300.00
3	8' DIA CMP W/ METAL LID (9' DEPTH)	$5,000.00	EA	1	$ 5,000.00
4	**Construction Subtotal**				**$ 12,300.00**
5	25% CONTINGENCY				$ 3,075.00
6	NMGRT @ 7.0625%				$ 1,085.86
7	**Construction Total**				**$ 16,460.86**

Southern Sandoval County Arroyo Flood Control Authority

Preliminary Engineer's Opinion of Probable Costs for On-lot Water Harvesting

EXAMPLE 2

Prepared by: HUITT-ZOLLARS

Date: NOVEMBER 2010

ITEM NO.	DESCRIPTION	UNIT PRICE	UNIT	QUAN.	AMOUNT
1	**Water Harvesting Quantities**				
2	TYPE A RETAINING WALL	$30.00	LF	105	$ 3,150.00
3	**Construction Subtotal**				**$ 3,150.00**
4	25% CONTINGENCY				$ 787.50
5	NMGRT @ 7.0625%				$ 278.09
6	**Construction Total**				**$ 4,215.59**

Southern Sandoval County Arroyo Flood Control Authority

Preliminary Engineer's Opinion of Probable Costs for On-lot Water Harvesting

EXAMPLE 3

Prepared by: HUITT-ZOLLARS

Date: NOVEMBER 2010

ITEM NO.	DESCRIPTION	UNIT PRICE	UNIT	QUAN.	AMOUNT
1	**Water Harvesting Quantities**				
2	8' DIA CMP W/ METAL LID (9' DEPTH)	$5,000.00	EA	1	$ 5,000.00
3	**Construction Subtotal**				**$ 5,000.00**
4	25% CONTINGENCY				$ 1,250.00
5	NMGRT @ 7.0625%				$ 441.41
6	**Construction Total**				**$ 6,691.41**

Southern Sandoval County Arroyo Flood Control Authority

Preliminary Engineer's Opinion of Probable Costs for On-lot Water Harvesting

EXAMPLE 4

Prepared by: HUITT-ZOLLARS

Date: NOVEMBER 2010

ITEM NO.	DESCRIPTION	UNIT PRICE	UNIT	QUAN.	AMOUNT
1	**Water Harvesting Quantities**				
2	6" DIA Drain Pipe w/ connections	$20.00	LF	320	$ 6,400.00
3	4000 Gal. Septic Tank, CIP	$6,000.00	EA	1	$ 6,000.00
4	**Construction Subtotal**				**$ 12,400.00**
5	25% CONTINGENCY				$ 3,100.00
6	NMGRT @ 7.0625%				$ 1,094.69
7	**Construction Total**				**$ 16,594.69**

Southern Sandoval County Arroyo Flood Control Authority

Preliminary Engineer's Opinion of Probable Costs for On-lot Water Harvesting

EXAMPLE 5

Prepared by: HUITT-ZOLLARS

Date: NOVEMBER 2010

ITEM NO.	DESCRIPTION	UNIT PRICE	UNIT	QUAN.	AMOUNT
1	**Water Harvesting Quantities**				
2	TYPE A RETAINING WALL	$30.00	LF	125	$ 3,750.00
3	**Construction Subtotal**				**$ 3,750.00**
4	25% CONTINGENCY				$ 937.50
5	NMGRT @ 7.0625%				$ 331.05
6	**Construction Total**				**$ 5,018.55**

Southern Sandoval County Arroyo Flood Control Authority

Preliminary Engineer's Opinion of Probable Costs for On-lot Water Harvesting

EXAMPLE 6

Prepared by: HUITT-ZOLLARS

Date: NOVEMBER 2010

ITEM NO.	DESCRIPTION	UNIT PRICE	UNIT	QUAN.	AMOUNT
1	**Water Harvesting Quantities**				
2	1000 Gal Above Ground Pre-Fab Tank	$1,200.00	EA	4	$ 4,800.00
3	**Construction Subtotal**				**$ 4,800.00**
4	25% CONTINGENCY				$ 1,200.00
5	NMGRT @ 7.0625%				$ 423.75
6	**Construction Total**				**$ 6,423.75**

The single largest expense is the storage tank, and the cost of the tank is based upon the size and the material. Table 6-1 shows a range of potential tank materials and costs per gallon of storage. The size of storage needed (see Chapter 4, Water Balance and System Sizing) and the intended end use of the water will dictate which of the materials are most appropriate. Costs range from a low of about $0.50 per gallon for large fiberglass tanks to up to $4.00 per gallon for welded steel tanks. As tank sizes increase, unit costs per gallon of storage decreases.

Table 6-1. Storage Tank
Cost Size Comments
Fiberglass $0.50–2.00/gallon 500–20,000 gallons Can last for decades w/out deterioration, easily repaired, can be painted
Concrete $0.30–1.25/gallon Usually 10,000 gallons or more Risks of cracks and leaks but these are easily repaired, immobile; smell and taste of water sometimes affected but the tank can be retrofitted with a plastic liner
Metal $0.50–1.50/gallon 150–2,500 gallons Lightweight and easily transported; rusting and leaching of zinc can pose a problem but this can be mitigated with a potable approved liner
Polypropylene $0.75–1.00/gallon 500–10,000 gallons Durable and lightweight; black tanks result in warmer water if tank is exposed to sunlight; clear/translucent tanks foster algae growth
Wood $2.00/gallon 700–50,000 gallons Esthetically pleasing, sometimes preferable in public areas and residential neighborhoods
Polyethylene $0.75–1.67/gallon 300–5,000 gallons
Welded Steel $0.80–$4.00/gallon 30,000–1 million gallons
Rain Barrel $100–55–100 gallons Avoid barrels that contain toxic materials, add screens for mosquitoes

Gutters and downspouts (Table 6-2) are needed to collect the water and route it to the tank. Two types of gutters are available for the "do-it-yourselfers": vinyl and plastic, which are available for approximately the same cost. For those desiring professionally installed materials, costs range from $3.50 to $12 per foot of gutter, including materials and installation, in 2004.

Table 6-2. Gutters
Cost Comments
Vinyl $.30/foot Easy to install and attach to PVC trunk lines
Plastic $.30/foot Leaking, warping and breaking are common problems

Aluminum $3.50-6.25/foot Must be professionally installed
Galvalume $9-12/foot Mixture of aluminum and galvanized steel, must be professionally installed

Roof washers consist of a tank, usually between 30- and 50-gallon capacity, with leaf strainers and a filter. A roof washer is a critical component of potable systems and is also needed to filter small particles to avoid clogging drip irrigation emitters. A wide range of equipment is available with different flow capacity and maintenance requirements. In Table 6-3 a list of different equipment used to intercept and pre-filter the water shows a range of costs from $50 to more than $800. It is important that the rainwater harvester pick a roof washer that is adequate for the size of collection area.

Table 6-3. Roof Washers

	Cost	Maintenance	Comments
Box Washer	$400-800	Clean the filter after every substantial rain	Neglecting to clean the filter will result in restricted or blocked water flow and may become a source of contamination
Post Filtering w/ Sand Filter	$150-500	Occasionally backwash the filter	Susceptible to freezing, a larger filter is best
Smart-Valve Rainwater Diverter Kit	$50 for kit	Occasional cleaning	Device installed in a diversion pipe to make it self-flushing and prevent debris contamination, resets automatically

Table 6-4 shows the ranges for pump costs including pressure tanks. Demand activated pumps such as Grundfos may

not require a pressure tank, and can often provide enough water to meet a home's demand for instantaneous flow. Careful thought should be given to the possibility of multiple simultaneous demands upon the system in determining the appropriate size pump. The range for pump costs runs from $385 for the lowest tankless pump to more than $1,000 for the combined price of a high-end pump and pressure tank.

Table 6-4. Pumps and Pressure Tanks

Cost	Comments
Tankless AIQ Water Supply System	
$385-600	Does not require a separate pressure tank
Shallow Well Jet Pump or Multi-Stage Centrifugal Pump	
$300-600	These require a separate pressure tank
Pressure Tank $200-500	Galvanized tanks are cheaper than bladder tanks but often become waterlogged, and this will wear out the pump more rapidly

Rainwater Harvesting

Step 3: Select a Cistern

[illegible]

Step 1: Select a Cistern	Step 2: Select a Filtration System	Step 3: Consider Your Cost Needs and Convert Air	Step 4: Know Your Benefits and Summary Report

Cistern Types:

Sort: [illegible]

Choose: [illegible]

[illegible]

[illegible]	Metal	Medium	High	High	Medium	High	No	Maybe	No
[illegible]	Metal	High	Low	High	Medium	Low	No	Maybe	Yes
[illegible]	Metal	High	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Maybe	Maybe
[illegible]	Metal	Medium	High	Medium	Medium	High	[illegible]	Maybe	Maybe
[illegible]	[illegible]	[illegible]	High	Medium	High	High	[illegible]	Maybe	Maybe

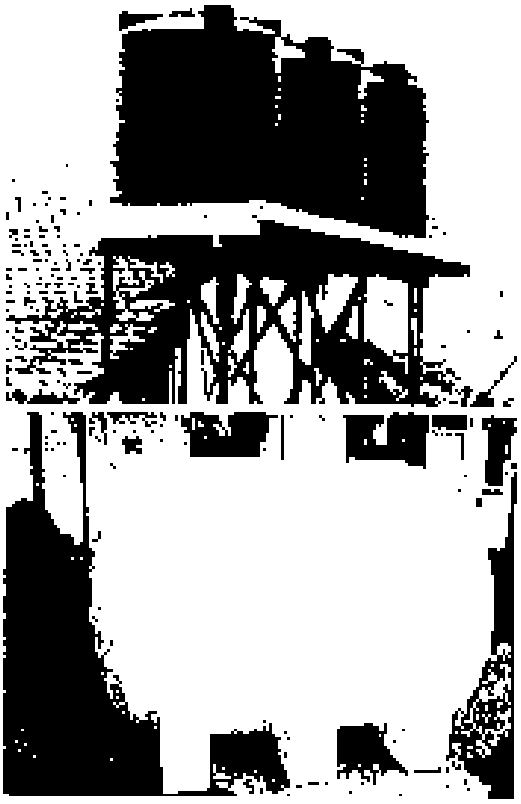
Rainwater Harvesting

Polypropylene / Polyethylene

[illegible]

Step 3: Select a Cistern | Step 4: Select a Purification System | Step 5: Consider Your Catchment and Conveyance | Step 6: View Your Results and Summary Report

Cisterns > Polypropylene / Polyethylene



Polypropylene or polyethylene cisterns are durable, inexpensive, and lightweight and easy to transport. They are easily modifiable and suitable for both above and below ground installations.

Polyethylene or polyethylene cisterns are petroleum-based, and their sustainable attributes range considerably from thin, blow-molded recycled "pool noodle" tanks with a life of 2-3 years to 0.25 inch walled rotationally molded cisterns with basic UV stability that can last 20 years. Plastic cisterns offer a lot of choices in terms of shape, size and color. Many have recycled content, but unfortunately this can reduce the life span of the vessel. Plastic cisterns of inferior quality that can fail will likely end up in a landfill sooner.

Polypropylene cisterns can deteriorate over time if not treated for UV radiation. If the cistern is UV stabilized, it will not break down under harsh outdoor weather conditions. To reduce algae growth, the polypropylene should be made of opaque and UV stabilized, as these paints tend to not remain paint well.

Key Specs:

Cost: 0.35 - $2.00 / gal.

Cost Level: Low

Material: Plastic

Transportability: Medium

Capacity: High
Durability: High
Customizability: High
Corrosion Resistance: Moderate
Scalability: High
Hand-Built: No
Recycled Content: Maybe
For Potable Use: Yes

Choose Tank Custom, or

Eco-Plus Package

The Ideal Solution for use in the Home and Garden

$3,600
300 ship
400 q+ & backfill 40 cy @ $10
500 Elec. / Misch
$4,800

Carat Underground Tank Package

- Economic package solution
- Patented self cleaning filter technology
- Automatic 1HP pump system
- Easy to assemble with modular and compatible components
- Only one cover viewable on the surface
- Mosquito proof design

Scope of Supply

- 1,700 gallon Carat underground tank
- Mini telescopic dome shaft for pedestrian loading with an adjustable PE lid and convenient hose connection access in lid
- Eco-Plus package, consists of:
  - Internal Optimax-Pro (self-cleaning) filter
  - Inflow stilling system for controlling water inflow
  - Overflow siphon and rodent guard
  - Spannfix pipe connection sleeve
- Eco-Plus pump package consists of:
  - 1HP, 115V automatic pump
  - Stainless steel floating extractor
  - 40 ft. cord

Optional Accessories

Rainwater System Controller
The Rainwater System Controller manages all of the functions required in a typical residential or commercial rainwater collection system.

Digital Water Level Indicator
The Digital Water Level Indicator accurately displays the water level in a rainwater tank from 0 to 100%.

Vehicle Loading Option
Heavy duty riser with cast iron lid.

www.rainharvest.com

Rainwater Management Solutions, Inc.
1260 West Riverside Drive
Salem, VA 24153

Estimate

Date	[illegible]
[illegible]	[illegible]

Name / Address	Ship To
[illegible]	

P.O. No.	Terms	Rep
	Due upon receipt	[illegible]

Item	Description	Qty	U/M	Cost	Total
RMS Package 1					
[illegible]	Downspout Flex Collector 4" top dia x [illegible] [illegible] sq ft	1		355.00	355.00
[illegible]	Leader Angle Elbow for Downspout Filter	1		29.95	29.95
[illegible]	Mounting Clip with Screw for Downspout Filters	1		65.36	65.36
[illegible]	Garden Hose Filter Pump 2 gpm	1		281.00	281.00
[illegible]	[illegible] downspout adapter	1		[illegible]	[illegible]
[illegible]	[illegible] bulkhead fitting	1		[illegible]	[illegible]
[illegible]	[illegible] black [illegible]			354.45	354.45
	[illegible]				
	Above for underground Package for [illegible] sq ft				1,411.55
	Estimate does not include shipping				

This estimate good for 30 days. Shipping [illegible] 20% restock fee for returned parts

Phone #	Fax #	Email
[illegible]	[illegible]	[illegible]

Total $1,411.55

Rainwater Management Solutions, Inc.
1260 West Riverside Drive
Salem, VA 24153

Estimate

Date	Estimate #
[illegible]	[illegible]

Name / Address	Ship to
[illegible]	

P.O. No.	Terms	Rep
	[illegible]	[illegible]

Item	Description	Qty	U/M	Cost	Total
RMS Package 4					
WF1.02	[illegible]	1		[illegible]	[illegible]
WHM-[illegible]	Wall Mount Bracket for WF1.150 and WF1.[illegible]	1		275.00	275.00
SHOSC	Screening Inlet	1		167.50	167.50
[illegible]	[illegible] Flange Hydrant Fire [illegible] Lead Crush Section Hose	1		[illegible]	[illegible]
[illegible]	[illegible] MPT X FIP Brass check valve [illegible]	1		[illegible]	[illegible]
DSI-[illegible]	[illegible] Model [illegible] Sump [illegible]	1		992.00	992.00
[illegible]	[illegible] Level Indicator	1		[illegible]	317.20
[illegible]	[illegible] Stainless Steel Strainer for WF1.[illegible] Water Filter	1		5.00	4.00
[illegible]	[illegible] Brass adapter male [illegible]	1		3.00	17.00
[illegible]	[illegible] poly tubing [illegible]	1		125.00	125.00
[illegible]	[illegible] gallon above ground black tank [illegible]			1,120.00	1,120.00
	Above Ground Residential & Commercial Package for [illegible]				4,287.58
	Price does not include shipping				

Estimate good for 30 days. Shipping not included. 20% restocking fee for returned parts.

Phone #	Fax #	E-mail
[illegible]	[illegible]	[illegible]

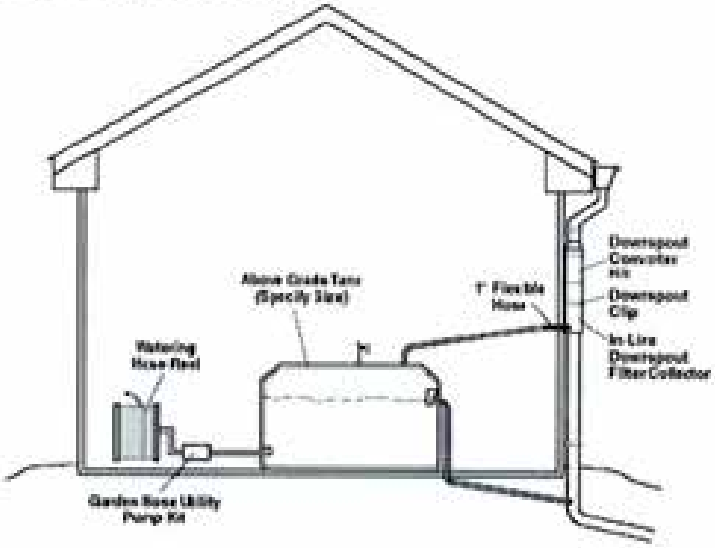
Total $4,287.58

PACKAGE 1:
IN-LINE ABOVE GROUND GARDEN

Package 1 is designed for a small residential storage capacity with above ground storage. This package is ideal for small gardens and each downspout filter will collect a roof area/section up to 1,600 sq.ft. The pump system will allow for drip or hand irrigation.

INCLUDES:

CONNECTION CONFIGURATION:

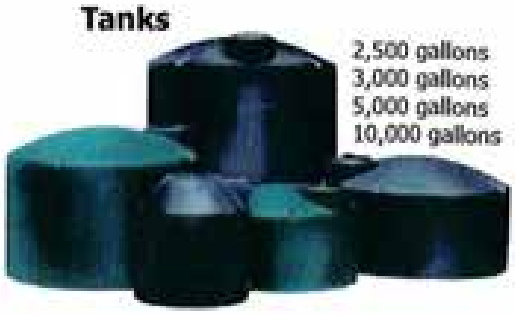


PACKAGE 4:

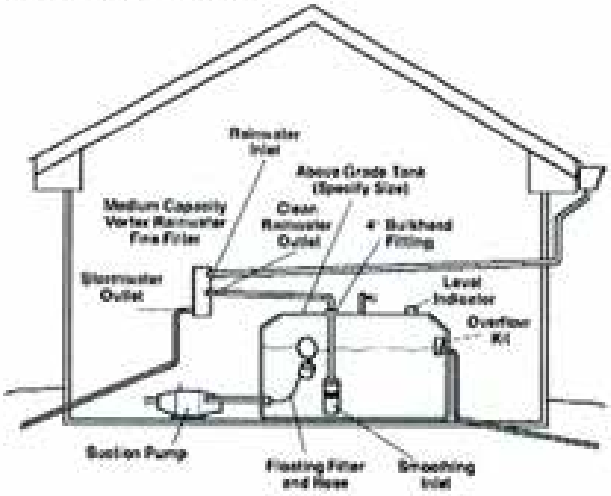
ABOVE GROUND RESIDENTIAL/COMMERCIAL

Package 4 is designed for a large residential or small commercial building with above ground storage. This package is ideal for non-potable needs inside and outside the building. Each filter will filter up to 5,500 sq.ft. of roof area. Multiple filters and tanks can be installed for a larger roof area and larger storage capacity.

INCLUDES:



CONNECTION CONFIGURATION:



Dodge, Clint

From: Bill Lynch [blynch@geosupply.com]
Sent: Tuesday, May 31, 2011 4:57 PM
To: Dodge, Clint
Subject: RE: Rainwater harvesting storage

Clint

Typical 2000 gallon systems will run approximately $5000 delivered. A lot depends on the shipping. Give me a call tomorrow to discuss.

Bill Lynch
General Manager
GeoSupply Soil Solutions
blynch@geosupply.com
Office: 602-305-8094
Fax: 602-305-8096
Cell: 480-710-4344

From: Dodge, Clint [mailto:CDodge@whpacific.com]
Sent: Tuesday, May 24, 2011 3:01 PM
To: Bill Lynch
Subject: Rainwater harvesting storage

We are working on a proposed rainwater harvesting program for the Rio Rancho area and are requesting some generic cost info for installed underground modular cisterns using rainstore with impermeable liner, or similar, to be pumped for irrigation. The proposed program would require rainwater harvesting on every new residence with a typical installation of about 2,000 gallons.
Can you help with some data to compare with other types of cisterns?
Thanks
Clint Dodge

WHPacific

Components:

Project: Type: Harvesting

To Store 2200 gallons of water... Requires a Minimum 89 RS3 Units

Your Site Configuration Unit Length 4 x Unit Width 6 x Unit Depth 4

Total Rainstore³ Units Needed = 96

Geotextile Fabric (8 oz) Needed =	147 sq yds	123 m^2
Geomembrane Liner (40 mil PVC)= *used mainly for capture and re-use	74 sq yds	62 m^2
Geogrid Needed =	139 sq yds	116 m^2
Excavated Volume Needed =	64 cu yds	49 m^3
Structural Backfill Material* = *Site soils may be used, check with soils engineer	37 cu yds	28 m^3
12 inches Cover (Porous Base Course) = *Cover varies from 12 to 36 inches	14 cu yds	11 m^3
Approx. Labor to Install System =	2 man hours	

<< back | Print Results | next >>

Up to 50% overages have been calculated for items above *This is not a quote

Copyright © 2007-2009

Components:

Project: Type: Harvesting

To Store 2200 gallons of water... Requires a Minimum 89 RS3 Units

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Geogrid Needed =	139 sq yds	116 m^2
Excavated Volume Needed =	64 cu yds	49 m^3
Structural Backfill Material* = *Site soils may be used, check with soils engineer	37 cu yds	28 m^3
12 inches Cover (Porous Base Course) = *Cover varies from 12 to 36 inches	14 cu yds	11 m^3
Approx. Labor to Install System =	2 man hours	

<< back | Print Results | next >>

Up to 20% overages have been calculated for some items above *This is not a quote

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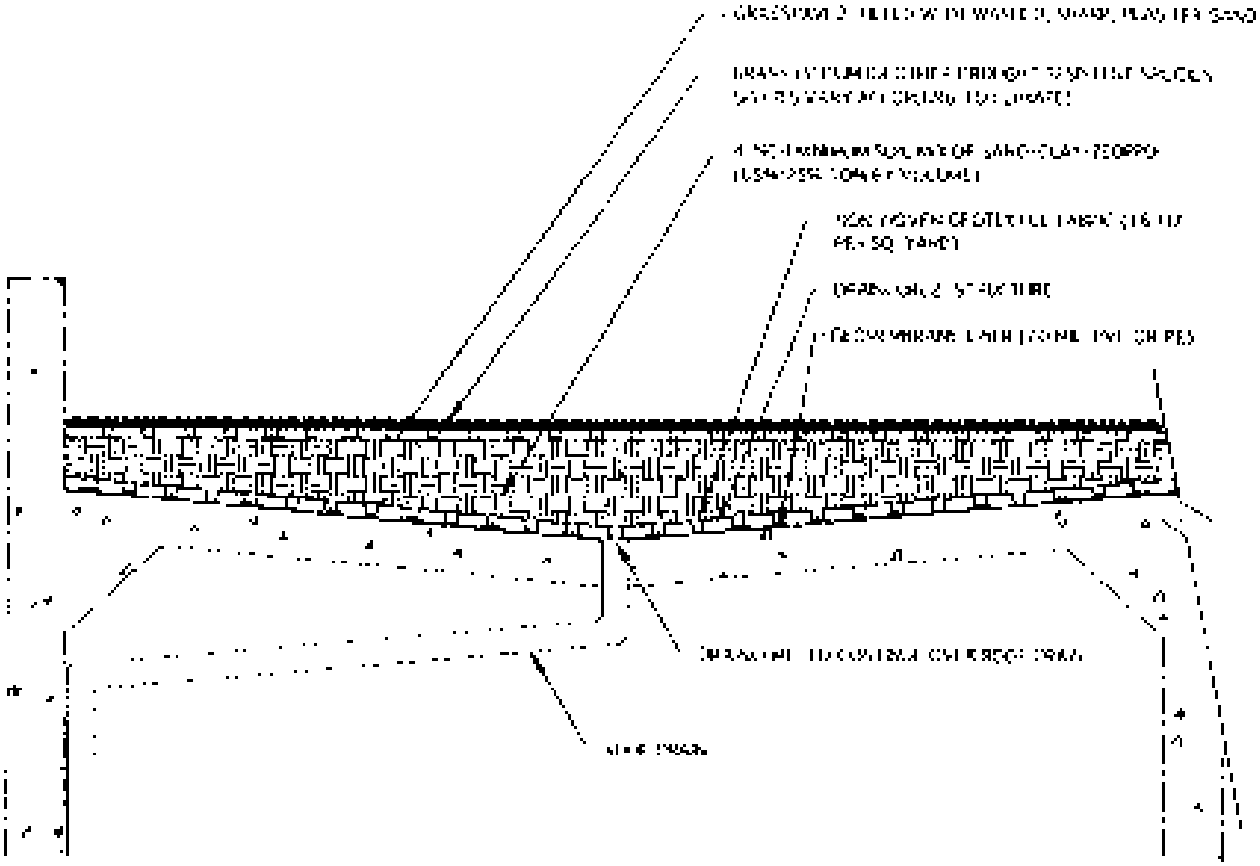


DRAINCORE® ROOF DRAINAGE DETAIL W/ GRASSPAVE2 REINFORCEMENT

HUC 13020203 Rio Grande - Albuquerque

Rio Grande (non-pueblo Alameda Bridge to Angostura Diversion)

This AU was split at the HWY 550 bridge during the 2010 listing cycle based on the assessment process. The original lumped AU is retained in the below paragraphs in italics. It is retained here for a historic record of the listing. The two new AUs from the resulting split were assessed during the 2010 listing cycle and have separate entries.

WQS: 20.6.4.106 AU: NM-2105.1_00

Previously listed as "Rio Grande from the northern boundary of Isleta Pueblo to the southern boundary of Santa Ana Pueblo" and listed for metals (Al), total ammonia, chloride, stream bottom deposits and fecal coliform. For aluminum, there are four stations for making the assessment. These stations have ratios of 2/7, 3/6, 2/8, and 2/8 for exceedances of the chronic screening criteria and no exceedances of the acute criteria. All of these data are from a 1991 NWQB survey. Additional information considered to be of greater confidence has recently been posted from the USGS 1994-1996 surveys of the Rio Grande from Isleta Pueblo to the Jemez River. In this database 0/57 Rio Grande samples were found to have dissolved aluminum levels greater than the chronic screening criteria. This reach will be listed as full support for aluminum. For total ammonia there are six stations that may be used for the assessment. Generally, in a time frame prior to 1998, there were numerous exceedances of the chronic screening criteria for ammonia. In WQS 2105 there are two stations MRG2105.005730 and 5740. At station 5739 there were 11/21 samples that exceeded the chronic screening criteria for ammonia from 1988 through 1992. From 1994 through 1997 there has been only one exceedance of the criteria (1/10). A similar pattern is seen at station 5740 where 5/26 1988-1992 samples exceeded the criteria but 0/13 within the last five years have exceeded the criteria. One four-day sampling event in 1988 documented a four-day chronic exceedance at station 5740 in 1988. There have been no four-day sampling events since then. In segment 2105.1 there are no six to ten year data. All data are from 1988 to 1992. Ratios at these stations are 3/19, 0/12, 4/16, and 2/21. Ammonia will continue to be listed as partially supporting until additional sampling information is available. For fecal coliform in segment 2105, there have been 0/28 samples with values greater than the criteria value. In segment 2105.1, which has a more restrictive criterion, the ratios are 3/4, 1/7, 3/9, and 1/3.

1998 ACTION: *Aluminum and stream bottom deposits were removed as causes of non-support. The reach continued to be listed as partially supported with ammonia, chloride and fecal coliform listed as causes of non-support.*

2000 ACTION:

Total Ammonia: *The exceedance ratio for total ammonia on this reach was 0/38.*

Water quality standards, as assessed using the 1998 Assessment Protocol, are currently being met for total ammonia on the Middle Rio Grande.

Fecal Coliform: *There are 12 sampling stations on this reach. Stations*

1, Rio Grande below Angostura Diversion (NS) exceedance ratio was 0/5, ***Station 2, Rio Grande at Highway 44 Bridge (NS)*** exceedance ratio was 2/5, *Station 3, Bernalillo WWTF effluent discharge (FS)* exceedance ratio was 0/5, ***Station 4, Rio Grande above RRUC #3 (NS)*** exceedance ratio was 2/5, ***Station 5, RRUC #3 effluent discharge (FSIO)*** exceedance ratio was 1/5, ***Station 6, Rio Grande above RRUC #2 (NS)*** exceedance ratio was 3/7, ***Station 7, RRUC #2 effluent discharge (NS)*** exceedance ratio was 7/7, ***Station 8, Rio Grande above Alameda Bridge (FSIO)*** exceedance ratio was 1/7, ***Station 9, Rio Grande above Rio Bravo Bridge (NS)*** exceedance ratio was 2/7, *Station 10, Albuquerque WWTF effluent discharge (FS)* exceedance ratio was 0/7, ***Station 11, Rio Grande above I-25 Bridge (NS)*** exceedance ratio was 2/7 and ***Station 12, Rio Grande above Isleta Diversion (FSIO)*** exceedance ratio was 1/7

Fecal coliform will be retained as a cause of non-support for this reach

2002 ACTION: *None. The original assessment unit "Rio Grande from the northern boundary of Isleta Pueblo to the southern boundary of Santa Ana Pueblo" was split into two because they fall under two different water quality standard segments. A TMDL was prepared for fecal coliform*

2004 ACTION: *None*

2006 ACTION: *The name was modified during 2005 ARCI survey. The recreational water quality criteria for contact use support was changed from fecal coliform to E. coli during the 2005 triennial review. These historic fecal coliform listings will be retained until E. coli data are collected to determine whether there is any impairment of contact uses*

*There were also three acute and two chronic water toxicity tests with significant effect noted at station "Rio Grande Below Bernalillo WWTF" between 2002 and 2004 as compared to controls or reference conditions (see http://www.epa.gov/owow/tmdl/ref/arcpreview/arcshtmls/arcpreview.htm). According to the Assessment Protocol, since significant effects were noted in more than one water test, **Water Biotoxicity - Acute and Water Biotoxicity-Chronic** will be added as a causes of non support. The NPDES permit for the Bernalillo WWTF was renewed in January, 2004, and contained compliance schedules for both chlorine and ammonia*

2008 ACTION: *This AU was part of the SWQB Middle Rio Grande (2005) intensive survey.*

as well as additional water quality survey work (2006 – 2007) funded by the US Bureau of Reclamation. There is also a significant amount of available USGS data in this AU. The data from eight stations were collected and assessed according to the 2005 Assessment Protocols and several additional. There were 6 of 17 exceedences of the 410 cfu/100 ml single sample E. coli criterion for secondary contact use. A sonde deployed by a UNM graduate student (Van Horn) from 6/2006 through 10/2007 recorded minimum saturation values below 25% for more than three consecutive hours. Significant effects to primary endpoints were noted in 4 acute ambient water and 0 chronic ambient water toxicity tests taken between 2003 and 2007. During the 2005 triennial, all fecal coliform criteria were replaced with E. coli criteria. Therefore, ***Water Bioassay – Acute remains, Water Bioassay-Chronic and fecal coliform were removed, and E. coli and dissolved oxygen were added as causes of non support.***

NOTE (2/11/2009): *EPA's Record of Decision states that "EPA concludes that the public participation process regarding the listing of two assessment unit/dissolved oxygen pollutant combinations, i.e., NM-2105_50 and NM-2105_1_00, is inconsistent with federal requirements and the New Mexico Water Quality Control Commission Continuing Planning Process (CPP) and Water Quality Management Plan (WQMP). ...Consequently, EPA is taking a disapproval action and de-listing these assessment unit/dissolved oxygen pollutant-combinations." EPA requested that NMED Public Notice the addition of these assessment unit/dissolved oxygen pollutant-combinations to the New Mexico § 303(d) List during either an addendum to the 2008 Integrated List or during the New Mexico 2010 Integrated List submission.*

Rio Grande (non-pueblo Alameda Bridge to Hwy 550 Bridge)
WQS: 20.6.4.106 AU: NM-2105.1_00

2010 ACTION: This AU is the result of the split of the AU named "Rio Grande (non-pueblo Alameda Bridge to Angostura Diversion)." All readily available data that were not assessed for the previous listing cycle were collated and assessed and compared to the conclusions of the previous list. There were 4 of 27 exceedences of the E. coli criterion (410 cfu/100 ml) utilizing the past five years of data. A sonde deployed by a UNM graduate student (Van Horn) from 6/2006 through 12/31/07 above Alameda bridge (n=41,624) recorded minimums of 0.43 mg/L with 6.0% saturation. The data, metadata, and general project QAPP are on the Sevilleta LTER website http://sev.lternet.edu/project_details.php?id=SEV130. The SWQB QA Officer reviewed the associated Statement of Work which included QA/QC information specific to the sonde data, and found these data meet SWQB QA/QC requirements. There were no new ambient toxicity testing data available at the time of assessment. **Therefore, the E. coli and Ambient Bioassays – Acute Aquatic Toxicity listings were carried over to this newly defined AU,** and dissolved oxygen was added as a cause of

impairment

PCBs in Fish Tissue was added as a Probable Cause because there are fish consumption guidelines for PCBs from I-25 to US 550. The fish consumption advisory for PCBs in channel catfish and white bass issued in 2009 is based on data from fish tissue collected 9-10 June 2008 between Bernalillo and Los Padillas. Seven channel catfish, ranging in size from 345 to 440 mm (total length), and 6 white bass, ranging in size from 200 to 260 mm (total length), were composited (keeping species separate) and analyzed for a variety of contaminants, including PCBs. The results from the channel catfish indicated a total PCB concentration of 0.0056 mg/g and a PCB Toxic Equivalency Quotient (TEQ) of 0.1576 pg/g. The PCB TEQ is a calculated value, based on the sum of the concentrations of the 12 dioxin-like PCB congeners, with each concentration multiplied by an equivalency factor, to represent the toxic equivalency of dioxin. The total PCB result corresponds to a recommendation of < 8 meals per month; the PCB TEQ result corresponds to a recommendation of ≤ 3 meals per month. The results from the white bass indicated a total PCB concentration of 0.1769 mg/g and a PCB TEQ of 3.1655 pg/g. Both of these results correspond to a recommendation of 0 meals per month. The meals per month recommendation is according to published guidance from the US Environmental Protection Agency (Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 2, Risk Assessment and Fish Consumption Limits, Third Edition, 2000) using cancer risk at a 1 in 100,000 risk level.

Rio Grande (non-pueblo Hwy 550 Bridge to Angostura Div)
WQS: 20.6.4.106 AU: NM-2105.1_02

2010 ACTION: This AU is the result of the split of the AU named "Rio Grande (non-pueblo Alameda Bridge to Angostura Diversion)." All readily available data that were not assessed for the previous listing cycle were collated and assessed and compared to the conclusions of the previous list. There were 1 of 13 exceedences of the E. coli criterion (410 cfu/100 mL) utilizing the past five years of data. Therefore, the E. coli listing was not carried over to this newly defined AU.

Rio Grande (Isleta Pueblo bnd to Alameda Street Bridge)
WQS: 20.6.4.105 AU: NM-2105_50

Previously listed as "Rio Grande from the northern boundary of Isleta Pueblo to the southern boundary of Santa Ana Pueblo" and listed for metals (Al), total ammonia, chlorine, stream bottom deposits and fecal coliform. For aluminum, there are four stations for making the assessment. These stations have ratios of 2/7, 3/6, 2/8, and 2/8 for exceedences of the chronic screening criteria and no exceedences of the acute criteria. All of these data are from a 1991 SWQB survey. Additional

information considered to be of greater confidence has recently been issued from the USGS 1994-1996 surveys of the Rio Grande from Isleta Pueblo to the Jemez River. In this database 0/57 Rio Grande samples were found to have dissolved ammonia levels greater than the chronic screening criteria. This reach will be listed as full support for aluminum. For total ammonia there are six stations that may be used for the assessment. Generally, in a time frame prior to 1988, there were numerous exceedences of the chronic screening criteria for ammonia. In WQS 2105 there are two stations MRG105.005730 and 5740. At station 5730 there were 11/21 samples that exceeded the chronic screening criteria for ammonia from 1988 through 1992. From 1993 through 1997 there has been only one exceedence of the criteria (1/10). A similar pattern is seen at station 5740 where 5/30 1988-1992 samples exceeded the criteria but 0/13 within the last five years have exceeded the criteria. One four-day sampling event in 1988 documented a four-day chronic exceedence at station 5740 in 1988. There have been no four-day sampling events since then. In segment 2105.1 there are no six to ten year data. All data are from 1988 to 1992. Ratios at these stations are 3/19, 0/12, 4/16, and 2/21. Ammonia will continue to be listed as partially supporting until additional sampling information is available. For fecal coliform, in segment 2105, there have been 0/38 samples with values greater than the criteria value. In segment 2105.1, which has a more restrictive criterion, the ratios are 3/9, 1/7, 3/9, and 0/3.

1998 ACTION: Aluminum and stream bottom deposits were removed as causes of non-support. The reach continued to be listed as partially supported with ammonia, chlorine and fecal coliform listed as causes of non-support.

2000 ACTION:

Total Ammonia: The exceedence ratio for total ammonia on this reach was 0/58.

Water quality standards, as assessed using the 1998 Assessment Protocol, are currently being met for total ammonia on the Middle Rio Grande.

Fecal Coliform: There are 12 sampling stations on this reach. Station 1, Rio Grande below Angostura Diversion (FS) exceedence ratio was 0/5. **Station 2, Rio Grande at Highway 44 Bridge (NS)** exceedence ratio was 2/5, Station 3, Bernalillo WWTF effluent discharge (FS) exceedence ratio was 0/5. **Station 4, Rio Grande above RRUC #3 (NS)** exceedence ratio was 2/5, **Station 5, RRUC #3 effluent discharge (FSIO)** exceedence ratio was 1/5. **Station 6, Rio Grande above RRUC #2 (NS)** exceedence ratio was 3/7, **Station 7, RRUC #2 effluent discharge (NS)** exceedence ratio was 7/7. **Station 8, Rio Grande above Alameda Bridge (FSIO)** exceedence ratio was 1/7, **Station 9, Rio Grande above Rio Bravo Bridge (NS)** exceedence ratio was 2/7. Station 10, Albuquerque WWTF effluent discharge (FS) exceedence ratio was 0/7. **Station 11, Rio Grande**

above **I-25 Bridge (NS)** exceedence ratio was 2/7 and **Station 12, Rio Grande above Isleta Diversion (FSIU)** exceedence ratio was 1/7.

Fecal coliform will be retained as a cause of non-support for this reach.

2002 ACTION: None. The original assessment unit "Rio Grande from the northern boundary of Isleta Pueblo to the southern boundary of Santa Ana Pueblo" was split into two because they fall under two different water quality standard segments. A TMDL was prepared for fecal coliform.

2004 ACTION: None

2006 ACTION: None

2008 ACTION: This AU was part of the SWQB Middle Rio Grande (2005) intensive survey, as well as additional water quality survey work (2006 - 2007) funded by the U.S Bureau of Reclamation. The data from five stations were collated and assessed according to the 2008 Assessment Protocols and associated addendum. There were 4 of 16 exceedences of the 410 cfu/100 ml single sample E. coli criterion for secondary contact use. A sonde deployed by a UNM graduate student (Van Horn) from 6/2/06 through 10/15/07 recorded minimum saturation values below 75% for more than three consecutive hours. During the 2005 triennial, all fecal coliform criteria were replaced with E. coli criteria. **Therefore, fecal coliform was removed, and E. coli and dissolved oxygen were added as causes of non support.**

NOTE (2/13/09): EPA's Record of Decision states that "EPA concludes that the public participation process regarding the listing of two assessment unit/dissolved oxygen pollutant combinations, i.e., NM-2106_50 and NM-2106_1_00, is inconsistent with federal requirements and the New Mexico Water Quality Control Commission Continuing Planning Process (CPP) and Water Quality Management Plan (WQMP). Consequently, EPA is taking a disapproval action and de-listing these assessment unit/dissolved oxygen pollutant combinations." EPA requested that NMED Public Notice the addition of these assessment unit/dissolved oxygen pollutant combination to the New Mexico § 303(d) List during either an addendum to the 2008 Integrated List or during the New Mexico 2010 Integrated List submission.

2010 ACTION: All readily available data that were not assessed for the previous listing cycle were collated and assessed and compared to the conclusions of the previous list. There were 4 of 20 exceedences of the E. coli criterion (410 cfu/100 ml.) utilizing the past five years of data. Thermographs deployed above Rio Bravo bridge and at the I-25 bridge both recorded excursions above the 32.2

degrees C criterion (max temperature of 33.1 degrees C for both). Sondes deployed by a UNM graduate student (Van Horn) from 6-2-06 through 12-31-07 above Rio Bravo bridge (n=30,635) and at Pac I-25 bridge (n=43,244) recorded minimums of 0.04 mg/L with 0.06% saturation and 0.12 mg/L with 1.7% saturation, respectively. The data, metadata, and general project QAPP are on the Sevilleta LTER website: http://sasy.lternet.edu/project_qrcode.php?id=NEW190. The SWQB QA Officer reviewed the associated Statement of Work which included QA/QC information specific to the sonde data, and found these data meet SWQB QA/QC requirements. **Therefore, the E. coli listing remains, and temperature and dissolved oxygen were added as causes of impairment.**

PCBs in Fish Tissue was added as a Probable Cause because there are fish consumption guidelines for PCBs from I-25 to US 550. The fish consumption advisory for PCBs in channel catfish and white bass issued in 2009 is based on data from fish tissue collected 9-10 June 2008 between Bernalillo and Los Padillas. Seven channel catfish, ranging in size from 345 to 440 mm (total length), and 6 white bass, ranging in size from 240 to 260 mm (total length), were composited (keeping species separate) and analyzed for a variety of contaminants, including PCBs. The results from the channel catfish indicated a total PCB concentration of 0.0056 mg/g and a PCB Toxic Equivalency Quotient (TEQ) of 0.1576 pg/g. The PCB TEQ is a calculated value, based on the sum of the concentrations of the 12 dioxin-like PCB congeners, with each concentration multiplied by an equivalency factor, to represent the toxic equivalency of dioxin. The total PCB result corresponds to a recommendation of <8 meals per month; the PCB TEQ result corresponds to a recommendation of >8 meals per month. The results from the white bass indicated a total PCB concentration of 0.1269 mg/g and a PCB TEQ of 3.1655 pg/g. Both of these results correspond to a recommendation of 0 meals per month. The meals per month recommendation is according to published guidance from the US Environmental Protection Agency (Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 2: Risk Assessment and Fish Consumption Limits, Third Edition, 2000) using cancer risk at a 1 in 100,000 risk level.

Rio Grande (Rio Puerco to Isleta Pueblo bnd)
WQS: 20.6.4.105 AU: NM-2105_40

Previous listed for metals (Hg) and stream bottom deposits. There are three stations for making the assessment. In 1994, these stations had a combined ratio of 0/9 for mercury, upgrading the reach to full support. In a January 9, 1998 letter to NMED, Jim Brooks of the U.S. Fish & Wildlife Service, New Mexico Fishery Resources Office stated that "... a total maximum daily load for siltation in the middle and lower Rio Grande in New Mexico would not improve habitat conditions for the native fish fauna".

1998 ACTION: Metals (mercury) and stream bottom deposits were removed as causes of non-support, therefore the reach was removed from the 303(d) list.

2000 ACTION: None

2002 ACTION: None

2004 ACTION: None

2006 ACTION: None

2008 ACTION: Has AU was part of the NWQB Middle Rio Grande (2005) intensive survey, as well as additional water quality survey work (2006 – 2007) funded by the US Bureau of Reclamation. The data from six stations were collated and assessed according to the 2008 Assessment Protocols and associated addendum. There were 2 of 7 exceedences of the 410 cfu/100 ml single sample E. coli criterion for secondary contact use. During the 2006 triennial, all fecal coliform criteria were replaced with E. coli criteria. **Therefore, fecal coliform was removed, and E. coli was added as a cause of non support.**

2010 ACTION: All readily available data that were not assessed for the previous listing cycle were collated and assessed and compared to the conclusions of the previous list. There were no additional E. coli data for comparison. **Therefore, the E. coli listing remains.** A thermograph deployed at Los Lunas recorded excursions above the 32.2 degrees C criterion (max temperature of 34.1 degrees C). **Therefore, temperature was added as a cause of impairment.**

Rio Grande (San Marcial at USGS gage to Rio Puerco)
WQS: 20.6.4.105 AU: NM-2105-10

Previously listed for pesticides, stream bottom deposits and total ammonia. There have been 8/18 exceedences of the total ammonia chronic screening criteria in the past ten years. This reach should be upgraded to full support for total ammonia. In 1987 there was a 1/1 hit for chlordane at station MRG195.9RU125. There has been no follow-up sampling at this station. This station will be listed as Full Support, Impacts Observed. Two other stations on this reach have ratios of 0/1 and 0/8 for chlordane. These stations will be listed as full support. In a January 9, 1998 letter to NMED, Jim Brown of the U.S. Fish & Wildlife Service, New Mexico Fishery Resources Office stated that "... a total maximum daily load for siltation in the middle and lower Rio Grande in New Mexico would not improve habitat conditions for the native fish fauna".

1998 ACTION: Stream bottom deposits and ammonia were removed as causes of non-support. The reach was upgraded to Full Support, Impacts Observed and therefore removed from the 303(d) list. It will be listed as Full Support, Impacts Observed on the 305(b) list for chlordane.

2000 ACTION: None

2002 ACTION: None

2004 ACTION: None

2006 ACTION: None

2008 ACTION: Name changed to "Rio Grande (San Marcial at USGS gage to Rio Puerco)." This AU was part of the SWQB Middle Rio Grande (2005) intensive survey, as well as additional water quality survey work (2006 – 2007) funded by the U.S. Bureau of Reclamation. The data from ten stations were collated and assessed according to the 2008 Assessment Protocols and associated addendum. There were 4 of 8 exceedances of the aluminum 87 ug/L aluminum criterion for aquatic life (chronic). There were 14 of 35 exceedances of the 410 cfu/100 ml single sample E. coli criterion for secondary contact use. **aluminum and E. coli were added as causes of non support.**

2010 ACTION: All readily available data that were not assessed for the previous listing cycle were collated and assessed and compared to the conclusions of the previous list. There were 1 of 13 exceedances of the E. coli criterion (410 cfu/100 ml). There were also 4 of 8 exceedances of the chronic aluminum criterion (87 ug/L). **Therefore, both the E. coli and aluminum listings remain.**

Tijeras Arroyo (Rio Grande to headwaters)
WQS: 20.6.4.99 AU: NM-9000.A_001

Previously listed as partially supported for metals (Cd, Hg, chronic) and nutrients. In 1984, there was a sewer break at Montessa Park that flowed into lower Tijeras Arroyo and made it into the Rio Grande. There are no STORET data available, but a report from *Potter, D.C. 1984, titled, Rio Grande Water Quality Survey (August 28-September 4, 1984) in Response to a Sewer Line Break at Tijeras Arroyo on August 25, 1984. NMED/SWQB-85/2. 52 p.*, documents the spill and 1998 Actions taken to abate the pollution.

1998 ACTION: This arroyo will be removed from the 303(d) list as fixing the sewer line solved the problem.

2000 ACTION: None

2002 ACTION: None

2004 ACTION: None

APPENDIX F

GRADE AND DRAIN EXAMPLES

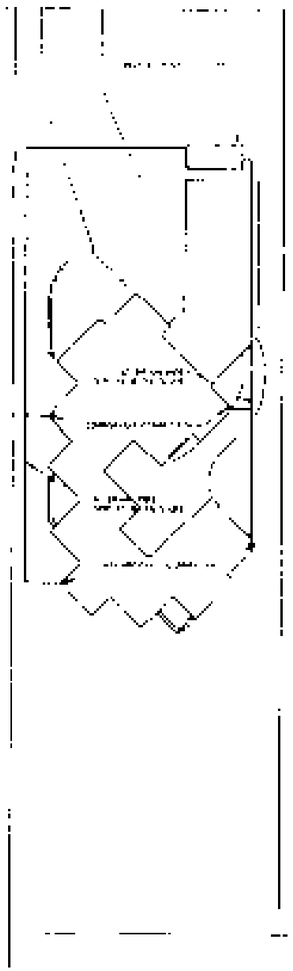
GENERAL NOTES

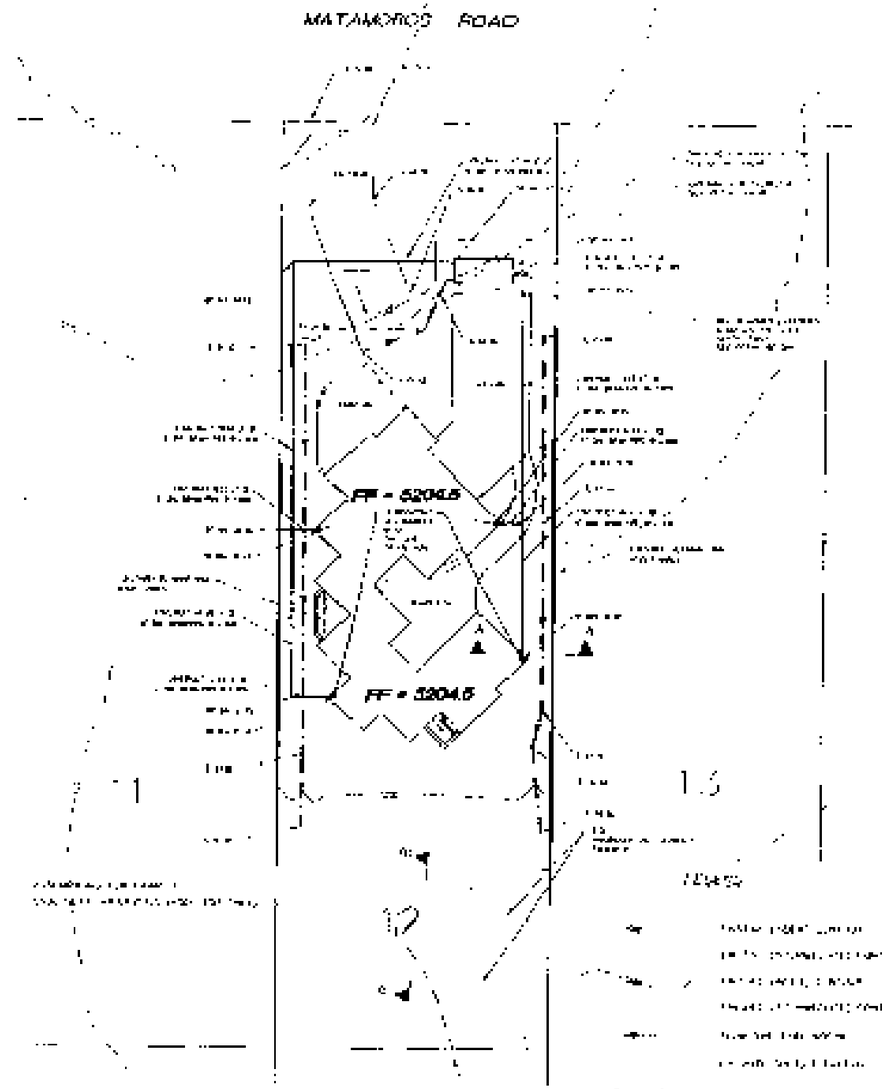
DRAINAGE CONCEPTS

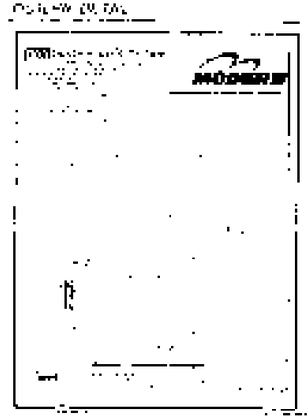
RAIN BARREL & RAIN HARVEST PLAN

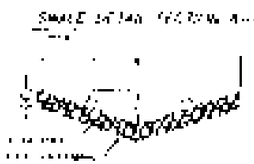
OPERATIONS & MAINTENANCE

DRAINAGE SECTION A-A









1			
2			
3			
4			
5			
NO.	DESCRIPTION	DATE	BY

REVISIONS FOR CHANGE ORDERS

HUITT-ZOLLARS

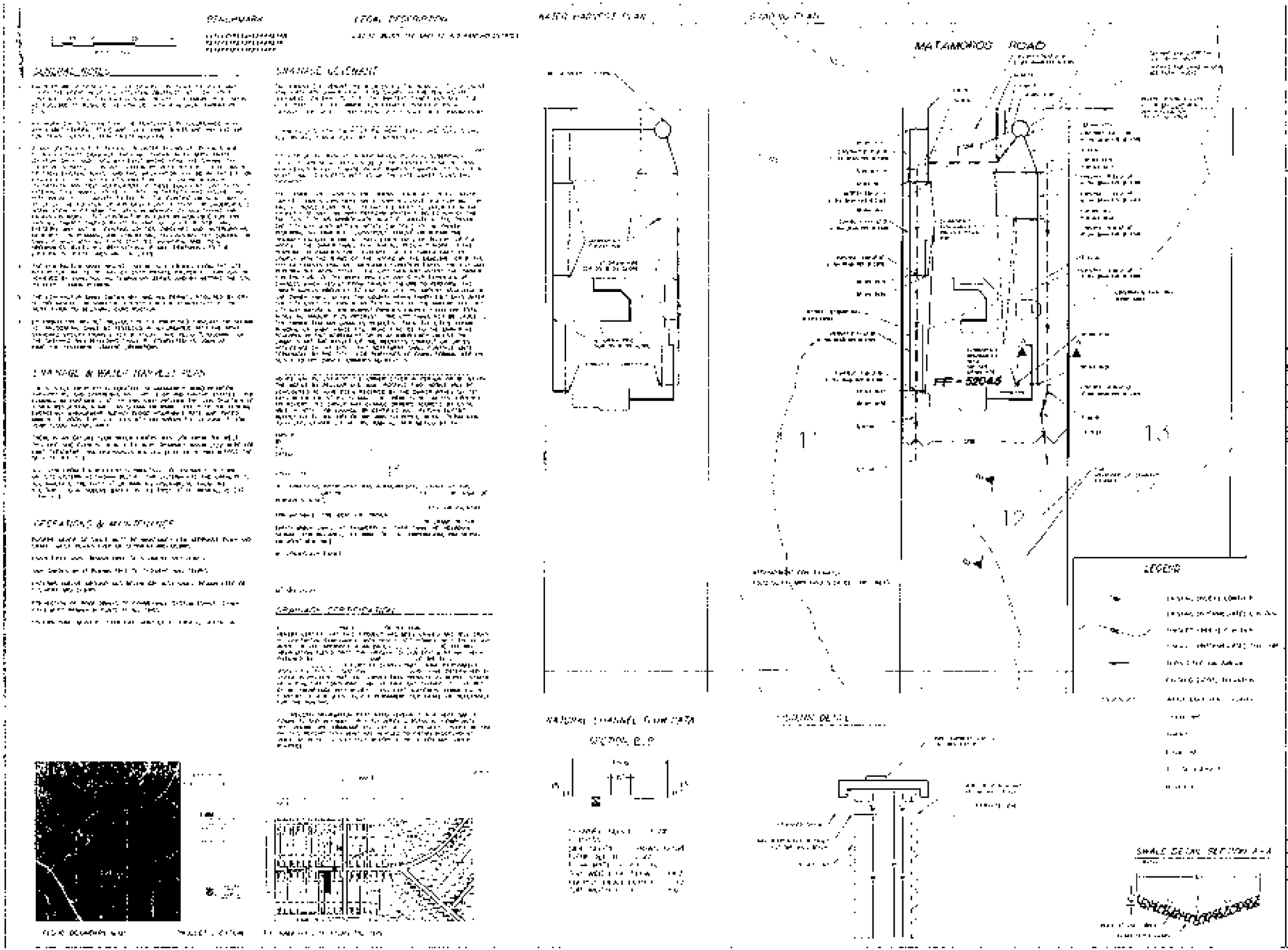
SSCAFCA

DRAINAGE & WATER HARVEST PLAN

BELOW ROADWAY ELEVATION
OFF-SITE PUBLIC DISCHARGE THROUGH SITE
BELOW GROUND CISTERN
EXAMPLE #4

PROJECT NO. [illegible]
DESIGNED BY [illegible]
DRAWN BY [illegible]
CHECKED BY [illegible]
DATE APR 15 201[illegible]
DWG. NO.

SHEET
G1

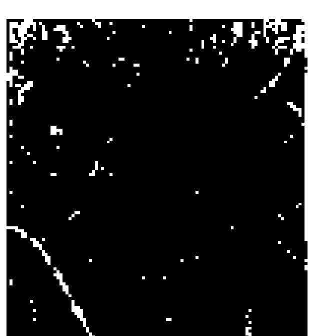

MATAMOROS ROAD
LEGEND
SHALE DRAIN SECTION A-A
HUITT-ZOLLARS
SSCAFCA
BELOW ROADWAY ELEVATION
OFF-SITE PUBLIC DISCHARGE THROUGH SITE
BELOW GROUND CISTERN
EXAMPLE #1
DRAINAGE, DRAINAGE & WATER HARVEST PLAN
DESCRIPTION
DATE
BY
REVISIONS FOR CHANGE NOTICES
SHEET
G1

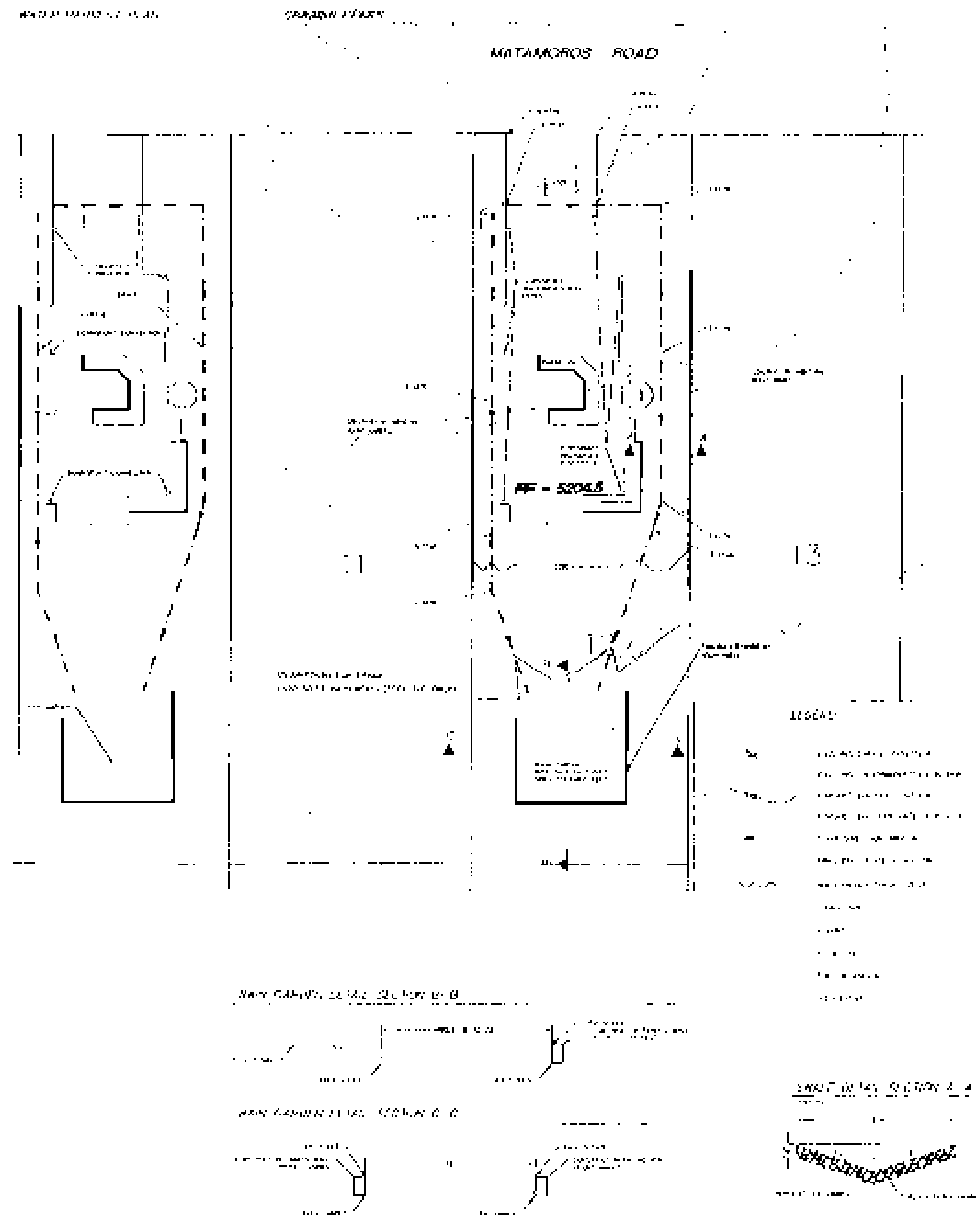
GENERAL NOTES

DRAINAGE & WATER HARVEST PLAN

OPERATIONS & MAINTENANCE

DRAINAGE CERTIFICATION





HUITT-ZOLLARS

SSCAFCA

GRADING, DRAINAGE & WATER HARVEST PLAN

BELOW ROADWAY ELEVATION
NO OFF-SITE DISCHARGE ONTO SITE
ABOVE GROUND RAIN GARDEN
EXAMPLE #2

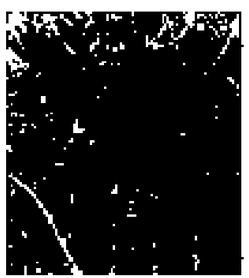
SHEET

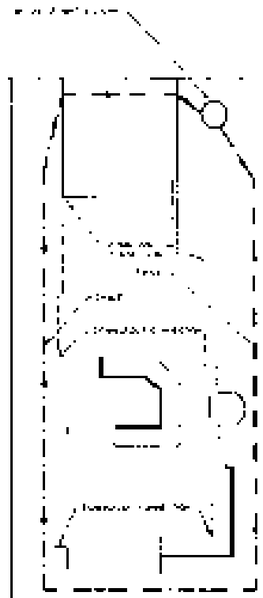
G1

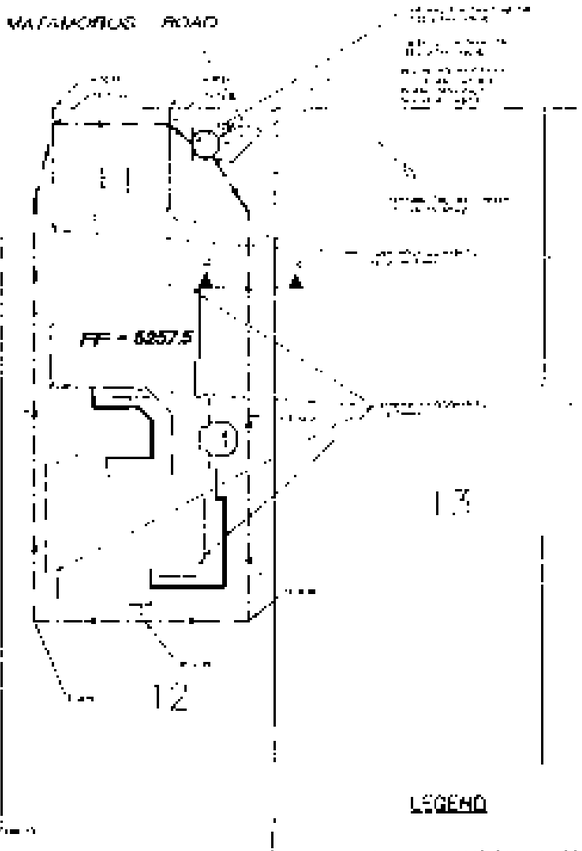
GENERAL NOTES

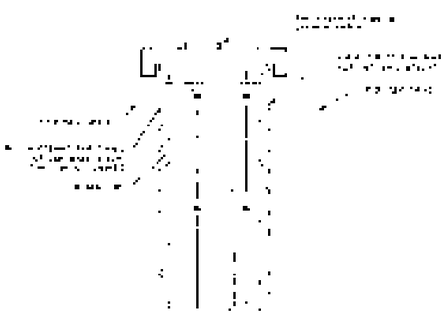
DRAINAGE & WATERSHED PLAN

DRAINAGE CONTROL PLAN

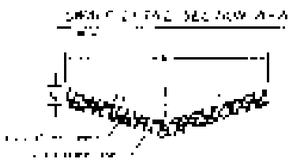








LEGEND



NO.	DESCRIPTION	BY
1	REVISED FOR CHANGE NOTICE	

HUITT-ZOLLARS

SIGNATURE

GRADING, DRAINAGE & WATER HARVEST PLAN

ABOVE ROADWAY ELEVATION
NO PUBLIC OFFSITE DISCHARGE ONTO SITE
BELOW GROUND CISTERN
EXAMPLE #3

PROJECT NO. [illegible]
DESIGNED BY JWB
DRAWN BY JWB
CHECKED BY JWB
DATE APR 23 2007
DWG CODE

SHEET

G1

BENCHMARK

XXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXX

LEGAL DESCRIPTION

LOT 12, BLOCK 112, UNIT 13, RIO RANCHO ESTATES

GENERAL NOTES

1. PRIOR TO ANY CONSTRUCTION, THE CONTRACTOR SHALL EXCAVATE AND VERIFY THE LOCATION OF ALL POTENTIAL OBSTRUCTIONS. SHOULD A CONFLICT EXIST, THE CONTRACTOR SHALL NOTIFY THE ENGINEER AS SOON AS POSSIBLE TO RESOLVE THE CONFLICT WITH A MINIMUM AMOUNT OF DELAY.
2. ALL WORK ON THIS PLAN SHALL BE PERFORMED IN ACCORDANCE WITH APPLICABLE FEDERAL, STATE AND LOCAL LAWS, RULES AND REGULATIONS CONCERNING CONSTRUCTION SAFETY AND HEALTH.
3. IF ANY UTILITY LINES, PIPELINES, OR UNDERGROUND UTILITY LINES ARE SHOWN ON THESE DRAWINGS, THEY ARE SHOWN IN AN APPROXIMATE LOCATION ONLY, AND LINES MAY EXIST WHERE NONE ARE SHOWN. THE LOCATION IS BASED UPON INFORMATION PROVIDED BY THE UTILITY OWNER OR FROM EXISTING PLANS, AND THIS INFORMATION MAY BE INCOMPLETE, OR OBSOLETE AT THE TIME OF CONSTRUCTION. THE ENGINEER HAS NOT UNDERTAKEN ANY FIELD VERIFICATION OF THESE LOCATIONS, LINE SIZES OR MATERIAL TYPE, MAKES NO REPRESENTATION THEREOF, AND ASSUMES NO RESPONSIBILITY OR LIABILITY THEREFOR. THE CONTRACTOR SHALL INFORM ITSELF OF THE LOCATION OF ANY UTILITY LINE, PIPELINE OR UNDERGROUND INSTALLATION IN OR NEAR THE AREA IN ADVANCE OF AND DURING ANY EXCAVATION WORK. THE CONTRACTOR IS FULLY RESPONSIBLE FOR ANY AND ALL DAMAGE CAUSED BY ITS FAILURE TO LOCATE, IDENTIFY AND PRESERVE ANY AND ALL EXISTING UTILITIES, PIPELINES AND UNDERGROUND FACILITIES. IN PLANNING AND CONDUCTING EXCAVATIONS, THE CONTRACTOR SHALL COMPLY WITH ALL STATE STATUTES, MUNICIPAL AND LOCAL ORDINANCES, RULES AND REGULATIONS, IF ANY, PERTAINING TO THE LOCATION OF THESE LINES AND FACILITIES.
4. THE CONTRACTOR SHALL INSURE THAT NO SOIL ERODES FROM THE SITE INTO PUBLIC RIGHTS-OF-WAY OR ONTO PRIVATE PROPERTY. THIS CAN BE ACHIEVED BY CONSTRUCTING TEMPORARY BERMS AND BY WETTING THE SOIL TO KEEP IT FROM BLOWING.
5. THE CONTRACTOR SHALL OBTAIN ANY AND ALL PERMITS REQUIRED BY CITY OF RIO RANCHO OR SANDOVAL COUNTY FOR THE COMPLETION OF THE WORK PRIOR TO BEGINNING CONSTRUCTION.
6. DISTURBED GROUND NOT INCLUDED IN THE PROPOSED DRIVEWAY OR SHOWN AS LANDSCAPING SHALL BE RESEEDED IN ACCORDANCE WITH THE APWA STANDARD SPECIFICATIONS (1101 & 1102). THE REQ'D "LOOSENING" OF THE SEEDBED AND RESEEDING SHALL BE COMPLETED AS SOON AS PRACTICAL FOLLOWING GRADING OPERATIONS.

DRAINAGE & WATER HARVEST PLAN

THE SUBJECT PROPERTY IS LOCATED ON MATAMOROS ROAD BETWEEN ... RD AND ... RD, UNIT 13 OF RIO RANCHO ESTATES. THE PLANNED IMPROVEMENTS TO THE PROPERTY INCLUDE THE CONSTRUCTION OF A NEW RESIDENTIAL HOME. AS SHOWN ON PANEL ... OF THE FEDERAL EMERGENCY MANAGEMENT AGENCY FLOOD INSURANCE RATE MAP, DATED MARCH 18, 2008, THIS SITE DOES NOT LIE WITHIN THE DESIGNATED 100 YEAR FLOOD HAZARD AREA.

ALL FLOW FROM THE ROOFTOP IS PROPOSED TO DISCHARGE INTO AN ON-SITE RAIN GARDEN AS SHOWN BELOW. THE RAIN GARDEN HAS THE CAPACITY TO ACCOMMODATE THE FIRST 1" OF RAINFALL DISCHARGING FROM THE ROOFTOP. TOTAL VOLUME BASED ON THE FIRST 1" OF RAINFALL IS 450 CUBIC FEET.

OPERATIONS & MAINTENANCE

POSITIVE GRADE OF SWALE MUST BE MAINTAINED PER APPROVED PLAN AND SWALES MUST REMAIN FREE OF SEDIMENT AND DEBRIS.

DRAIN PIPES MUST REMAIN FREE OF SEDIMENT AND DEBRIS.

RAIN GARDEN MUST REMAIN FREE OF SEDIMENT AND DEBRIS.

CISTERNS (ABOVE GROUND AND BELOW GROUND) SHALL REMAIN FREE OF SEDIMENT AND DEBRIS.

CONNECTION OF ROOF DRAINS TO CONVEYANCE SYSTEM (SWALE, DRAIN PIPE) MUST REMAIN IN PLACE AT ALL TIMES.

CISTERN PUMP MUST BE EXERCISED MONTHLY TO ENSURE OPERATION.

DRAINAGE COVENANT

THIS DRAINAGE COVENANT, BETWEEN [STATE THE NAME OF THE PRESENT REAL PROPERTY OWNER EXACTLY AS SHOWN ON THE REAL ESTATE DOCUMENT CONVEYING TITLE TO THE PRESENT OWNER AND STATE THE LEGAL STATUS OF THE OWNER, FOR EXAMPLE, "SINGLE PERSON," "HUSBAND AND WIFE," CORPORATION OF THE STATE OF X," "PARTNERSHIP"]

____

("OWNER") [HIS, HER, THEIR, OR ITS] HEIRS, EXECUTORS, SUCCESSORS, ASSIGNS AND TRANSFEREES, WHOSE ADDRESS IS

______________________________ AND

THE CITY OF RIO RANCHO, A NEW MEXICO POLITICAL SUBDIVISION ("COUNTY"), WHOSE ADDRESS IS 3200 CIVIC CENTER CIR NE, RIO RANCHO, NEW MEXICO 87144, IS MADE IN RIO RANCHO, SANDOVAL COUNTY, NEW MEXICO AND IS ENTERED INTO AS OF THE DATE OWNER SIGNS THIS EASEMENT.

THE OWNER SHALL MAINTAIN THE DRAINAGE FACILITIES ON THE WATER HARVEST PLAN SHOWN HERE ON AT OWNER'S COST IN ACCORDANCE WITH THIS APPROVED PLAN. THE CITY HAS THE RIGHT TO ENTER UPON THE PROPERTY AT ANY TIME AND PERFORM WHATEVER INSPECTION OF THE FACILITIES IT DEEMS APPROPRIATE, WITHOUT LIABILITY TO THE OWNER. THE CITY MAY SEND WRITTEN NOTICE ("NOTICE") TO THE OWNER REQUIRING THE OWNER TO CONSTRUCT, REMOVE OR REPAIR THE DRAINAGE FACILITY WITHIN 30 DAYS ("DEADLINE") OF RECEIPT OF THE NOTICE. THE OWNER SHALL PERFORM ALL REQUIRED WORK BY THE DEADLINE, AT OWNER'S SOLE EXPENSE. IF THE OWNER FAILS TO COMPLY WITH THE TERMS OF THE NOTICE BY THE DEADLINE, OR IF THE CITY DETERMINES THAT AN EMERGENCY CONDITION EXISTS, THE CITY MAY PERFORM THE WORK ITSELF. THE CITY THEN MAY ASSESS THE OWNER FOR THE COST OF THE WORK AND FOR ANY OTHER EXPENSES OR DAMAGES WHICH RESULT FROM OWNER'S FAILURE TO PERFORM. THE OWNER AGREES PROMPTLY TO PAY THE CITY THE AMOUNT ASSESSED. IF THE OWNER FAILS TO PAY THE COUNTY WITHIN THIRTY (30) DAYS AFTER THE CITY GIVES THE OWNER WRITTEN NOTICE OF THE AMOUNT DUE, THE CITY MAY IMPOSE A LIEN AGAINST OWNER'S PROPERTY FOR THE TOTAL RESULTING AMOUNT PLUS INTEREST. THE CITY SHALL NOT BE LIABLE TO THE OWNER FOR ANY DAMAGES RESULTING FROM THE CITY'S REPAIR, REMOVAL OR MAINTENANCE FOLLOWING A NOTICE TO THE OWNER AS REQUIRED IN THIS AGREEMENT OR IN AN EMERGENCY UNLESS THE DAMAGES ARE THE RESULT OF THE RECKLESS CONDUCT OR GROSS NEGLIGENCE OF THE CITY. THIS AGREEMENT SHALL CONTINUE UNTIL TERMINATED BY THE CITY. FOR PURPOSES OF GIVING FORMAL WRITTEN NOTICE TO THE OWNER, OWNER'S ADDRESS IS

____

NOTICE MAY BE GIVEN TO THE OWNER EITHER IN PERSON OR BY MAILING THE NOTICE BY REGULAR U.S. MAIL, POSTAGE PAID. NOTICE WILL BE CONSIDERED TO HAVE BEEN RECEIVED BY THE OWNER WITHIN SIX (6) DAYS AFTER THE NOTICE IS MAILED IF THERE IS NOT ACTUAL EVIDENCE OF RECEIPT. THE OWNER MAY CHANGE OWNER'S ADDRESS BY GIVING WRITTEN NOTICE OF CHANGE BY CERTIFIED MAIL, RETURN RECEIPT REQUESTED, TO THE CITY OF RIO RANCHO PUBLIC WORKS DEPARTMENT, 3200 CIVIC CENTER CIR NE, RIO RANCHO, NEW MEXICO 87144.

OWNER: ______________
BY: ______________
ITS: ______________
DATED: ______________

COUNTY OF ______________) SS

THE FOREGOING INSTRUMENT WAS ACKNOWLEDGED BEFORE ME THIS ______ DAY OF ______________, 19___, BY (NAME OF PERSON SIGNING) ______________ (TITLE OR CAPACITY, FOR INSTANCE, "PRESIDENT" OR "OWNER") ______________ OF (NAME OF ENTITY WHICH OWNS THE PROPERTY IF OTHER THAN THE INDIVIDUAL SIGNING, FOR INSTANCE, THE NAME OF THE CORPORATION, PARTNERSHIP, OR JOINT VENTURE)

MY COMMISSION EXPIRES: ______________

____
NOTARY PUBLIC

DRAINAGE CERTIFICATION

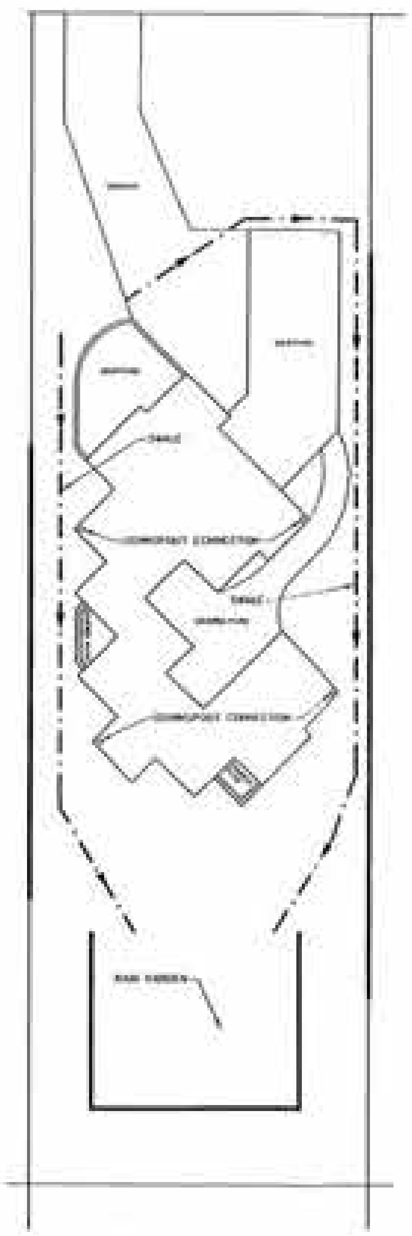
I, ______________, NMPE ______, OF THE FIRM ______________ HEREBY CERTIFY THAT THIS PROJECT HAS BEEN GRADED AND WILL DRAIN IN SUBSTANTIAL COMPLIANCE WITH AND IN ACCORDANCE WITH THE DESIGN INTENT OF THE APPROVED PLAN DATED ______________. THE RECORD INFORMATION EDITED ONTO THE ORIGINAL DESIGN DOCUMENT HAS BEEN OBTAINED BY ______________, NMPS ______ OF THE FIRM ______________. I FURTHER CERTIFY THAT I HAVE PERSONALLY VISITED THE PROJECT SITE ON ______________ AND HAVE DETERMINED BY VISUAL INSPECTION THAT THE SURVEY DATA PROVIDED IS REPRESENTATIVE OF ACTUAL SITE CONDITIONS AND IS TRUE AND CORRECT TO THE BEST OF MY KNOWLEDGE AND BELIEF. THIS CERTIFICATION IS SUBMITTED IN SUPPORT OF A REQUEST FOR A PERMANENT CERTIFICATE OF OCCUPANCY FOR THE BUILDING.

THE RECORD INFORMATION PRESENTED HEREON IS NOT NECESSARILY COMPLETE, AND INTENDED ONLY TO VERIFY SUBSTANTIAL COMPLIANCE OF THE GRADING AND DRAINAGE ASPECTS OF THIS PROJECT. THOSE RELYING ON THIS RECORD DOCUMENT ARE ADVISED TO OBTAIN INDEPENDENT VERIFICATION OF ITS ACCURACY BEFORE USING IT FOR ANY OTHER PURPOSE.

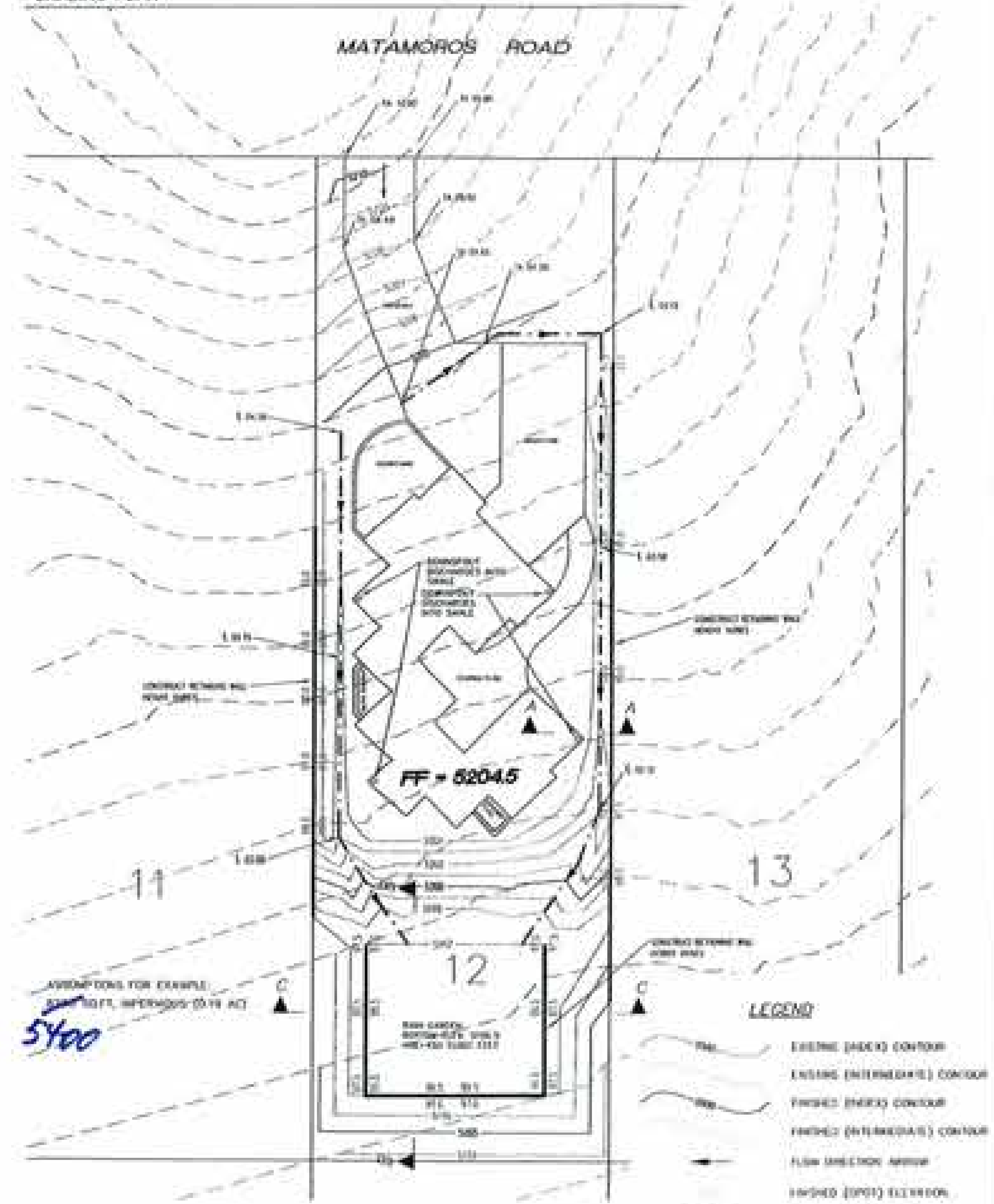
______________ (SEAL)
______________ NMPE ______
DATE

FLOOD BOUNDARY MAP   PROJECT LOCATION   RIO RANCHO CITY ATLAS PG 105

WATER HARVEST PLAN



GRADING PLAN



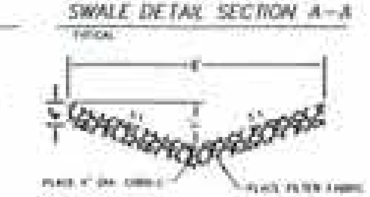
LEGEND

EXISTING (INDEX) CONTOUR
EXISTING (INTERMEDIATE) CONTOUR
FINISHED (INDEX) CONTOUR
FINISHED (INTERMEDIATE) CONTOUR
FLOW DIRECTION ARROW
FINISHED (SPOT) ELEVATION
WATERBLOCK (HIGH POINT)
DRAIN PIPE
INVERT
FLOW LINE
TOP OF ASPHALT
HIGH POINT

RAIN GARDEN DETAIL SECTION B-B

RAIN GARDEN DETAIL SECTION C-C

SWALE DETAIL SECTION A-A



Rio Rancho City of Vision

NO.	DESCRIPTION	DATE	BY
1			
2			
3			
4			
5			
6			
7			

REVISIONS (OR CHANGE NOTICES)

HUITT-ZOLLARS

SSCAFCA

GRADING, DRAINAGE & WATER HARVEST PLAN

BELOW ROADWAY ELEVATION
NO OFF-SITE DISCHARGE ONTO SITE
ABOVE GROUND RAIN GARDEN
EXAMPLE #5

PROJECT NO: 17-0917-01
DESIGNED BY: JWH
DRAWN BY: JWH
CHECKED BY: KSK
DATE: APR 29, 2011
DPW CHK:
SHEET:
G1

PROGRAMME

LEGAL DESCRIPTION

SITE HARVEST PLAN

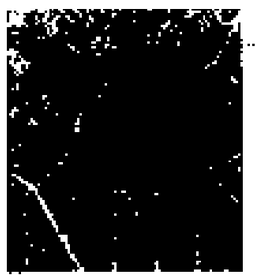
LOCATION PLAN

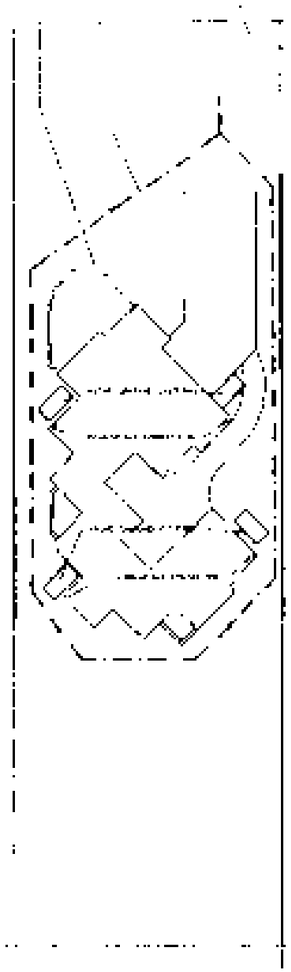
GENERAL NOTES

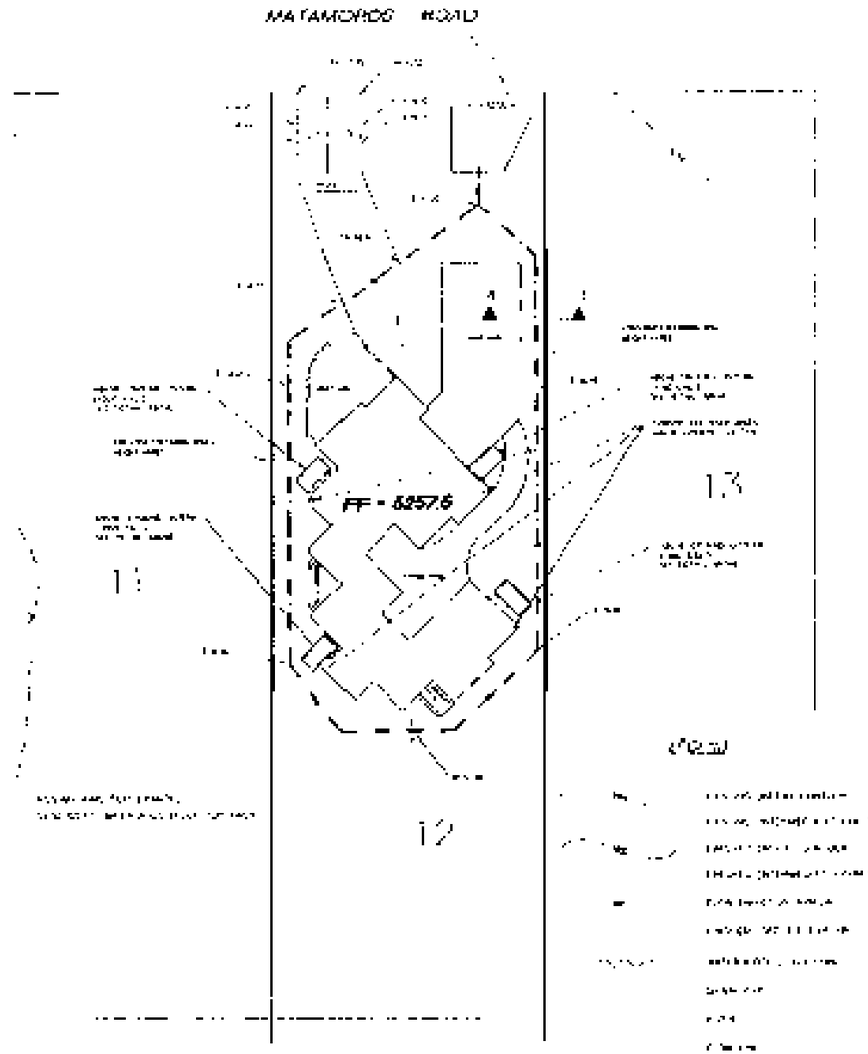
SITE SPECIFICS

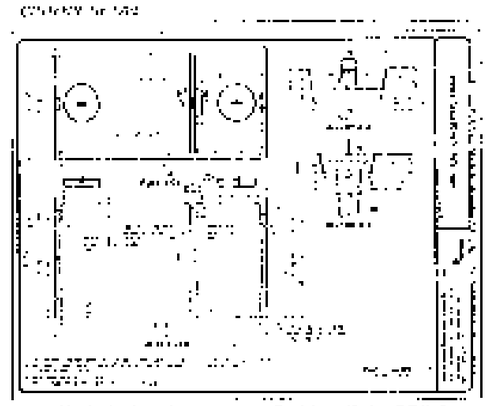
SITE USAGE & WATER HARVEST PLAN

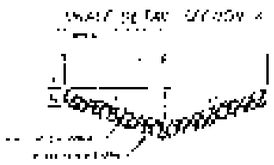
OPERATIONS & MAINTENANCE











No.	DESCRIPTION	DATE	BY
1	Revised to 10th Concept NOTIFICATION		

HUITT-ZOLLARS

SSCAFCA

SITE HARVEST PLAN

ABOVE ROADWAY ELEVATION
NO PUBLIC OFFSITE DISCHARGE CATO SITE
5 - ABOVE GROUND CISTERNS
PERVIOUS DRIVEWAY PAVEMENT
EXAMPLE #6

DATE: [illegible]
DESIGNED BY: JWH
DRAWN BY: JWH
CHECKED BY: JWH
DATE: [illegible]
DRAWING

SEPT

G1