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Evaluating Stormwater Best Management Practices in a Small Urban Watershed:

A Case Study of the Adobe Acres Drainage Basin
In Bernalillo County, New Mexico

by

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Abstract

Urban growth adversely affects water quality by increasing the amount of non-point source pollutants that are transported to receiving waters. Phase II of the National Pollutant Discharge Elimination System (NPDES) is a regulatory program designed to confront the non-point source pollution problem. Bernalillo County, New Mexico, is one of many counties that are required to identify Best Management Practices (BMPs) to control non-point source pollution under Phase II of the NPDES.

The Adobe Acres stormwater lift station drains storm flows that originate from an urban residential area in Bernalillo County and discharge to the Rio Grande. This project begins to characterize water quality for the Adobe Acres drainage basin. Understanding the quantities and sources of non-point source pollutants in Adobe Acres will help identify appropriate BMPs and give a reference point for tracking BMP success over time. The Adobe Acres basin provides an opportunity to find the most effective BMPs based on site-specific basin characteristics where land use is completely residential. Implementing BMPs on a small basin scale might be the best way to control cost on a larger scale. This project selected and analyzed four BMPs from a broad list of BMPs that Bernalillo County submitted as a requirement of the NPDES. A mix of non-structural source control BMPs that concentrate on pollution prevention along with a structural control that concentrates on pollution mitigation were selected.

There are many innovative educational BMPs that could be used in the Adobe Acres basin. Educational BMPs can raise awareness of community members to the problems of pollution in stormwater and promote positive behaviors that reduce stormwater pollution. Educational BMPs could also create a sense of community
involvement and ownership, which would have a positive effect on motivations to prevent stormwater pollution.

The Adobe Acres storm drainage system, which was installed over the last few years, has alleviated nuisance flooding in the subdivision. However, an opportunity may have been missed for the Los Padillas Detention Basin to act as a pollutant trap. The Los Padillas Detention Basin could be retrofitted in the future to improve its pollutant removal capabilities if other BMPs are not effective.

Bernalillo County is trying to develop a GIS coverage of watersheds, sub-basins and storm drainage infrastructure. This project also explored methods to delineate small urban basins using GIS.
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Introduction

Background

Stormwater is blamed for one-third of all surface water quality impairments in the United States (USEPA, 1995). The impacts on receiving waters can vary from short-term physical impacts to long-term impacts to the aquatic environment. Stormwater from urban areas is a significant source of contaminated runoff. Development and urbanization can magnify the impacts of pollutant loading from stormwater. Urbanization results in a higher percentage of impervious surfaces, which causes runoff from storm events to be amplified. Along with that increased flow, rides a wide variety of non-point source pollutants whose concentrations can be highly elevated from urban activity in developed areas.

To protect receiving waters from non-point source pollution, Congress amended the Federal Clean Water Act (CWA) in 1987 to require permits for stormwater discharges under the National Pollutant Discharge Elimination System (NPDES). The NPDES stormwater program was initiated as a phased approach with Phase I requiring cities with populations over 100,000 that operate separate storm sewers to file for a permit under the program. Under the permit, municipalities must determine to the maximum extent practicable, the extent of pollutants that are discharged from their separate storm sewers. Phase II of the NPDES program expands the criteria to include smaller municipalities that operate municipal separate storm sewer systems (MS4). In summary, Phase II regulations require that municipalities that operate MS4s that were not covered in Phase I
prepare Storm Water Quality Management Plans (SWQMPs) that identify ways to address storm water pollution, and protect water quality to the maximum extent practical. The regulations require that MS4 operators identify Best Management Practices (BMPs) to address six general topics:

1. Public Education on Impacts of Storm Water Pollution,
2. Public Involvement/Participation,
3. Illicit Discharge Detection & Elimination,
4. Construction Site Storm Water Runoff Control,
5. Post-Construction Storm Water Management in New Development and Redevelopment, and
6. Pollution Prevention/Good Housekeeping for Municipal Operations.

Bernalillo County, New Mexico, (see Figure 1), which operates a MS4, is required under Phase II of the NPDES to submit a SWQMP. The County complied with this requirement by submitting a SWQMP to the United States Environmental Protection Agency (USEPA) in March of 2003. The SWQMP included a broad list of Best Management Practices (BMPs) and measurable goals associated with each of the specific BMPs. Finding the most effective BMPs for different areas in the County is important for successful implementation of the SWQMP.

This project evaluates BMPs for a small drainage basin in Bernalillo County by comparing projected cost and pollutant removal potential for specific BMPs. Evaluating BMPs on a small basin scale might be the most efficient way to get an effective mix of BMPs on a larger scale to meet the maximum extent practicable requirement of the Phase II regulation.
Figure 1. Location of Bernalillo County, New Mexico
Objectives and Scope

The main objective of this project is to evaluate and make recommendations for BMP options for the control and mitigation of non-point source pollution in stormwater from the Adobe Acres subdivision. There are several secondary objectives.

One is to inventory and describe the resources, infrastructure, and characteristics of the Adobe Acres drainage basin with emphasis on those characteristics that influence the collection and transport of stormwater and non-point source pollution.

Another objective is to characterize stormwater quality for the Adobe Acres basin by identifying the sources and quantifying the amount of non-point source pollutants found in runoff. The data will be important as the county continues with the NPDES process over the next few years. The baseline information can be used to compare the effectiveness of BMPs as they are implemented over time. The data can be also used to develop constituent load information for other basins in Bernalillo County where monitoring may not be feasible.

A final objective is to explore automatic delineation methods for the Adobe Acres drainage basin using GIS. Bernalillo County would like to develop an accurate GIS representation of stormwater drainage basins and sub-basins. An accurate GIS coverage of stormwater drainage basins and infrastructure could help the county track NPDES Phase II requirements.
Drainage Basin Description

Urban Drainage Basin Delineation in GIS

Bernalillo County would like to develop an accurate GIS representation of stormwater drainage basins and sub-basins in the county. Accurate basin and sub-basin information will help the County as it progresses through the NPDES Phase II permit process.

In non-urban areas delineation of watersheds using geographic information systems (GIS) such as ArcView and digital elevation models (DEM)s is fairly routine. However, urban and semi-urban watersheds can be difficult to delineate because roads, homes, flood control features, and irrigation ditches influence surface water flow, but are not well represented in DEM data. Therefore, basins created automatically from DEMs that have flat areas and/or constructed drainage features may not be accurate (Maidment, 2002).

The Adobe Acres drainage basin in this project was used to test methods of delineation that could be applied to basins and sub-basins across the county since it similar to other small urban sub-basins in the county. A case study of the GIS methods used to delineate the Adobe Acres drainage basin is found in Appendix A.
Adobe Acres Drainage Basin

Adobe Acres Land Use

The Adobe Acres Subdivision is located in the southern portion of Bernalillo County, New Mexico, near Rio Bravo and Isleta Boulevards (see Figure 2). The Adobe Acres subdivision is zoned for medium density residential development. Except for the Adobe Acres Elementary School located in the eastern portion of the basin, Bernalillo County zoning ordinances limit land use in the Adobe Acres Subdivision to single family residential homes. There are approximately 550 lots in the drainage basin with an average lot size of just over 1/4 acre. The drainage basin covers approximately 218 acres.

Impervious cover is the most important land use characteristic that influences runoff in urban watersheds. Impervious area in a drainage basin is dependent on local characteristics such as population density and type of development. Impervious cover can range from as little as 10% in low-density residential areas to greater than 75% in commercial and industrial areas.

Methods to estimate impervious percentage and runoff coefficient based on population densities have been developed in other studies (USEPA, 1995). However, this project estimated the impervious percentage of the basin using ARCGIS and a sample of 37 lots. A polygon shapefile was created, then aerial photos were used to trace rooftops driveways, sheds, cement areas and roadways with a polygon drawing tool. The areas of the polygons were calculated using the calculate fields function in ARCGIS. The area of impervious area was then related to the total area of the 37 lots. The results indicate that approximately 35% percent of the area is impervious. The estimate is consistent with
Figure 2. Location of Adobe Acres Subdivision in Bernalillo County
results from equation developed and published by the USEPA to predict impervious surfaces from a given population density (USEPA, 1994). The equation predicts that an urban area with a population density of 10 people per acre would have 33% impervious area. The equation is:

**Impervious Proportion = 0.096 x population density \((0.573-0.0391 \times \log(\text{population density}))\)**

Studies have shown that impervious area of a watershed can be linked to many negative impacts on receiving water including increased pollutant loading, accelerated stream bank erosion, and biologic degradation (Davenport, 2002; Bledsoe, 2002; Swietlik, 2002; USEPA, 1995). Impervious cover reduces infiltration and subsequently increases runoff volume. As runoff flows across impervious surfaces, it accumulates pollutants, such as oil leaked from cars, that build up between storms and transports them downstream. Stream degradation can begin in watersheds with as little as 5% impervious cover. In addition, most urban streams originating from watersheds with more than 25% impervious cover cannot support diverse benthic communities (Cook et al., 2002). Since the Adobe Acres subdivision has a significant percentage of land covered with impervious surfaces, it is expected that runoff and the pollutants it carries would be elevated.

**Basin Hydrology**

Storm drainage problems have plagued the Adobe Acres subdivision since construction began in the early 1950's. The lack of elevation change in the area caused stormwater to pond in subdivision roads generating numerous complaints from
area residents (see Figure 3) (Unless otherwise stated, the author took all the photos in this report). In response to the complaints, the Bernalillo County Public Works Division (BCPWD) would pump the standing water with portable equipment after most rain events (see Figure 4) (Leedshill-Herkenhoff, 1999).

To solve the drainage problems, the BCPWD completed three phases of storm drainage improvement projects in the Adobe Acres subdivision during the 1990’s. Improvements made during the three phases included construction of:

- A stormwater collection system in the roadways of the subdivision,
- A stormwater detention facility south of the subdivision called the Los Padillas Detention Basin, and
- A stormwater lift station that pumps water from the detention basin to an existing storm drain under Isleta Blvd.

Locations of these improvements are shown in Figure 5.
Figure 5. Adobe Acres Storm Drainage Infrastructure
Storm flows now are collected by the storm drainage system and flow to the Los Padillas Detention Basin (LPDB). The basin is 2079 feet long by 50 feet wide by 10 feet deep with a maximum flood storage capacity of 16.6 acre feet. The outlet of the detention basin is a lift station equipped with two lift pumps that have a combined maximum capacity of 113 cubic feet per second (cfs). The list station is needed because of the flat nature of the area. The lift station pumps runoff into a storm drain line under Isleta Boulevard that discharges water to the Rio Grande at an outfall southeast of Adobe Acres.

The storm drainage improvements were designed to handle a 100-year, 24-hour rainfall event. The 100-year event is equivalent to 2.70 inches of rain over a 24-hour period. Hydrologic modeling predicted that the runoff from the drainage basin during a 100-year storm would be 15.78 acre feet and the maximum water depth in the LPDB would be 3.6 feet (Leedshill-Herkenhoff, 1999).
Characterizing Stormwater Quality in the Adobe Acres Basin

Bernalillo County is in the process of establishing a stormwater quality-monitoring program. The county started the program by sampling runoff from two small local thunderstorms in the Adobe Acres drainage basin in August of 2003. Preliminary data from these two events is available and presented later in this section. Since data from only two storms and no other historical data are available, a detailed characterization of Adobe Acres stormwater runoff may not be practical for this project. However, data from other stormwater quality studies in similar residential drainage basins can be used to predict the nature and extent of pollutants that will be found in the Adobe Acres drainage basin.

Characterizing stormwater runoff from urban areas can be difficult because pollutants can vary greatly in number and characteristics. Some common questions to answer when trying to characterize stormwater are:

- What are the pollutant sources?
- What are the pollutant concentrations?
- What are the pollutants of concern?

Examining these questions using examples from other studies and data from similar watersheds, then comparing the answers to the limited data from the Adobe Acres sampling should provide adequate results for characterizing Adobe Acres runoff for some common stormwater pollutants.
**What are the Pollutant Sources?**

The pollutants found in urban runoff will vary with each watershed or drainage basin. The makeup of urban runoff is heavily dependent upon land use and type of human activity in the watershed. Looking at the source of pollutants and comparing the types of activities from which they originate to the type of activities that are occurring in the Adobe Acres watershed would be a good place to start.

Many studies have tried to link specific pollutants to their sources; some of their results are summarized in Table 1. One of the most widely referenced of these studies is the Federal Highway Administration study that was done in the 1980s (Kobriger et al., 1984). The study showed that many metals found in stormwater originate from automobiles and automobile products and accessories. These contaminants can be washed directly into stormwater or attach themselves to sediments which washed away...
with runoff (Burton et al., 2002). Other studies have shown gutters to be the cause of high Zinc concentrations that were found in runoff from roofs (Burton et al., 2002).

In the Adobe Acres basin, there are many of the same pollution sources listed in the above studies. There are roadways, automobiles, landscapes, fertilizers, organic litter, animal droppings, and soil erosion. Therefore, stormwater runoff from Adobe Acres should carry many of the common pollutants that these activities create. The question is, in what concentrations?

**What are the Pollutant Concentrations?**

There have been several comprehensive studies that have characterized pollutant concentrations. One of the most frequently referenced is a study conducted in the early 1980s under the National Urban Runoff Program (NURP) (USEPA, 1994). The NURP study characterized urban runoff from 81 residential and commercial sites for more than 2,300 storm events from. Although NURP examined other pollutants, the study focused on ten pollutants that are considered standard pollutants for characterizing urban runoff (USEPA, 1994). The 10 priority pollutants are listed in Table 2.

The NURP studies found pollutant concentrations vary considerably from site to site. The study proposed that for planning purposes where local information is lacking, the best general characterization of runoff is pooled data from many sites (USEPA, 1994).

Therefore, to estimate the pollutant

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Suspended Solids (TSS)</td>
<td></td>
</tr>
<tr>
<td>Total Kjeldahl Nitrogen (TKN)</td>
<td></td>
</tr>
<tr>
<td>Biochemical Oxygen Demand (BOD)</td>
<td>Nitrate + Nitrite (N)</td>
</tr>
<tr>
<td>Chemical Oxygen Demand (COD)</td>
<td>Total Copper (Cu)</td>
</tr>
<tr>
<td>Total Phosphorus (TP)</td>
<td>Total Lead (Pb)</td>
</tr>
<tr>
<td>Soluble Phosphorus (SP)</td>
<td>Total Zinc (Zn)</td>
</tr>
</tbody>
</table>

(Source: USEPA, 1994)
concentration found runoff from the Adobe Acres basin, the mean from over 2300 NURP samples can be used as a starting point. The NURP data can be compared to data from the San Jose Drainage basin in the City of Albuquerque that has similar characteristics to the Adobe Acres basin and to preliminary sampling results from Adobe Acres runoff.

The City of Albuquerque has been sampling stormwater from several drainage basins since 1992 as part of their NPDES Phase I permit application. Of the basins the city monitors, the San Jose drainage basin has the most similar land use characteristics as the Adobe Acres subdivision (Meinz and Kelly, personal communication). A summary of data collected between 1992 and 2002 from the San Jose basin. The San Jose drainage basin is located in the south valley of Albuquerque NM. The San Jose basin is approximately two square miles and is drained by the San Jose drain. Although much larger, the San Jose basin’s residential land use is similar to that found in the Adobe Acres subdivision. However, the San Jose basin land use is about 30 to 40% commercial and industrial.

Adobe Acres Stormwater Sampling

Bernalillo County would like to build baseline stormwater quality information in preparation for NPDES Phase II activities. Two sites were selected for monitoring during the summer of 2003. The Adobe Acres lift station was selected as a sample site because it is the only site the county operates that collects runoff from a basin with 100% residential land use. The monitoring results from this site could be used to represent runoff from other county residential areas where monitoring may not be possible.
Two stormwater samples were analyzed for some common pollutants in August 2003. The author collected all samples. The samples were taken from runoff of two small thunderstorms in the Adobe Acres vicinity. The thunderstorms were both small convective cells that moved through the area quickly. There are no rain gauges in the drainage basin. Rainfall from each storm was estimated at 0.20 of an inch. The estimate was made by looking at weather service radar rainfall estimates on the internet. Samples were taken at the sump at the east end of Los Padillas Detention Basin where two of the storm conveyance pipes discharge (see Figure 6).

Figure 6. Sampling Location at the Adobe Acres Lift Station

Flow meters are not installed at the Adobe Acres lift station, making flow weighted composite sampling difficult. Therefore, the author took manual time series
composite sampling was used to get representative samples from different periods during runoff. Sub-samples of equal aliquots were collected at 10-minute intervals and poured into a larger composite container. Composite samples were analyzed for oxygen consuming materials, solids, metals, and nutrients. Grab samples were taken and analyzed for microbiological pathogens including fecal coliform and *E. coli* bacteria. The samples were analyzed by Assaigai Analytical Laboratory. Complete analytical results from the two sample dates can be found in Appendix B. A summary of the two sample sets including the same priority constituents that were presented in the NURP findings are shown in Table 3.

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Concentration</th>
<th>Sample 1</th>
<th>Sample 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Suspended Solids (TSS)</td>
<td>200</td>
<td>1840</td>
<td></td>
</tr>
<tr>
<td>Biochemical Oxygen Demand (BOD)</td>
<td>120</td>
<td>78.4</td>
<td></td>
</tr>
<tr>
<td>Chemical Oxygen Demand (COD)</td>
<td>506</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>Total Phosphorus (TP)</td>
<td>0.95</td>
<td>0.24</td>
<td></td>
</tr>
<tr>
<td>Soluble Phosphorus (SP)</td>
<td>NR</td>
<td>NR</td>
<td></td>
</tr>
<tr>
<td>Total Kjeldahl Nitrogen (TKN)</td>
<td>8.6</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td>Nitrate + Nitrite (N)</td>
<td>3.44</td>
<td>2.58</td>
<td></td>
</tr>
<tr>
<td>Total Copper (Cu)</td>
<td>0.02</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Total Lead (Pb)</td>
<td>ND</td>
<td>0.11</td>
<td></td>
</tr>
<tr>
<td>Total Zinc (Zn)</td>
<td>0.04</td>
<td>0.51</td>
<td></td>
</tr>
</tbody>
</table>

NR=Not reported ND=Not Detected

There is a noticeable variation in data from the two storms. Variations can possibly be attributed to factors such as storm frequency, storm intensity, and storm duration. All the nutrients (TKN, N, and TP) and oxygen consuming materials (BOD and COD) had higher concentrations in the first sample. This may have been a result of the long antecedent period of dry weather that preceded the storm on August 6th, 2003. The
frequency of rainstorms can affect pollution concentrations. When there are long periods between storms, pollutants build up on impervious surfaces creating higher concentrations in runoff when it does rain. Total Suspended Solids (TSS) and metals (Cu, Pb, and Zn) were higher in sample 2. This may be a result of the storm intensity.

Quality Summary

When data from the NURP, San Jose, Adobe Acres sampling are compared, some trends are noticed (see Table 4). Concentrations of all constituents except lead and copper are higher in the San Jose and Adobe Acres data when compared to the NURP mean. Lead concentrations are most likely lower in the San Jose and Adobe Acres data because of the ban on use of leaded gasoline. The NURP study was done before the ban

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>NURP Mean a mg/L</th>
<th>San Jose Drainage Basin b mg/L</th>
<th>Adobe Acres Drainage Basin c mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Suspended Solids (TSS)</td>
<td>180</td>
<td>590</td>
<td>1020</td>
</tr>
<tr>
<td>Biochemical Oxygen Demand (BOD)</td>
<td>12</td>
<td>37.2</td>
<td>145</td>
</tr>
<tr>
<td>Chemical Oxygen Demand (COD)</td>
<td>82</td>
<td>248</td>
<td>403</td>
</tr>
<tr>
<td>Total Phosphorus (TP)</td>
<td>0.42</td>
<td>1.05</td>
<td>0.60</td>
</tr>
<tr>
<td>Soluble Phosphorus (SP)</td>
<td>0.15</td>
<td>.54</td>
<td>NR</td>
</tr>
<tr>
<td>Total Kjeldahl Nitrogen (TKN)</td>
<td>1.9</td>
<td>2.93</td>
<td>6.5</td>
</tr>
<tr>
<td>Nitrate + Nitrite (N)</td>
<td>0.86</td>
<td>3.9</td>
<td>3.01</td>
</tr>
<tr>
<td>Total Copper (Cu)</td>
<td>0.04</td>
<td>0.05</td>
<td>0.04</td>
</tr>
<tr>
<td>Total Lead (Pb)</td>
<td>0.18</td>
<td>0.13</td>
<td>0.06</td>
</tr>
<tr>
<td>Total Zinc (Zn)</td>
<td>0.20</td>
<td>0.42</td>
<td>0.28</td>
</tr>
</tbody>
</table>

Sources: a) USEPA, 1995, number of samples = 2,300; b) City of Albuquerque NPDES Phase I Monitoring Program, 2003, number of samples = 27; c) Sampling results from Adobe Acres, Average of two samples, August 2003. NR=Not reported
was in complete effect. Copper concentrations in the San Jose data were slightly higher, while the Adobe Acres data were slightly lower when compared to the NURP data. The elevated levels of all other constituents might be attributed to regional or local climate. Albuquerque, which receives an average of only 8.6 inches of precipitation per year, may have higher concentrations in runoff than areas that receive more precipitation because of the build up of pollutants discussed earlier. The data also show that TSS, BOD, and COD are all higher in the Adobe Acres runoff than both the NURP and San Jose runoff. This could be a result of the limited amount of data from the Adobe Acres basin. The recent drought may have caused these concentrations to be elevated. As more samples are added over time these averages would be expected to approach the San Jose averages.

Pollution concentrations estimates can be used to estimate loading rates from the Adobe Acres drainage basin. Loading is the concentration multiplied by the total runoff volume. Since there is not a flow meter at the Adobe Acres lift station, runoff volume can be estimated from the following equation.

\[ \text{Runoff volume} = \text{Area} \times \text{Annual Rainfall} \times \text{Runoff Coefficient} \]

Runoff coefficient can be estimated from the following equation if the percent of impervious area of the basin is known (USEPA, 1995).

\[ \text{Runoff coefficient} = 0.15 (1 - \text{impervious proportion}) + 0.90 (\text{impervious proportion}) \]

The runoff coefficient was for Adobe Acres was estimated at 0.41. Runoff volume was estimated at 79,000 m³/year. Annual loading rates for the 10 pollutants were calculated for the Adobe Acres basin and are shown in Table 5.
### Table 5. Annual Pollutant Loading Rates from Adobe Acre Drainage Basin

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Loading Rate (lbs/year)</th>
<th>Loading Rate (lbs/Acre/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Suspended Solids (TSS)</td>
<td>178,000</td>
<td>815</td>
</tr>
<tr>
<td>Biochemical Oxygen Demand (BOD)</td>
<td>25,200</td>
<td>116</td>
</tr>
<tr>
<td>Chemical Oxygen Demand (COD)</td>
<td>70,200</td>
<td>322</td>
</tr>
<tr>
<td>Total Phosphorus (TP)</td>
<td>105</td>
<td>0.48</td>
</tr>
<tr>
<td>Soluble Phosphorus (SP)</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Total Kjeldahl Nitrogen (TKN)</td>
<td>1132</td>
<td>5.19</td>
</tr>
<tr>
<td>Nitrate + Nitrite (N)</td>
<td>524</td>
<td>2.41</td>
</tr>
<tr>
<td>Total Copper (Cu)</td>
<td>7</td>
<td>0.03</td>
</tr>
<tr>
<td>Total Lead (Pb)</td>
<td>10</td>
<td>0.48</td>
</tr>
<tr>
<td>Total Zinc (Zn)</td>
<td>49</td>
<td>0.22</td>
</tr>
</tbody>
</table>

NR = Not Reported

There are other important pollutants found in stormwater runoff that are commonly tested for. Fecal coliform bacteria have been routinely tested for in stormwater as an indicator of possible human pathogens. More recently, more agencies have added *E. Coli* bacteria as a monitoring parameter, believing that it may provide a better indicator of possible pathogens.

Samples from Adobe Acres were analyzed for the presence of Fecal Coliform *E. Coli* bacteria. Lab results did not give a number of colonies for *E. Coli* bacteria. Fecal Coliform results were 370,000 colonies/100ml for sample 1 and 430,000 colonies/100 ml for sample 2. These results are relatively high. However, bacteria results in stormwater can be highly variable and very high colony counts are not uncommon.

**What are the Pollutants of Concern?**

Pollutants should not be assessed based solely on a list of compounds and concentrations found in runoff. Pollutants should be assessed based on potential impact to the environment and designated uses of the receiving waters. The receiving water of runoff from Adobe Acres is the Rio Grande. The State of New Mexico Water Quality
Control Commission has established water quality standards for the Middle Rio Grande designed to protect the designated uses of the river. Designated uses for this reach of the river include: limited warm water fishery, wildlife habitat, livestock watering, irrigation, and secondary human contact. Additionally, the Pueblo of Isleta, which is directly downstream from Bernalillo County, established its own water quality standards in 1991. The Isleta standards include an additional designated use of primary human contact for ceremonial and recreation purposes.

If Adobe Acres water quality was assessed based on impact to designated uses in receiving waters, then the two most important uses to consider would be wildlife habitat and primary contact for ceremonial and recreation from the Pueblo of Isleta standards.

The impacts of stormwater on wildlife habitat are far too complex and dependent on site-specific conditions for this project to assess. However, a few generalizations can be made. Copper and other metals can pose a hazard to aquatic life and high levels can adversely affect fish populations. Excess sediments and runoff volume can cause degradation of benthic habitat.

Fecal coliform bacteria are generally accepted to be an indicator of the possible presence of human pathogens. High levels of fecal coliform bacteria could cause impairment of the primary human contact designated use for short periods after rainstorm.
Evaluating Selected BMPs for the Adobe Acres Drainage Basin

Selecting BMPs for a Systematic Watershed Approach

Managing stormwater has developed around the concept of best management practices (BMPs). BMPs are management practices, procedures, measures, or mechanisms that reduce pollution. BMPs are a widely used method for reducing and controlling human caused pollutants discussed in the previous section. BMPs for pollution control in stormwater are typically divided into two categories, structural and non-structural. Generally, non-structural controls cost less and concentrate on prevention from the source while structural controls are more expensive and concentrate on mitigation. Examples of structural and non-structural controls are shown in Table 6.

### Table 6. Examples of Structural and Non-Structural Controls

<table>
<thead>
<tr>
<th>Best Management Practice (BMP)</th>
<th>Relative Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non- Structural Controls</td>
<td></td>
</tr>
<tr>
<td>Educational/Awareness Programs</td>
<td>Low</td>
</tr>
<tr>
<td>Good Housekeeping Practices</td>
<td>Low</td>
</tr>
<tr>
<td>Ordinances and Regulations</td>
<td>Low</td>
</tr>
<tr>
<td>Structural Controls</td>
<td></td>
</tr>
<tr>
<td>Detention Basins</td>
<td>High</td>
</tr>
<tr>
<td>Retention Basins with Sand Filter</td>
<td>High</td>
</tr>
<tr>
<td>Wetlands</td>
<td>High</td>
</tr>
<tr>
<td>Retention/Infiltration</td>
<td>High</td>
</tr>
</tbody>
</table>

Early urban stormwater management theories centered on the idea of structural control methods. More recently, stormwater management has expanded to include non-structural BMPs (Horner et al., 2002). The idea of integrating both structural and non-structural strategies to manage stormwater pollution has also grown in recent years. This systematic approach for managing a watershed moves away from a simple technical
approach to one that provides controls at multiple levels creating a series of control methods.

The most effective BMPs will vary depending upon site-specific variables in the watershed such as land use, public awareness, percent of impervious area, hydrology, and others. Controlling some pollutants is more efficient with structural controls while in some cases targeted pollutants may be controlled with non-structural controls alone. Site-specific conditions and variations in pollutant loading may require a combination of non-structural source controls and structural solutions. Finding the most efficient mix of BMPs for Bernalillo County watersheds will become more and more important as the county proceeds with its municipal NPDES Phase II stormwater permit process.

Finding the most efficient mix of BMPs will also help reduce cost. Developing BMPs on a small basin scale may be the most effective way to control costs. Some basins may only need non-structural BMPs while others may need a combination of structural and non-structural BMPs. Cost information of structural BMPs and non-structural source control BMPs can be compared to develop sensible alternatives for controlling site-specific conditions (Taylor, 2003). In addition, reducing pollutants and runoff on a small scale with onsite and small watershed-level controls may reduce the need for expensive structural controls further downstream in the hydrologic system.

Applying the concepts noted above, four BMPs were selected for evaluation for the Adobe Acres drainage basin. The BMPs selected for evaluation and the NPDES general topic they address are listed in Table 7. BMPs were selected from the list of BMPs that Bernalillo County submitted as part of the SWQMP. The SWQMP and list of BMPs can be found in Appendix C. Selections were based on how the BMPs address the
Table 7. Selected BMPs for Further Evaluation

<table>
<thead>
<tr>
<th>NPDES General Topic</th>
<th>Selected BMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Public Education on Impacts of Storm Water Pollution</td>
<td>1) Educate the general public on stormwater issues via appropriate media, including brochures, flyers, pony panels, etc.</td>
</tr>
<tr>
<td>2. Public Involvement/Participation</td>
<td>No BMP selected</td>
</tr>
<tr>
<td>3. Illicit Discharge Detection &amp; Elimination</td>
<td>2) Storm drains marked to indicate that they drain to river</td>
</tr>
<tr>
<td>4. Construction Site Stormwater Runoff Control</td>
<td>No BMP Selected</td>
</tr>
<tr>
<td>5. Post-Construction Stormwater Management in New Development and Redevelopment</td>
<td>No BMP Selected</td>
</tr>
<tr>
<td>6. Pollution Prevention/Good Housekeeping for Municipal Operations</td>
<td>3) Inspect and Clean Storm Inlet/Outlet Structures 4) Stormwater quality structural BMPs</td>
</tr>
</tbody>
</table>

Six general topics in the SWQMP, the type of land use in the basin, what is currently being done that could be improved upon, selected target pollutants, and what site-specific conditions would allow for future structural control methods.

No BMPs were selected for the Adobe Acres basin for NPDES general topic two, which addresses public involvement and participation. The list of BMPs in the SWQMP did not have any BMPs that were applicable to the Adobe Acres area. No BMPs were selected for the Adobe Acres basin for general topics four and five. Topics four and five address construction and post-construction runoff from development and new development. The Adobe Acres area has no vacant areas where development is currently taking place or where future development could take place.
BMP Projected Benefits and Costs

Educational Outreach

The main goal of stormwater educational programs is to raise community awareness. In many cases community awareness on stormwater issues is low, pollution is washed off of streets into the storm drain system and is out of sight and out of mind. There are many mechanisms that can be used for public education and outreach programs. Several mechanisms and possible programs to raise community awareness on stormwater issues are listed in Table 8.

Table 8. Public Education Outreach Mechanisms and Program Examples

<table>
<thead>
<tr>
<th>Outreach Mechanism</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Media</td>
<td>Press releases, public service announcements, articles, and interviews</td>
</tr>
<tr>
<td>Educational Materials</td>
<td>Brochures, web-sites, flyers, door hangers, and posters</td>
</tr>
<tr>
<td>Community Events And Meetings</td>
<td>Speakers and distribution of educational materials at neighborhood association and public meetings</td>
</tr>
<tr>
<td>Training</td>
<td>Hazardous waste, fertilizer and pesticide, xeriscape, and water harvesting training programs</td>
</tr>
<tr>
<td>Public Involvement Programs</td>
<td>Watershed watch</td>
</tr>
</tbody>
</table>

There are many innovative examples of successful educational programs that have been developed in the United States and other countries. Some notable examples include:

1) The Grate Mate program is an inventive technique developed in Washington State in 1998 to teach people about stormwater pollution. The program utilizes a catch basin insert that is installed and removed by the same group of people 6 to 12 months later for examination. When the insert is removed, the participants see
first hand the contaminants that are washed into the storm drain system (Hrachovec, 2003).

2) A program in Dubbo, Australia, uses street theatre to reach a target audience that was not receptive to conventional educational methods. The Circus West troupe consists of students that perform scripts that were developed to explain stormwater pollution and describe the health of the local river (NSW EPA, 2003).

3) In Sacramento, California, students learn from a working stormwater model display. The interactive exhibit emulates a typical urban community and features flowing water and periodic rainstorms.

These are only a few of the many educational programs that have been developed to advance understanding and awareness about the causes and effects of stormwater pollution.

There may be several good mechanisms for educating and increasing public awareness of stormwater issues in the Adobe Acres drainage basin. Two examples are, the Adobe Acres Elementary School and the Adobe Acres Neighborhood Association.

There are not much data on the effectiveness of non-structural BMPs such as educational outreach programs. Quantifying pollution reduction from educational and community awareness programs is difficult. The American Society of Civil Engineers National Stormwater database was searched for information on educational BMPs with no results. However, studies have shown that community awareness programs do increase understanding of the causes and effects of stormwater pollution. Some studies have done surveys to measure changes in awareness from specific outreach and educational methods. The studies estimated that educational programs can raise
awareness from 10 to 50%. However, the percentage of community members that positively changed their pollution causing behaviors was generally smaller. Compared to structural control methods, most educational programs are relatively inexpensive and their success is dependent upon the design if the program, outreach mechanism, simplicity of message, and the target audience. BCPWD estimate that stormwater educational programs will cost $6,000 per year for the whole county.

**Marking Storm Drains**

Improper and illicit disposal of pollutants can contribute to pollutant loads of stormwater. In fact, the improper disposal of household hazardous chemicals, motor oils, and radiator fluids is a large problem nationwide. A 1984 survey showed that the following percentages of households disposed of the listed materials in the street or storm sewer (USEPA, 1994).

- 3% paints and thinners
- 11% used motor oil
- 83% radiator fluids

The U.S Environmental Protection Agency estimates that 135 million gallons of used oil from do-it-yourself motor oil changes are improperly disposed of each year (USEPA, 1994). In comparison, the Exxon Valdez, one of the largest maritime oil spills in U.S. history spilled 11 million gallons of oil.

Marking storm drains to indicate that they drain to river is a BMP that is listed under the 3rd general topic (Illicit Discharge Detection & Elimination) in Bernalillo County's SWQMP. However, it could also address topic #1 Public Education on Impacts of Storm Water Pollution. Raising people's awareness about storm drainage
systems and their discharge points will help prevent illicit and improper disposal of pollutants.

The Adobe Acres storm drains are marked with a logo that indicates that they drain to a river (see Figure 7). The markers were affixed to the cement surrounding the storm drain inlets during construction.

Like educational outreach programs, it may be difficult to quantify how much pollution is eliminated as a result of marking storm drains. But considering the magnitude of the problem, any reductions would be helpful. There are approximately 550 homes in the Adobe Acres drainage basin. If the percentages from the above study are used, then approximately 55 households improperly dump motor oil and over 450 households improperly dump radiator fluids in Adobe Acres.

Bernalillo County has approximately 1000 storm drains in its storm drainage system. Bernalillo County plans to affix markers to the storm drains by 2008. The cost of marking the storm drains is expected to cost $4,000 or about $4.00 each (BCPWD, 2003). Therefore, the cost to mark Adobe Acres' 137 storm drains would be $548.

**Clean Storm Drain Inlets**

Storm drain inlets, also called catch basins, are sumps or chambers built below street level under some type of grate that screens large objects. Many catch basins have a low area below the inlet pipe designed to keep coarse sediments and debris from entering...
the stormwater conveyance system. Catch basins need to be cleaned occasionally to preserve their ability to trap sediments (USEPA, 1999).

The Bernalillo County Public Works Division (BCPWD) is responsible for maintaining over 1000 storm drainage inlets. Catch basins can be cleaned manually or by using a specialized vacuum truck. The BCPWD uses a vacuum truck with a three person crew to maintain storm drain inlets (see Figure 8).

Catch basin cleaning can provide water quality benefits by reducing oxygen demanding substances and suspended solids from runoff. However, quantifying the water quality benefits generated from catch basin cleaning is difficult. Studies have estimated catch basins can capture as much as 17% of organic materials which contribute to BOD and 57% of coarse solids which contribute to TSS. Other data from the NURP studies have shown that catch basins cleaned every year and a half contained about 60 pounds of materials when they were cleaned (USEPA, 1999). However, the rate that catch basins fill with debris and sediment would be different based on local conditions and difficult to estimate on a consistent basis.

The USEPA estimates that, for planning purposes, catch basin cleaning with a vacuum system should average about $8.00 per basin cleaned. BCPWD estimates that the catch basins in the Adobe Acres area are cleaned on average once a year. In the Adobe Acres basin there are 137 inlets with catch basins, using $8.00 per basin as a
guide, the cost would be $1,096 per year. The BCPWD estimates that it will cost $9,600 per year to clean all the catch basins in the county.

Structural BMPs

The Los Padillas Detention Basin (LPDB) is considered a structural BMP. However, the design of the LPDB is different than most detention basin designs. Most detention basins collect storm flows and slowly release them over a period of 24-72 hours through a control structure and/or infiltration. The slow release of the storm water allows pollutants time to settle to the bottom of the pond. The design of LPDB results in a large percentage of storm flow being pumped directly out of the basin and into another conveyance system that is released directly into the Rio Grande. Two of the conveyance pipes discharge into a sump that is directly connected to the electric lift pumps at the east inlet of the basin (Figure 9). The configuration of the LPDB and subsequent immediate release of storm flows prevents pollutants from settling to the bottom.

The characteristics of the LPDB may make it suitable for retrofitting to include an offline retention basin or constructed stormwater wetland. Offline detention or retention systems are dual pond systems. The first pond stores a volume of runoff that infiltrates into the ground. Once that pond fills, water flows to a larger pond for flood control purposes. These types of systems have the capability of capturing the first flush of a storm event which generally carries the most pollutants. These systems also have excellent pollutant removal efficiencies if properly designed (UWIMC, 2001). Retention and infiltration of stormwater also the added benefit of groundwater recharge. In
Figure 9. Inlet Locations at the Los Padillas Detention Basin

Bernalillo County groundwater recharge is desirable because of aquifer water-level draw downs from municipal and residential pumping.

A constructed stormwater wetland may be possible in the LPDB. The detention basin is about 10 feet deep and the bottom of the basin is close to the groundwater table. In several places in the basin species such as cattails have infested areas that appear to be saturated near the surface. This may provide a constant source of water for constructed wetlands. However, wetlands may have some disadvantages. The recent outbreak of West Nile virus in New Mexico has raised concerns over wet areas that may provide a breeding ground for mosquito populations. Wetlands also require a constant source of water, which could cause more evaporation when compared to offline retention system.
Excess evaporation may not be politically popular since water conservation has become an important issue in the area.

Retrofitting the Los Padillas Detention Basin has the potential of reducing pollutants. Water quality benefits of an offline dual pond retention system would depend on the size of retention pond (first pond) that could be built. If the pond were large enough, some small storms could be totally captured and infiltrated which would be 100% pollutant reduction. Overflow from storms large enough to overflow the first pond would receive additional treatment though settling processes in the second pond.

Physical, chemical, and biological processes drive pollutant removal in constructed wetlands. The major physical removal mechanism for pollutants in wetlands is sedimentation. Suspended solids, heavy metals and particulate nitrogen are removed when particulates settle in low velocity slow moving water. (USEPA, 1994). Because of design factors, seasonal variability, and plant species, constructed wetlands can have wide variations in their ability to remove pollutants (UWIMC, 2001). Removal rates for offline retention and constructed wetlands from studies in Florida are shown in Table 9.
Table 9. Removal Rates for Offline Retention and Stormwater Wetlands in Florida

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Removal Rate (%)</th>
<th>Offline Retention</th>
<th>Wetlands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Suspended Solids (TSS)</td>
<td>92</td>
<td>67*</td>
<td></td>
</tr>
<tr>
<td>Biochemical Oxygen Demand (BOD)</td>
<td>77</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Chemical Oxygen Demand (COD)</td>
<td>NR</td>
<td>NR</td>
<td></td>
</tr>
<tr>
<td>Total Phosphorus (TP)</td>
<td>84</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>Soluble Phosphorus (SP)</td>
<td>79</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td>Total Kjeldahl Nitrogen (TKN)</td>
<td>83</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>Nitrate + Nitrite (N)</td>
<td>92</td>
<td>94</td>
<td></td>
</tr>
<tr>
<td>Total Copper (Cu)</td>
<td>66</td>
<td>79</td>
<td></td>
</tr>
<tr>
<td>Total Lead (Pb)</td>
<td>NR</td>
<td>83</td>
<td></td>
</tr>
<tr>
<td>Total Zinc (Zn)</td>
<td>86</td>
<td>84</td>
<td></td>
</tr>
</tbody>
</table>

(Sources: UWIMC, 2001 *USEPA, 1999) NR=Not reported

The cost of building a retention system or offline retention system is estimated at $25,000 per acre excluding land costs (UWIMC, 2001). The LPDB is approximately 2.4 acres which would be $60,000. In many cases retrofitting can cost more than new construction. However, since the basin is already shaped, it may only require building a weir or control structure across the basin and modifying the east inlet pipes to discharge further to the west (see Figure 10). Therefore, the cost estimate may be reasonable.
Benefit Cost Summary

The BMPs selected have a wide range of costs and benefits (see Table 10). The costs and benefits of educational BMPs may be the most difficult to assign dollar values to on a small scale. Some educational programs such as media campaigns and brochures will be intended for a countywide audience.
Table 10. BMP Cost Benefit Summary

<table>
<thead>
<tr>
<th>BMP</th>
<th>Costs</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Educational and Awareness Programs</td>
<td>$6,000</td>
<td>Creates sense of ownership by community members</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Can be flexible as awareness grows and needs change</td>
</tr>
<tr>
<td>Marking Storm Drains</td>
<td>$548</td>
<td>Prevents improper and/or illicit disposal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Can reduce petroleum products</td>
</tr>
<tr>
<td>Clean Storm Drains</td>
<td>$1,096/yr</td>
<td>Can reduce BOD TSS and metals</td>
</tr>
<tr>
<td>Structural BMPs</td>
<td>$60,000</td>
<td>Good pollutant removal ability for all pollutants</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Additional benefit of aquifer recharge</td>
</tr>
</tbody>
</table>

Retrofitting the LPDB basin to increase stormwater retention time and infiltration would have the added benefit of recharging groundwater. Approximately 64 acre-feet of water a year could be added to the aquifer if all runoff was retained and infiltrated. The current purchase price for an acre-foot of water in the Middle Rio Grande is $4,000 to $6,000. Therefore, the dollar value of the additional benefit could be from $256,000 to $384,000.
Recommendations

Bernalillo County should continue monitoring stormwater from the Adobe Acres basin. A larger data set is needed that represents a variety of storms, dry periods, and seasonal variations.

Educational and public awareness BMPs may be the most flexible of the BMP options evaluated for the Adobe Acres basin. Educational BMPs are limited only by the imagination of people involved in establishing the programs. Educational BMPs may be the most effective way to get people to take ownership of their watershed and their communities. Although it may be hard to quantify the long term pollution reduction benefits of educational BMPs, benefits keep accumulating over time, suggesting that the sooner they are implemented the greater the long term benefit. The long-term benefit of having knowledgeable people who care about their community is vital to the continued success of programs. Once the knowledge is gained and people take ownership in their watershed, the knowledge is shared and passed on to friends, family, and children.

There are good outreach mechanisms available in the Adobe Acres basin. Bernalillo County should start educational BMPs in the Adobe Acres basin as soon as possible to delay the possibility of having to add more expensive structural BMPs later. A beginning educational program and methods to measure effectiveness for the Adobe Acres is presented in Table 11.
Table 11. Recommended Educational Program for Adobe Acres

<table>
<thead>
<tr>
<th>Targeted Group</th>
<th>Educational Instrument</th>
<th>Targeted Behavior</th>
<th>Method to Measure Effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adobe Acres Neighborhood Association</td>
<td>Brochures</td>
<td>Littering</td>
<td>Surveys</td>
</tr>
<tr>
<td></td>
<td>Brochures</td>
<td>Improper disposal of wastes</td>
<td>Track proper disposals for increases and surveys</td>
</tr>
<tr>
<td>Training</td>
<td>Training</td>
<td>Proper fertilizer use</td>
<td>Surveys</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Impervious area disconnection and on-site storage</td>
<td>Track number of projects</td>
</tr>
<tr>
<td>Adobe Acres Elementary School</td>
<td>Hands on demonstration</td>
<td>Littering</td>
<td>Feedback from teachers</td>
</tr>
</tbody>
</table>

Marking storm drains to indicate they drain to the river should also be emphasized in an educational program. The storm drains and markers are new to the area, so many people may not have seen them yet. Reminding people what the marker looks like and what it means would help increase understanding.

The maintenance and cleaning of storm drain inlets is helping stormwater quality in the Adobe Acres basin and should be continued as needed to keep the conveyance system operating efficiently.

A feasibility study that explores the possibility of retrofitting the LPDB should be completed. The LPDB could provide an opportunity to mitigate non-point source pollution through natural processes such as settling and infiltration. If the value of groundwater recharge is considered, retrofitting the basin might become desirable.

**Implications for Other Bernalillo County Basins**

The issues identified in the Adobe Acres basin have implications for stormwater management and planning in other county basins.
Watershed information can be stored and tracked in a GIS format. Contact information for neighborhood associations, schools and watershed groups can be accessed on a basin-by-basin basis. A history of implemented BMPs and water quality monitoring results could also be stored in a spatial format to track trends as they develop.

Educational packages could be designed to target specific groups. If groups are identified on a small enough watershed scale such as an elementary school, then the appropriate educational program can be identified and implemented.

Maintenance schedules for storm drain inlet cleaning could be studied to find the most efficient schedules based on seasonal runoff conditions. Identifying the areas where trash and sediment build-up is the worst and cleaning those areas before the seasonal monsoon rains may provide additional benefits.

Engineering philosophy has been to design for extreme events and get rid of runoff as fast as possible. In the rush to satisfy the goals of lowest cost, flood control and flood insurance issues, managing stormwater for quality purposes is sometimes secondary. This approach could result in missed opportunities to protect water quality that may have long-term intangible costs that are hard to foresee. Water quality alternatives need to be addressed in the budgeting and engineering phases of future project development. New drainage and engineering projects should have pollution reduction options priced and considered when in design phase. Retrofitting existing structures will inherently cost more than incorporating them in the design phase. To reduce the impacts of stormwater discharges from Bernalillo County storm drainage facilities, flood control projects should be designed with feature that allow maximum pollutant removal by mimicking natural processes whenever possible. An integrated
systems approach that combines both structural and non-structural elements by preventing pollution from the sources and using natural processes to mitigate pollution on a small basin scale may be the most efficient and cost effective method to comply with NPDES requirements.
Appendix A. A Case Study Evaluating Watershed Delineation Methods for the Adobe Acres Lift Station Sub-basin
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Introduction and Objectives

The main goal of this case study was to find a watershed delineation method for small Bernalillo County watersheds using an ARCGIS or Arcview platform and data currently available on the county's GIS system. The county in would like to develop an accurate GIS representation of stormwater drainage basins and sub-basins. However, developing accurate representations of its stormwater drainage basins using GIS can be more difficult in urban areas because infrastructure such as storm sewers and roadways interferes with natural drainage patterns. The County expects that in the future, it will have to comply with the NPDES Phase II program for its MS4. An accurate GIS representation of its stormwater infrastructure and sub-basins will be helpful in developing and maintaining NPDES a compliance program. Although the county has a GIS representation of some larger watersheds, it does not have an accurate GIS coverage for smaller sub-watersheds. In addition, the stormwater infrastructure coverage is incomplete and accuracy is inconsistent. An accurate, efficient method for sub-basin delineation could be duplicated for all the basins and sub-basins in the county.

This study focuses on delineation of the Adobe Acres lift station drainage basin in the Bernalillo County area. The Adobe Acres subdivision is typical of many urban areas in the Albuquerque area. The area is crossed by irrigation and drainage ditches that are elevated, creating natural barriers to drainage. The area relies completely on a storm drainage system that crosses underneath the irrigation ditches in a couple of places. The lessons learned in this case study could be used as the county proceeds in defining the remainder of sub-basins in the county.
Methodology

- One-foot Digital Elevation Model (DEM) data created from LIDAR radar were used as an input grid.
- Arcview 3.2, ARCGIS 8.1, ARC HYDRO and the TOPAGNPS script were used to perform drainage analysis and watershed delineation on the Adobe Acres lift station drainage area.
- Automatic delineations were compared to a manually delineated basin that was completed using one-foot contour lines and field observations.

Data Sources and Projections:

Unless otherwise noted all data came from data that are currently stored on the Bernalillo County Public Works Division GIS server. The data have been generated internally and compiled from other agencies over the last several years. Most data are stored as shapefiles except for LIDAR which is grid based. The projections used for all Bernalillo county data is UTM NAD 83 Zone 13. A list of shapefiles and grids used for this study is available in the references and data dictionary section. All data used is not available for download. However, data may be requested by contacting Bernalillo County Public Works Division.

Watershed Delineations

DEMs are grid based representations of elevation. Delineation of watersheds from DEM data is done using a cell based model in which each cell is connected to one of its eight neighbor cells, two vertically, two horizontally, and four diagonally (Maidment, 1996). GIS software defines flow characteristics by creating flow direction and flow accumulation grids from the DEM data. The flow direction and flow accumulation grids
can be used to define a stream network and watershed boundaries. A conceptual model as seen in the software help system of the GIS watershed processing is shown in Figure A-1.

Figure A-1. Conceptual Flowchart Model of GIS Watershed Processing from DEMs

A grid was constructed for the Adobe Acres Subdivision vicinity by joining four sections of LIDAR DEMs available on the county GIS server (Figure A-2). The DEM was processed using the DEM reconditioning function in the terrain processing tools on the ArcHydro tool bar extension.
If a cell does not have one lower than it, it is considered a sink since it has no outlet or pour point. It is important that sinks in a DEM are filled before delineating watersheds or performing hydrological analysis. Sinks in DEM data can cause parts of the stream network to be missing or disconnected which would cause the delineated watershed to be inaccurate. Sinks in the Adobe Acres area DEM were filled using the terrain processing functions on the ArcHydro toolbar.

Figure A-2. Digital Elevation Model of the Adobe Acres Subdivision Vicinity

Water flow direction is assigned according to the direction of steepest descent of the eight surrounding cells assuming that each cell has at least one cell touching it that is...
lower than the original cell. A flow direction grid was created for the Adobe Acres area using the DEM as an input grid (Figure A-3).

Figure A-3. Flow Direction Grid for the Adobe Acres Subdivision Vicinity

ARCGIS calculates flow accumulation grids by counting the number of cells upstream of a given cell on the flow direction grid. A flow accumulation grid was
constructed for the Adobe Acres drainage basin using ArcHydro (Figure A-4)

Figure A-4. Flow Accumulation Grid for the Adobe Acres Subdivision Vicinity

ARCGIS identifies streams as connected cells whose flow accumulation exceeds a specified number of cells specified by the modeler to size an upstream drainage area. Stream networks were generated for the Adobe Acres area using the flow direction and flow accumulation grids created from the earlier steps using cell area for drainage area (Figure A-5).
Watersheds in ARCGIS are found by identifying the contributing area of cells that drain through a given cell or outlet point. Several attempts to delineate watersheds using different methods and different outlet points were completed. The resulting outputs are summarized in the following section.

Results

A manually generated drainage basin was made by creating a polygon shapefile using ArcCatalog. A watershed boundary was made by manually drawing and editing a polygon using the editor tool bar in ARCGIS. One-foot contour intervals available on the Bernalillo County GIS server were used as elevation guides to find limits of the drainage...
area. The manually created basin was used to compare basins created from automatic different delineation methods.

ArcHydro was used to try to create a system of small watersheds using storm drain inlets as watershed outlet points. ArcHydro was used to create batch points that matched the location of storm drain inlet locations. The watersheds were delineated using the batch points and the watershed processing features of ArcHydo. The resulting watersheds were very small and did not join together. The stream grid did show some resemblance to roadways in the basin and some storm drains did overlay the stream network (Figure A-6). However, the results were inconsistent.

Figure A-6. Adobe Acres Area Streams and Storm Drain Inlets
The TOPAGNPS tool is a Visual Basic 6.0 Script created by Huaguo Xiao and Xiaoyong Zhan. It is available for download at http://arcscripts.esri.com/. The tool customizes the spatial analyst toolbar and allows the user to fill sinks in DEM data, create flow direction and flow accumulation grids, and delineate watersheds. It also allows the user to delineate watersheds from a user-defined point. The user defined point function of the TOPAGNPS tool was used to delineate a watershed with the outlet point at the stream intersection where the Adobe Acres lift station is located. The resulting watershed was the closest to the manually generated watershed (Figure A-7).

![Figure A-7 Watershed Created with TOPAGNPS Tool](image.png)

The delineation recognized the man-made barrier of the irrigation ditch that bisects the subdivision from the northeast to southwest. However, the delineated
watershed extended past some man-made barriers such as Rio Bravo Boulevard and had no way to recognize the sewer inlets that contribute to flows from the northwest of that ditch.

**Lessons Learned**

- Creating stream networks from DEMs created from LIDAR did a good job representing some man-made features such as roads and irrigation ditches. However, some features were not recognized and it was unclear why.

- The flat nature of the Adobe Acres area terrain combined with constructed irrigation and drainage channels made accurate automatic delineation difficult using the LIDAR, DEM data, delineation programs, and scripts used in this project.

- For small basins, it is more difficult and takes more time to combine and edit automatically generated watersheds compared to manually generating watersheds using contour lines.

- For basins with storm drainage infrastructure, an accurate representation of the infrastructure is needed to manually delineate the watershed.
Appendix B. Laboratory Results from Adobe Acres Stormwater Sampling
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<td>EPA-160.2</td>
<td>Total Suspended Solids</td>
<td>1940</td>
<td>mg/L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC ADOBE ACRES AA2</td>
<td>8/25/2003 12:00 KB</td>
<td>EPA-418.1</td>
<td>Total Recoverable Petroleum Hydrocarbons</td>
<td>TRPH</td>
<td>ND</td>
<td>mg/L</td>
<td></td>
</tr>
</tbody>
</table>
Appendix C. Bernalillo County Stormwater Quality Management Plan BMPs
BERNALILLO COUNTY
STORM WATER QUALITY
MANAGEMENT PLAN

Submitted as a Requirement of the National Pollution Discharge
Elimination System NPDES Phase II Regulation

March 10, 2003
1.0 Public Education and Outreach on Storm Water Impacts

1.1 Permit Requirement. You must implement a public education program to distribute educational materials to the community or conduct equivalent outreach activities about the impact of storm water discharges on water bodies and the steps that the public can take to reduce pollutants in storm water runoff.

Bernalillo County (County) will conduct an educational outreach program to the general public regarding the impact of storm water discharges and mitigation factors via appropriate media, including brochures, flyers, pony panels, etc. The County will also make available “household hazardous waste wheels” that provide information on reducing the use of hazardous materials in the home and a reminder that this reduction also impacts storm water. These wheels will be distributed during our household hazardous waste quarterly collection events and available at the hazardous waste collection center. Specific audiences, such as restaurant and pet owners, will be advised of their impact on storm water during the licensing process.

1.2 Decision process. You must document your decision process for the development of a storm water public education and outreach program. Your rationale statement must address both your overall public education program and the individual Best Management Practices (BMPS), measurable goals and responsible persons for your program. The rationale statement must include the following information, at a minimum:

1.2.1 How you plan to inform individuals and households about the steps they can take to reduce storm water pollution.

The County will conduct an educational outreach program to the general public regarding the impact of storm water discharges and mitigation factors via appropriate media, including brochures, flyers, pony panels, etc. Storm drains will also be marked to indicate that they drain to the river.

Currently, the County, along with the City of Albuquerque, conducts quarterly household hazardous waste collection events. We also contract with a local hazardous waste company that operates a stationary collection center whose services are available to the public. The County will make available “household hazardous waste wheels” that provide information on reducing the use of hazardous materials in the home and reminder that this reduction also impacts storm water at these events. Specific audiences, such
as restaurant and pet owners, will be advised during the licensing process of how grease and oil and pet waste impact storm water.

1.2.2. How you plan to inform individuals and groups on how to become involved in the storm water program (with activities such as local stream and beach restoration activities).

Prior to developing our BMPs, four public meetings were held in which the public was invited to share their ideas about achievable BMPs. When we did not receive any comments from the public, each department within the County submitted BMPs for their department. After developing the BMPs we held two public meetings to inform the public and engage them in discussion. Again, attendance was minimal. Once the permit application is submitted, we will continue to conduct outreach and educational sessions about storm water with neighborhood associations, public interest and impacted industry groups.

1.2.3. Who are your target audiences for your education program who are likely to have significant storm water impacts (including commercial, industrial and institutional entities) and why those target audiences were selected.

Our target audiences for our educational program include the general public and restaurant and pet owners. We will also conduct educational outreach to the construction industry. These target audiences were selected based on how the Phase II Storm Water regulations will impact them.

1.2.4. What are the target pollutant sources your public education program is designed to address.

The County has identified pet waste, floatables, and drainage and grading (erosion and sediment) as our target pollutant sources. Based on a study begun in 2000, fecal coliform readings sometimes exceed total maximum daily loads in the Middle Rio Grande. Sources of fecal coliform included waste from pets and other domestic animals. Floatables enter the storm drainage system from poorly contained solid waste. Often the wind in the region is strong and gusts over 30 mph are not uncommon. Reducing the amount of floatables that make their way into the

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storm drain system and into waters of the United States is a priority. Due to the intensity of storm events, the high volume of water delivered to storm drain facilities in a brief period of time and the high velocity of flood flows, sediment loads are of great concern from a water quality and facility maintenance perspective.

1.2.5 What is your outreach strategy including the mechanisms (e.g., printed brochures, newspaper, media, workshops, etc.) you will use to reach your target audiences, and how many people do you expect to reach by your outreach strategy over the permit term.

One outreach strategy will be the distribution of throughout the County of brochures and flyers at environmental fairs that are held several times a year. These fairs draw approximately 100-200 attendees. Pony panels will be exhibited at least twice a year during the permit term.

Other means of outreach include the County’s Animal Control licensing and permitting process. Animal Control issues approximately 6,000 licenses and permits per year to pet owners/breeders. The County’s Environmental Health Section issues approximately 450 permits to restaurant owners. Both of these target audiences will be advised during the licensing process of how wastes (pet waste and grease and oil, respectively) impact storm water. The County’s Public Works Division (PWD) will also apply approximately 1000 curb markers near storm drains that read “No Dumping - Drains to the Rio Grande.”

The County, along with the City of Albuquerque, conducts quarterly household hazardous waste collection events. We also contract with a local hazardous waste company that operates a stationary hazardous waste collection center whose services are available to the public. During these events and at the Collection Center the County will make available “household hazardous waste wheels” that provide information on reducing the use of hazardous materials in the home and reminder that this reduction also impacts storm water.

The PWD annually issue 16 drainage and grading permits for construction projects that impact one-acre or more. Public Works will provide information to construction companies as part of the permitting process, and will also conduct training for staff, contractors, and consulting engineers.

1.2.6 Who is responsible for overall management and implementation of your storm water public education and outreach program and, if
different, who is responsible for each of the BMPs identified for this program.

The PWD will be responsible for oversight of the public education and outreach program targeted to the general public and construction activities.

1.2.7 How will you evaluate the success of this minimum measure, including how you selected the measurable goals for each of the BMPs.

The County will implement the following BMPs under this minimum measure and evaluate the success of BMP in the following manner:

<table>
<thead>
<tr>
<th>BMP</th>
<th>Measurable Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Educate the general public on storm water issues via appropriate media, including brochures, flyers, pony panels, etc.</td>
<td>Distribute information to the public via civic events, environmental fairs, office distribution, etc.</td>
</tr>
<tr>
<td>Inform pet owners and pet related business of impact of pet waste on storm water.</td>
<td>The application will contain information on the impact of pet waste on approximately 6000 licenses/permit per year.</td>
</tr>
<tr>
<td>Septic System/Alternative Systems (Training and Outreach).</td>
<td>Number of wastewater evaluators receiving certification and number of flyers/brochures distributed to public.</td>
</tr>
<tr>
<td>Inform restaurant owners of impact of improper disposal of grease and oil on storm water.</td>
<td>Permits (approximately 450 issued each year) will include information on BMPs for proper disposal of grease and oil.</td>
</tr>
<tr>
<td>Increase awareness of storm water issues at Household Hazardous Waste Collection Center.</td>
<td>Number of household hazardous waste wheels distributed at Collection Center.</td>
</tr>
<tr>
<td>Provide information on storm water quality and BMPs to the public on the County Web page.</td>
<td>Number of visitors to storm water quality information section of the web site.</td>
</tr>
<tr>
<td>Provide receptacles for plastic bags for pet waste collection.</td>
<td>Reduction in pet waste observed by staff.</td>
</tr>
<tr>
<td>Install signs reminding pet owners to pick up after their pets.</td>
<td>Reduction in pet waste observed by staff.</td>
</tr>
</tbody>
</table>

Given the County's extremely limited resources, these measurable goals were selected based upon the total population impacted and the low cost and ease of implementation.

2.0 Public Involvement/Participation

2.1 Permit requirements. You must at a minimum, comply with State, Tribal, and local public notice requirements when implementing a public involvement/participation program.

2.2 Decision process. You must document your decision process for the development of a storm water public involvement/participation program. Your rationale statement must address both your overall public involvement/participation program and the individual BMPs, measurable
goals and responsible persons for your program. The rationale statement must include the following information, at a minimum:

2.2.1 How you have involved the public in the development and submittal of your Notice of Intent (NOI) and storm water management program.

Prior to the development of our Storm Water Quality Management Program (SWQMP), the County sponsored four meetings to receive public input. Over 800 flyers were sent to neighborhood associations, homebuilders associations, and other community organizations in September and October of 2002. Fewer than 10 participants attended the meetings. After each department submitted their BMPs, two additional meetings were held to give the public an opportunity to participate in the decision-making process. Over 200 notices were sent to neighborhood associations and other civic groups. The meetings were advertised in area newspapers and less than a total of twenty individuals attended both meetings. In addition to these meetings, PWD Technical Planning staff met on several occasions with the Central New Mexico Homebuilder's Associations and the Associated General Contractors to discuss the construction and post-construction section of the proposed regulations. Also, two public hearings were convened as part of the Storm Drainage Ordinance revision process.

2.2.2 What is your plan to actively involve the public in the development and implementation of your program.

The County will continue to engage the public through public meetings and exhibits at environmental events. Storm water information will also be available on the County website and distributed at our offices. Additional information will be available at the Hazardous Waste Collection Center and during hazardous waste collection events.

2.2.3 Who are the target audiences for your public involvement program, including a description of the types of ethnic and economic groups engaged. You are encouraged to actively involve all potentially affected stakeholder groups, including commercial and industrial businesses, trade associations, environmental groups, homeowners associations, and educational organizations, among others.

Our target audiences are the general public via homeowner associations and environmental groups, the construction industry, restaurant owners and pet owners. The County's population is
58.0% Non-Hispanic and 42.0% Hispanic, according to 2000 Census data.\textsuperscript{b} The median household income in Bernalillo County is $38,788 with 10.2% of the population living below the poverty level.\textsuperscript{c}

2.2.4 What are the types of public involvement activities included in your program. Where appropriate, consider the following types of public involvement activities.

2.2.5 Citizen representatives on a storm water management panel.

2.2.6 Public hearings.

2.2.7 Working with citizen volunteers willing to educate others about the program.

2.2.8 Volunteer monitoring or stream/beach clean-up activities.

The County will continue to engage the public through public meetings, exhibits at environmental events, storm water information available on the County website, and information distributed through our offices. Additional information will be available at the Hazardous Waste Collection Center and during hazardous waste collection events.

2.2.9 Who is responsible for the overall management and implementation of your storm water public involvement/participation program and, if different, who is responsible for each of the BMPs identified for this program.

The PWD will be responsible for the overall management and implementation of the SWQMP.

2.2.10 How will you evaluate the success of this minimum measure, including how you selected the measurable goals for each of the BMPs.

The County will implement the following BMPs under this minimum

\textsuperscript{b} Consensus 2000 P.L. 94-171 Redistricting Data (University of New Mexico, Bureau of Business & Economic Research).

\textsuperscript{c} U.S. Census Bureau website, 2000 census data for Bernalillo County.
measure and evaluate the success of these BMP in the following manner:
Given the County’s extremely limited resources, these measurable goals were selected based upon the total population impacted and the low cost and ease of implementation.

### 3.0 Illicit Discharge Detection and Elimination

#### 3.1 Permit requirement. You must:

1. Develop, implement and enforce a program to detect and eliminate illicit discharges (as defined in 40 CFR §122.26(b)(2)) into your small Municipal Separate Storm Sewer System (MS4);

2. Develop, if not already completed, a storm sewer system map, showing the location of all outfalls and the names and location of all waters of the United States that receive discharges from those outfalls;

3. To the extent allowable under State, Tribe or local law, effectively prohibit, through ordinance, or other regulatory mechanism, non-storm water discharges into your storm sewer system and implement appropriate enforcement procedures and actions;

4. Develop and implement a plan to detect and address non-storm water discharges, including illegal dumping, to your system;

5. Inform public employees, businesses, and the general public of hazards associated with illegal discharges and improper disposal of waste; and

6. Address the following categories of non-storm water discharges of flows (i.e., illicit discharges) only if you identify them as significant contributors of pollutants to your small MS4: water line flushing, landscape irrigation, diverted stream flows, rising ground waters, uncontaminated ground water infiltration (as defined at 40 CFR 35.2005 (20)), uncontaminated pumped ground water, discharges from potable water sources, foundation drains, air conditioning condensation, irrigation water, springs, water from crawl space pumps, footing drains, lawn watering, individual residential car washing, flows from riparian habitats and wetlands, dechlorinated swimming pool discharges, and street wash water (discharges or flows from fire fighting activities are excluded from the effective prohibition...
against non-storm water and need only be addressed where they are identified as significant sources of pollutants to waters of the United States).

The County has not identified water line flushing, landscape irrigation, diverted stream flows, rising ground waters, uncontaminated ground water infiltration (as defined at 40 CFR 35.2005 (20)), uncontaminated pumped ground water, discharges from potable water sources, foundation drains, air conditioning condensation, irrigation water, springs, water from crawl space pumps, footing drains, lawn watering, individual residential car washing, flows from riparian habitats and wetlands, dechlorinated swimming pool discharges, and street wash water as significant contributors of pollutants to our small MS4. The significant contributors of pollutants in Bernalillo County are animal and pet waste (fecal coliform bacteria), floatables, and drainage and grading (erosion and sediment).

3.1.7 You must also develop a list of other similar occasional incidental non-storm water discharges (e.g., non-commercial or charity car washes, etc.) that will not be addressed as illicit discharges. These non-storm water discharges must not be reasonably expected (based on information available to the permittees) to be significant sources of pollutants to the Municipal Separate Storm Sewer System, because of either the nature of the discharges or conditions you have established for allowing these discharges to our MS4 (e.g., a charity car wash with appropriate controls on frequency, proximity to sensitive waterbodies, BMPs on the wash water, etc.). You must document in your SWQMP any local controls or conditions placed on the discharges. You must include a provision prohibiting any individual non-storm water discharge that is determined to be contributing significant amounts of pollutants to your MS4.

Bernalillo County is in the fourth year of a ten-year drought cycle. Average temperatures for summer 2002 were 79.10°, 78.53°, 75.87°, (June through August) with precipitation averages for those months at 0.02, 0.18, and 0.88, respectively. These conditions make the occasional incidental non-storm water discharges from non-commercial or charity car washes, etc. insignificant contributors of pollutants to our small MS4.

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3.2. Decision Process. You must document your decision process for the development of a storm water illicit discharge detection and elimination program. Your rationale statement must address both your overall illicit discharge detection and elimination program and the individual BMPs, measurable goals, and responsible persons for your program. The rationale statement must include the following information, at a minimum:

3.2.1 How will you develop a storm water sewer map showing the locations of all outfalls and the names and locations of all receiving waters. Describe the sources of information you used for the maps, and how you plan to verify the outfall locations with field surveys. If already completed, describe how you developed this map. Also, describe how your map will be regularly updated.

The PWD has developed a storm water sewer map using Global Positioning System data. This map indicates outfall and storm drain locations, as well as the locations of Public Works maintenance facilities. This map is a part of the SWQMP and will be maintained as such. This will occur on an ongoing basis as facilities are added to our maintenance schedule they will be added to our map.

3.2.2 The mechanism (ordinance or other regulatory mechanism) you will use to effectively prohibit illicit discharges into the MS4 and why you chose that mechanism. If you need to develop this mechanism, describe your plan and a schedule to do so. If your ordinance or regulatory mechanism is already developed, include a copy of the relevant sections with your program.

3.2.3 Your plan to ensure through appropriate enforcement procedures and actions that your illicit discharge ordinance (or other regulatory mechanism) is implemented.

3.3 Your plan to detect and address illicit discharges to your system, including charges from illegal dumping and spills. Your plan must include dry weather field screening for non-storm water flows and field tests of selected chemical parameters as indicators of discharge sources. Your plan must also address on-site sewage disposal systems that flow into your storm drainage system. Your description must address at a minimum:

As part of the County's on-going maintenance of our storm drainage facilities, these facilities are inspected on a regular basis. County storm drain maintenance crews inspect in dry weather for any dry weather flow. If such flows are found, the crew will track the flow back to the source, find the cause of the discharge and inform the property owner of the non-storm water discharge. If the non-storm water discharge has not been
identified as a significant contributor of pollutants, then no corrective action would be required. Bernalillo County does not anticipate that many, if any, dry weather flows will be found, primarily because the County's roadway storm drain system is not extensive.

3.3.1 Procedures for locating priority areas which includes areas with higher likelihood of illicit connections (e.g., areas with older sanitary sewer lines, for example) or ambient sampling to locate impacted reaches.

Priority areas would be areas where there are storm drains installed in the roadways, where the possibility of illicit discharges to the storm drain system exist.

3.3.2 Procedures for tracing the source of an illicit discharge, including the specific techniques you will use to detect the location of the source.

The Operations and Maintenance Department of the PWD, will conduct dry weather inspections as part of the County's good housekeeping minimum control measures. The crews will identify if there are dry weather flows and track them upstream to the source. If necessary, sampling may be conducted to determine any water quality impacts of an identified flow.

The Solid Waste Ordinance Section 70-42 (See Appendix B) specifies that if three pieces of evidence with an individual's name and address are found at an illegal dumpsite, that this constitutes proof of violation of the ordinance. Upon discovering this evidence, the County allows the violator to clean up the site at their cost. If the violator refuses, then the case is sent to court for prosecution. Once an illegal dumpsite has been cleaned, the County seeks to restrict access, and also posts signs that inform the public that illegal dumping is prohibited.

3.3.3 Procedures for removing the source of the illicit discharge.

If an illicit discharge were identified as a significant source of pollutants then the property owner would be apprised of the illicit discharge and requested to correct the problem. Under the general police powers of the County, the County can seek corrective action. As part of the review of the development of a comprehensive Storm Water Quality Ordinance, which the County will undertake during the first permit period, additional actions may be identified.
With reference to illegal dumping, the County has a proactive program to identify illegal dump sites. As part of the NPDES Phase II permit, the County prioritization of illegal dump sites for cleanup will include an assessment of their impact on storm water runoff. Under the Solid Waste Ordinance the County prohibits illegal dumping and establishes penalties. These penalties include responsibility for cleanup or the cost of cleanup and legal action for non-compliance.

3.3.4 Procedures for program evaluation and assessment.

All of the BMPs identified to target illegal dumping will be monitored. Based upon the success of the program, available funding and BMP goals, the program will be evaluated and any necessary improvements will be identified as part of the annual reporting process to EPA.

3.3.5 How you plan to inform public employees, businesses, and the general public of hazards associated with illegal discharges and improper disposal of waste. Include in your description how this plan will coordinate with your public education minimum measures and your pollution prevention/good housekeeping minimum measure programs.

Public employees will be given annual training on the disposal of materials that may contribute to the pollution of storm water discharge. New public employees will receive information in their new employee's package.

Restaurant owners will be advised of the impact of the illegal disposal of oil and grease on storm water during the business licensing process.

The Technical Services Department of the PWD will provide information to construction companies as part of the permitting process and will also conduct training for contractors and consulting engineers.

The County will conduct an educational outreach program to the general public regarding the impact of storm water discharges and mitigation factors via appropriate media, including brochures, flyers, pony panels, etc. The County will also make available "household hazardous waste wheels" that provide information on reducing the use of hazardous materials in the home and a reminder that this reduction also
impacts storm water. These wheels will be distributed during our quarterly collection events and available at the hazardous waste collection center. Pet owners will receive information about the impact of pet waste on storm water during the permitting and licensing process.

3.3.6 Who is responsible for overall management and implementation of your storm water illicit discharge detection and elimination program, and if different, who is responsible for each BMP identified for this program.

*The PWD will be responsible for the overall management and implementation of the SWQMP.***

3.3.7 How will you calculate the success of this minimum measure, including how you selected measurable goals for each of the BMPs.

*The County will implement the following BMPs under this minimum measure and evaluate the success of these BMP in the following manner:*

<table>
<thead>
<tr>
<th>BMP</th>
<th>Measurable Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storm drains will be marked to indicate that they drain to the river.</td>
<td>Affix approximately 1000 storm drain markers to county property.</td>
</tr>
<tr>
<td>Residential Waste Collection System Expansion.</td>
<td>Number of new accounts/year.</td>
</tr>
<tr>
<td>Expand County Recycling Program for used motor oil, steel and aluminum cans, cardboard and newspapers.</td>
<td>Tonnage of recycling collected.</td>
</tr>
<tr>
<td>Implement a Green Waste Recycling Program.</td>
<td>Number of truckloads of ground waste delivered to composting facility.</td>
</tr>
<tr>
<td>Expand County Transfer Station Capabilities.</td>
<td>Increase in number of visits per station per year.</td>
</tr>
<tr>
<td>Increase awareness of household hazardous waste collection events.</td>
<td>Increase volume of material collected.</td>
</tr>
<tr>
<td>Develop a program to address illegal dumping.</td>
<td>Decrease in the amount of illegal dumping complaints.</td>
</tr>
<tr>
<td>Inspect channels.</td>
<td>16 mile/year</td>
</tr>
<tr>
<td>Valley Utilities Project -- provide sewer connections to the South and North Valley.</td>
<td>Number of available connections provided.</td>
</tr>
<tr>
<td>Maintain a system map.</td>
<td>Map will be updated annually.</td>
</tr>
<tr>
<td>Assist low-income residences with sewer connections through the Partners in Improvement and Protection of the Environment (PIPE) program.</td>
<td>Increase in the number of Sewer/Drinking Water Connections.</td>
</tr>
</tbody>
</table>
3.3.7 How will you calculate the success of this minimum measure, including how you selected measurable goals for each of the BMPs. (cont.)

<table>
<thead>
<tr>
<th>BMP</th>
<th>Measurable Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household Hazardous Waste Collection</td>
<td>Increase number of household hazardous waste collection events from four to eight, as funding becomes available.</td>
</tr>
<tr>
<td>Events.</td>
<td></td>
</tr>
<tr>
<td>Septic System/Alternative Systems.</td>
<td>Increase in number of wastewater permits issued annually.</td>
</tr>
</tbody>
</table>

Given the County's extremely limited resources, these measurable goals were selected based upon the total population impacted and the low cost and ease of implementation.

4.0 Construction Site Storm Water Runoff Control

4.1 Permit Requirement. You must develop, implement and enforce a program to reduce pollutants in any storm water runoff to your small MS4 from construction activities that result in a land disturbance of greater than or equal to one acre. Reduction of storm water discharges from construction activity disturbing less than one acre must be included in your program if that construction activity is part of a larger common plan of development or sale that would disturb one acre or more. If the NPDES permitting authority waives requirements for storm water discharges associated with small construction activity in accordance with 122.26 (b)(15)(i), you are not required to develop implement, and or enforce a program to reduce pollutant discharges from such sites. Your program must include the development and implementation of, at a minimum:

4.1.1 An ordinance or other regulatory mechanism to require erosion and sediment controls, as well as sanctions to ensure compliance, to the extent allowable under State Tribal or local law;

_The County has revised its Storm Drainage Ordinance (Appendix C) to incorporate additional requirements for construction sites disturbing one or more acre. The ordinance revisions require the construction operator to obtain a “Storm Water Quality Control” permit._

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4.1.2 Requirements for construction site operators to implement appropriate erosion and sediment control BMPs;

The Storm Drainage Ordinance requires operators to comply with the small construction permit requirements of the Environmental Protection Agency (EPA). The ordinance also requires operators to certify that they have submitted a NOI to the EPA, and that operators submit their Storm Water Pollution Prevention Plan (SWPPP) to the County prior to the issuance of a Storm Water Quality Control permit. The County Engineer has the authority to require additional BMPs if he or she deems it necessary.

4.1.3 Requirements for construction site operators to control waste such as discarded building materials, concrete truck washout, chemicals, litter, and sanitary waste at the construction site that may cause adverse impacts to water quality;

The Storm Drainage Ordinance requires operators to comply with the small construction permit requirements of the EPA. The ordinance also require operators to certify that they have submitted a NOI to the EPA, and require that operators submit their SWPPP to the County prior to the issuance of a Storm Water Quality Control permit. The County Engineer has the authority to require additional BMPs if he or she deems it necessary to protect water quality.

4.1.4 Procedures for site plan review which incorporate consideration of potential water quality impacts;

The Storm Drainage Ordinance incorporates land disturbances equal to or greater than one acre into the County Development Review process. All operators of sites disturbing one acre or greater must now obtain a permit from the County, which requires operators to comply with the small construction permit requirements of the EPA. The County Engineer has the authority to require additional BMPs if he or she deems it necessary to protect water quality. Prior to the approval of the permit, the County Engineer or their designee evaluates the completeness of the site plan with respect to a number of considerations, one of which is protection of water quality and reduction of erosion and runoff.

4.1.5 Procedures for receipt and consideration of information submitted by the public; and

The public may submit information, identify issues and concerns and ask questions through the development review process. If there
are complaints about a property, the PWD Technical Services inspectors investigate the complaints. Several land use boards are also part of the development review process, and the public has an opportunity to comment during these public meetings. The County may also require signs and public notice for requests for variances or other changes.

4.1.6 Procedures for site inspection and enforcement of control measures.

The Storm Drainage Ordinance has provisions for inspection of construction-phase storm water quality controls. The ordinance also has provisions for penalties for non-compliance with the requirements of the EPA small construction permit, the SWPPP and any other County requirement. Public Works inspectors will inspect sites that are one acre or greater of disturbed area, specifically to monitor the construction phase storm water quality controls, which were identified in the site plan and approved by the County.

4.2 Decision Process. You must document your decision process for the development of a construction site storm water control program. Your rationale statement must address both your overall construction site storm water control program and the individual BMPs, measurable goals and responsible persons for your program. The rationale statement must include the following information, at a minimum:

4.2.1 The mechanism (ordinance or other regulatory mechanism) you will use to require erosion and sediment controls at construction sites and why you chose that mechanism. If you need to develop this mechanism, describe your plan and a schedule to do so. If your ordinance or regulatory mechanism is already developed, include a copy of the relevant sections with your storm water management program description.

The County chose to revise an existing storm drainage ordinance to incorporate the requirements of the Construction Minimum Control Measure. This ordinance is already familiar to property owners, developers and contractors in Bernalillo County. The ordinance revision enabled the County to incorporate the NPDES Phase II requirements into the existing development review and inspection process. The ordinance was revised to include requirements for construction phase storm water quality controls for sites disturbing an area equal to or greater than one acre, including sites less than one acre but comprising a common plan of development. The ordinance requires that operators
undertaking construction on these sites obtain a Storm Water Quality Control Permit. This ordinance was approved on January 14, 2003 and will take effect on March 10, 2003.

4.2.2 Your plan to ensure compliance with your erosion and sediment control regulatory mechanism, including the sanctions and enforcement mechanisms you will use to ensure compliance. Describe your procedures for when you will use certain sanctions. Possible sanctions include non-monetary penalties (such as stop work orders), fines, bonding requirements, and/or permit denials for non-compliance.

The County Storm Drainage Ordinance has provisions for inspection of construction-phase storm water quality controls. The ordinance also has provisions for penalties for non-compliance with the requirements of the EPA permit, the SWPPP and any other County requirement. These penalties include stop work orders, denial of permits, including business permits, and liens on property. If the Public Works inspector determines that the construction controls are not properly installed or maintained, he or she may require corrective action. If the situation is not resolved, the inspector can issue a stop work order until the problem is corrected.

4.2.3 Your requirements for construction site operators to implement appropriate erosion and sediment control BMPs and control waste at construction sites that may cause adverse impacts to water quality. Such waste includes discarded building materials, concrete truck washouts, chemicals, litter and sanitary waste.

The County ordinance is written such that the site operator must conform to the EPA requirements for the NOI and the SWPPP as part of their submittal to the County for their County permit. The County may then require additional measures should the County Engineer determine they are required.

4.2.4 Your procedures for site plan review, including the review of pre-construction site plans, which incorporate consideration of potential water quality impacts. Describe your procedures and the rationale for how you will identify certain sites for site plan review, if not all plans are reviewed. Describe the estimated number and percentage of sites that will have pre-construction site plans reviewed.

The County permitting process will require that the contractor submit a SWPPP to the County as a condition of permit approval
inspectors if they observe that the BMPs do not appear to be properly installed or maintained. Public Works inspectors will then schedule a site inspection based upon these potential concerns. If the County Engineer determines that a particular site has a higher than average potential to impact storm water quality, he or she may instruct staff to perform additional inspections at that site. This will include situations where the site conditions are extreme, or where the site is adjacent to sensitive watercourses. If an operator is not properly maintaining required BMPs, the County may increase inspections until these situations are remedied.

4.2.7 Who is responsible for overall management and implementation of your construction site storm water control program, and if different, who is responsible for each of the BMPs identified for this program.

The PWD is responsible for the management and implementation of Bernalillo County’s construction site storm water control program.

4.2.8 Describe how you will evaluate the success of this minimum measure, including how you selected the measurable goals for each of the BMPs.

This information is summarized below.

<table>
<thead>
<tr>
<th>BMP</th>
<th>Measurable Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assist PW in identifying problems with construction phase BMPs.</td>
<td>BPZ inspectors to notify PWD inspectors of potential construction phase BMP compliance issues.</td>
</tr>
<tr>
<td>Implement Construction NPDES Phase II Requirements by Ordinance.</td>
<td>Revise existing ordinance and implement through Development Review Process.</td>
</tr>
<tr>
<td>Implement Post Construction NPDES Phase II Requirements by Ordinance.</td>
<td>Revise existing ordinance.</td>
</tr>
<tr>
<td>Inspection of one-acre or larger disturbed areas.</td>
<td>Inspect projects with one acre disturbed area intermittently during construction and at completion for proper installation of post construction BMPs.</td>
</tr>
<tr>
<td>Coordinate with other County departments on enforcement of ordinances and monitoring of BMPs.</td>
<td>Formalize process of notification of Technical Services Inspectors by inspectors from other departments.</td>
</tr>
<tr>
<td>Train inspectors in proper installation of construction phase BMPs.</td>
<td>Train 75% of Public Works inspectors annually.</td>
</tr>
<tr>
<td>Train contractors in installation of construction phase BMPs.</td>
<td>Offer one training per year to contractors.</td>
</tr>
<tr>
<td>Hold workshops for County design engineers on construction and post construction BMPs.</td>
<td>Train 75% of engineers annually.</td>
</tr>
<tr>
<td>Hold workshops with consultant design engineers on construction and post construction BMPs.</td>
<td>Conduct one training course per year for design engineers and contractors.</td>
</tr>
<tr>
<td>Ensure compliance of County construction projects with one acre or greater disturbed area.</td>
<td>Inspect projects with one acre or greater disturbed area periodically during construction for proper installation of BMPs.</td>
</tr>
</tbody>
</table>
Incorporate post construction BMPs into design and construction of County facilities, one acre or greater disturbed area.

Develop design standards for County projects.

Given the County's extremely limited resources, these measurable goals were selected based upon the total population impacted and the low cost and ease of implementation.

5.0 Post-Construction Storm Water Management in New Development and Redevelopment

5.1 Permit Requirement: You must:

5.1.1 Develop, implement and enforce a program to address storm water runoff from new development and redevelopment projects that disturb greater than or equal to one acre, including projects less than one acre that are part of a larger common plan of development or sale, that discharge into your small MS4. Your program must ensure that controls are in place that would prevent or minimize water quality impacts;

5.1.2 Develop and implement strategies which include a combination of structural and/or non-structural BMPs appropriate for your community; and

5.1.3 Use an ordinance or other regulatory mechanism to address post-construction runoff from new development and redevelopment projects to the extent allowable under State Tribal or local law; and

5.1.4 Ensure adequate long-term maintenance of BMPs.

5.2 Decision Process: You must document your decision process for the development of a post-construction storm water management program. Your rationale statement must address both your overall post-construction storm water management program and the individual BMPs, measurable goals and responsible persons for your program. The rationale statement must include the following information at a minimum:

5.2.1 Your program to address storm water runoff from new development and redevelopment projects. Include in this description any specific priority areas for this program.

As part of the development review process, Bernalillo County will evaluate site plans for projects disturbing one acre or more within the Urbanized Area. In this site plan review, the County will look for structural and non-structural BMPs that reduce runoff and/or
improve the quality of storm water runoff. Post-construction non-structural BMPs include opportunities for cluster development, infill development and low-density residential development where appropriate. In addition, water conservation efforts can also reduce storm water runoff by diverting water from rooftops into landscape areas. All of these measures are provided for existing land use plans.

Also, the County's impact fee system typically assesses a fee for storm drainage based upon the amount of impervious cover that a development will create. This fee serves as an incentive for developers to reduce impervious area and thus reduce runoff volumes.

5.2.2 How your program will be specifically tailored for your local community, minimize water quality impacts and attempt to maintain pre-development runoff conditions.

Storm events in this region tend to be of short duration of high intensity. Storm water runoff is typically of high velocity. Structural and non-structural BMPs will seek to reduce velocities in order to reduce the amount of sediment flowing into the MS4. BMPs will also focus on diverting the first flush of storm water and reducing floatables, which are two significant contributors of pollutants within the MS4.

5.2.3 Any non-structural BMPs in your program, including, as appropriate:

5.2.3.1 Policies and ordinances that provide requirements and standards to direct growth to identified areas, protect sensitive areas such as wetlands and riparian areas, maintain and/or increase open space (including dedicated funding source for open space acquisition) provide buffers along sensitive water bodies, minimize impervious surfaces and minimize disturbance of soils and vegetation;

The Flood Protection Ordinance (Appendix D) restricts development in flood plains, which include natural arroyos. These restrictions help create buffer areas near arroyos and natural drainage features. Typically, the arroyo then becomes a public drainage easement.

Bernalillo County has a proactive open space acquisition program. This program is funded through bond funds,
and seeks to acquire and protect open space and agricultural lands. Over the first permit period, Bernalillo County will review the criteria for open space acquisition and look to incorporate storm water quality protection into these criteria. This could include purchase of buffer zones, sensitive areas and/or watershed restoration projects.

The County's Storm Drainage Ordinance requires:

All construction activities within the jurisdiction of the county shall conform to the requirements of the county engineer with respect to drainage control, flood control and erosion control. Original construction and modifications and/or additions to existing structures are excluded when they constitute less than 500 square feet, in plain view, or the county engineer determines will not adversely affect other properties, arroyos, watercourses, or easements, by finding that the property of the proposed development is not within a designated 100-year floodplain as shown on the National Flood Insurance Program's flood insurance rate maps, and the proposed development will not alter, block or divert any arroyos, watercourses or swales. (Chapter 38-171)

5.2.3.2 Policies or ordinances that encourage infill development in higher density urban areas, and areas with existing storm sewer infrastructure;

Land Use area plans that include portions of the County in the Urbanized Area, such as the Southwest Area Plan, identify village centers where commercial and higher density housing would be appropriate. This plan also identifies opportunities for cluster development, narrower roadways, and large-lot zoning where appropriate. Since the Urbanized Area of the County excludes the City of Albuquerque, much of the County has developed with suburban or rural development patterns. The North Valley Plan, which is the other land use plan for the Urbanized Area of the County, identifies opportunities for cluster development, commercial nodes and infill areas. These plans are independent of the NPDES program, but assist in promoting non-structural BMPs.
The Impact Fee Ordinance (see Appendix E) for Bernalillo County assesses a fee for percentage of impervious cover on development. This fee encourages reduced impervious cover as a means of reducing the fees associated with development.

Finally, the County Engineer will evaluate the contribution of non-structural BMPs in determining what additional structural BMPs will be required of any development disturbing an acre or greater.

5.2.3.3 Education programs for developers and the public about project designs that minimize water quality impacts; and

Bernalillo County, the Albuquerque Metropolitan Arroyo and Flood Control Authority, and the City of Albuquerque have been conducting meetings to identify preferred BMPs for storm water quality management. These BMPs are both structural and non-structural BMPs. As this information is developed, the County will seek to make it available to developers and the general public.

5.2.3.4 Other measures such as minimization of the percentage of impervious area after development, use of measures to minimize directly connected impervious areas and source control measures often thought of as good housekeeping, preventive maintenance and spill prevention.

The Impact Fee Ordinance for Bernalillo County assesses a fee for percentage of impervious cover on development. This fee encourages reduced impervious cover as a means of reducing the fees associated with development.

Finally, the County Engineer will evaluate the contribution of non-structural BMPs in determining what additional structural BMPs will be required of any development disturbing an acre or greater.

5.2.3.5 Any structural BMPs in your program, including, as appropriate:

5.2.3.5.1 Storage practices such as wet ponds and extended detention outlet structures;
In conjunction with other local agencies, Bernalillo County will evaluate BMPs for their appropriateness for our regional climate and conditions. Additionally, the County Engineer must evaluate BMPs based upon their capacity to address potentially conflicting water quality aims. As an example, extended detention structures may be beneficial for reducing sediment loads, but may actually increase the occurrence of fecal coliform because they attract waterfowl. Additionally, by State law, no entity can detain storm water for more than 72 hours without a valid water right to that water. All of these issues must be considered in developing structural BMPs.

5.2.3.5.2 Filtration practices such as grassed swales, bioretention cells, sand filters and filter strips; and

The above-referenced BMPs would be appropriate in low volume flows to reduce velocity and promote infiltration into the groundwater with an opportunity for percolation and evaporation to occur. The appropriateness of these BMPs will directly relate to site conditions, slopes and volume and velocity of runoff. In conjunction with other local agencies, Bernalillo County will evaluate BMPs for their appropriateness for our regional climate and conditions. Additionally, the County Engineer must evaluate BMPs based upon their capacity to address the specific conditions of each site development. It will be the responsibility of the developer to prepare a site plan with appropriate BMPs. The County Engineer will evaluate the appropriateness of these BMPs and may require modification of the BMPs.

5.2.3.5.3 Infiltration practices such as infiltration basins and infiltration trenches.

In conjunction with other local agencies, Bernalillo County will evaluate BMPs for
their appropriateness for our regional climate and conditions. Additionally, the County Engineer must evaluate BMPs based upon their capacity to address the specific conditions of each site development. Infiltration basins are not typically successful in this region because the high sediment loads cause them to clog easily, and make them inefficient from a maintenance perspective. However, they could be useful in some situations, which would be determined by the County Engineer.

5.2.3.6 What are the mechanisms (ordinance or other regulatory mechanisms) you will use to address post-construction runoff from new developments and redevelopment and why did you chose that mechanism. If you need to develop a mechanism, describe your plan and a schedule to do so. If your ordinance or regulatory mechanism is already developed, include a copy of the relevant sections with your program.

Bernalillo County has revised the Storm Drainage Ordinance to require Post-Construction BMPs for development and redevelopment project disturbing one acre or greater. This ordinance is attached as Appendix C.

5.2.3.7 How you will ensure the long-term operation and maintenance of your selected BMPs. Options to help ensure that future Operations & Maintenance (O&M) responsibilities are clearly identified include an agreement between you and another party such as the post-development landowners or regional authorities.

The County has revised the County Storm Drainage Ordinance to require maintenance of Post-construction BMPs. Maintenance of BMPs is the responsibility of the property owner up to the point where storm water enters County facilities. Requirements for maintenance and penalties for non-maintenance are described in the ordinance. Any facilities for which the County assumes ownership or maintenance will be maintained by the County. These facilities will then be addressed in the Good Housekeeping portion of our NPDES Phase II permit as a function of the PWD’s O&M Department.
5.2.3.8 Who is responsible for the overall management and implementation of your post-construction storm water management program and, if different, who is responsible for each of the BMPs identified for this program.

While the PWD is responsible for the overall management of the SWQMP, the County’s Building, Zoning and Planning Department is responsible for all of the land-use BMPs specified as part of the post-construction storm water management program. The PWD is responsible for all structural BMPs identified.

5.2.4 How you will evaluate the success of this minimum measure, including how you selected the measurable goals for each of the BMPs.

This information is summarized below.

<table>
<thead>
<tr>
<th>BMP</th>
<th>Measurable Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Promote/encourage cluster development.</td>
<td>Use existing subdivision ordinance to allow for cluster development and increase number of cluster developments by 20%.</td>
</tr>
<tr>
<td>Promote/encourage developments to reduce impervious cover.</td>
<td>Allow variances for certain roadway standards to reduce impervious cover.</td>
</tr>
<tr>
<td>Base drainage impact fees on amount of impervious surface.</td>
<td>Reduce impervious cover. Diminished disturbed areas.</td>
</tr>
<tr>
<td>Utilize Transfer of Development Rights.</td>
<td>Amend the Zoning Ordinance to include Transfer of Development Rights criteria.</td>
</tr>
<tr>
<td>Encourage development within existing neighborhood and commercial nodes.</td>
<td>Adopt plans and policies that encourage utilization of existing commercial and residential infrastructure in identified areas.</td>
</tr>
<tr>
<td>Support/adopt low density residential planning areas where appropriate.</td>
<td>Adopt large lot zoning.</td>
</tr>
</tbody>
</table>

Given the County's extremely limited resources, these measurable goals were selected based upon the total population impacted and the low cost and ease of implementation.

6.0 Pollution Prevention/Good Housekeeping for Municipal Operations

6.1 Permit requirement. You must:

6.1.1 Develop and implement an operation and maintenance program that includes a training component and has the ultimate goal of preventing or reducing pollutant runoff from municipal operations, and

6.1.2 Using training materials that are available from EPA, your State, Tribe, or other organizations, your program must include employee training to
prevent and reduce storm water pollution from activities such as park and open space maintenance, fleet and building maintenance, new construction and land disturbances, and storm water system maintenance.

6.2 Decision process. You must document your decision process for the development if a pollution prevention/good housekeeping program for municipal operations. Your rationale statement must address both your overall pollution prevention/good housekeeping program and the individual BMPs, measurable goals, and responsible persons for your program. The rationale statement must include the following information, at a minimum:

6.2.1 Your operation and maintenance program to prevent or reduce pollutant runoff from your municipal operations. Your program must specifically list the municipal operations that are impacted by this operation and maintenance program. You must also include a list of industrial facilities that you own or operate that are subject to EPA’s Multi-Sector General Permit (MSGP) or individual National Pollution Discharge Elimination System (NPDES) permits for discharges of storm water associated with industrial activity that ultimately discharge to your MS4. Include the EPA permit number of a copy of the industrial NOI form for each facility.

The following sections within the PWD will be responsible for the following: the Roads Section will be responsible for road maintenance, the Storm Drainage Maintenance Section will be responsible for inspecting and cleaning storm drains, storm channels, storm water ponds, culverts, and storm sewer lines. Fleet Maintenance will be responsible for recycling hazardous materials in the shop, as well as maintaining the shop in an environmentally sound manner and the Technical Services Department will be responsible for identifying and installing structural BMPs for storm water facilities and County property. The County’s Parks & Recreation Department will implement a program to reduce the use of pesticides and run-off at County-owned parks and facilities. (For specific BMPs and Measurable Goals, please see the chart below.)

The County does not own or operate any industrial facilities that are subject to EPA’s MSGP or individual NPDES permits for discharges of storm water associated with industrial activity that ultimately discharge into the City of Albuquerque’s MS4.

6.2.2 Any government employee training program you will use to prevent and reduce storm water pollution from activities such as park and open space maintenance, fleet and building maintenance, new construction and land disturbances, and storm water system maintenance. Describe any existing available materials you plan to use. Describe how this training program will be coordinated with the outreach programs developed for the public
information minimum measure and the illicit discharge minimum measure.

The County will develop and implement training material based on the Storm Water Management Fact Sheet, EPA 832-F-99-010 and any future training guidance that EPA publishes. This training will include a thorough description of the Storm Water Management Plan, processes and materials that the staff works with, safety hazards, practices for preventing discharges, and procedures for responding quickly and properly to hazardous materials incidents. The information provided to employees on the impact of storm water contamination will be similar to the information provided to the general public under our public information BMPs. The staff currently receives training on the proper handling of hazardous materials and the impact of improper disposal of these materials on storm water will be added to the information.

6.2.3 Your program description must specifically address the following areas:

6.2.3.1 Maintenance activities, maintenance schedules, and long-term inspection procedures for controls to reduce floatables and other pollutants to your MS4.

*See the chart included as part of the NOI and the BMPs listed below for the schedule of maintenance and inspection for storm drainage facilities.*

6.2.3.2 Controls for reducing or eliminating the discharge of pollutants from streets, roads, highways, municipal parking lots, maintenance and storage yards, waste transfer stations, fleet or maintenance shops with outdoor storage areas, and salt/sand storage locations and snow disposal areas you operate.

*The PWD’s O & M Department will be responsible for road maintenance and storm drainage maintenance. One of the BMPs listed below is the construction of a cover for the salt storage facilities. The Fleet-Facilities Management Department of the PWD will be responsible for recycling hazardous materials in the shop, as well as maintaining the shop in an environmentally sound manner. (For specific BMPs and Measurable Goals, please see the chart below.)*

6.2.3.3 Procedures for the proper disposal of waste removed from your MS4 and your municipal operations, including dredge soil, accumulated sediments, floatables, and other debris.
In the Urbanized Area, dredge soil or soil and debris from manholes, catch basins and storm lines is typically taken to the City of Albuquerque landfill after it has been de-watered at the Public Works yard. Floatables and other similar debris are also taken to the landfill. Sediment from ponds is frequently incorporated back into the walls of the pond. If it contains significant debris, it is taken to the landfill.

6.2.3.4 Procedures to ensure that new flood management projects are assessed for impacts on water quality and existing projects are assessed for incorporation of additional water quality protection devices or practices.

As part of the County’s good housekeeping BMPs, Bernalillo County residents have already approved funding for Storm Water Quality Structural Controls. This funding will be used to prioritize existing storm water facilities and identify appropriate controls to improve storm water quality coming into those facilities and exiting those facilities. Future storm water projects in the County will have requirements for water quality BMPs.

6.2.3.5 Who is responsible for overall management and implementation of your pollution prevention/good housekeeping program and, if different, who is responsible for each BMP identified for this program.

The PWD is responsible for the overall management and implementation of the pollution prevention/good housekeeping program. Parks and Recreation, a department within the Community Services Division, is responsible for all BMPs listed below that are associated with maintaining County parks and recreational facilities.

6.2.3.6 How will you evaluate the success of this minimum measure, including how you selected the measurable goals for each of the BMPs.

The County will implement the following BMPs under this minimum measure and evaluate the success of these BMP in the following manner:

<table>
<thead>
<tr>
<th>BMP</th>
<th>Measurable Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facility Management will notify the appropriate department when they observe problems or potential problems around the exterior of buildings they maintain.</td>
<td>Number of work orders requested and corrected.</td>
</tr>
<tr>
<td>Mow the shoulders of the roads instead of grading.</td>
<td>Increase in the number of miles mown.</td>
</tr>
<tr>
<td>Activity</td>
<td>Measurement</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Cover road salt storage areas in the urbanized area.</td>
<td>Construct a cover for the facilities.</td>
</tr>
<tr>
<td>Clean roadways.</td>
<td>Increase in the number of road miles swept.</td>
</tr>
<tr>
<td>Inspect channels.</td>
<td>Number of channels inspected per year.</td>
</tr>
<tr>
<td>Clean and reshape channels.</td>
<td>Cubic yards per year of debris removed or documentation that removal was not required.</td>
</tr>
<tr>
<td>Inspect and clean storm water ponds.</td>
<td>Cubic yards per year of debris removed or documentation that removal was not required.</td>
</tr>
<tr>
<td>Inspect and clean storm inlet/outlet structures.</td>
<td>Number of structures inspected and cleaned per year.</td>
</tr>
<tr>
<td>Inspect storm sewers to ensure integrity of the system and also identify any dry weather flows.</td>
<td>Miles per year inspected and dry weather flows identified.</td>
</tr>
<tr>
<td>Clean storm sewer lines.</td>
<td>Number of feet of storm sewer cleaned per year.</td>
</tr>
<tr>
<td>Inspect culverts.</td>
<td>Number of culverts inspected per year.</td>
</tr>
<tr>
<td>Clean/flush culverts.</td>
<td>Number of culverts cleaned and flushed per year.</td>
</tr>
<tr>
<td>Storm water lift station maintenance.</td>
<td>Number of hours per year spent maintaining lift stations.</td>
</tr>
<tr>
<td>Training in appropriate safety, BMPs, regulations, and other area as needed.</td>
<td>Percentage of staff that completes training.</td>
</tr>
<tr>
<td>Construct/maintain a containment area for vactor truck debris.</td>
<td>Loads contained for removal.</td>
</tr>
<tr>
<td>Spills on shop floors captured using dry chemicals and stored in collection containers.</td>
<td>Number of incidents of runoff noted.</td>
</tr>
<tr>
<td>Used oils are captured and recycled.</td>
<td>Volume and percentage of motor oil recycled.</td>
</tr>
<tr>
<td>All used antifreeze is captured and recycled.</td>
<td>Volume and percentage of antifreeze recycled.</td>
</tr>
<tr>
<td>All oil filters are drained, crushed and metal is recycled.</td>
<td>Number/ pounds of used oil filters recycled.</td>
</tr>
<tr>
<td>On site drainage traps are maintained and pumped.</td>
<td>Clean traps three times per year.</td>
</tr>
<tr>
<td>Parts cleaners are reusable/recycled fluids.</td>
<td>Annual inspection of cleaning devices and products.</td>
</tr>
<tr>
<td>Provide annual review to staff on use of hazardous chemicals and environmental practices.</td>
<td>Documentation of review of staff.</td>
</tr>
<tr>
<td>Storm Water Quality Structural BMPs.</td>
<td>Number of projects identified, and the number constructed.</td>
</tr>
</tbody>
</table>

(Continued on the next page.)
6.2.3.6 How will you evaluate the success of this minimum measure, including how you selected the measurable goals for each of the BMPs. (cont.)

<table>
<thead>
<tr>
<th>BMP</th>
<th>Measurable Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce fertilizer applications on park facilities.</td>
<td>Reduction in fertilizer per acre/number of times per year applied.</td>
</tr>
<tr>
<td>Use herbicides with short residual life at lowest effective concentration.</td>
<td>Verify that herbicides are suitable for conditions through description of herbicides utilized.</td>
</tr>
<tr>
<td>Move sprinkler heads away from curbs.</td>
<td>Move sprinklers to two facilities a year.</td>
</tr>
<tr>
<td>Put paths around perimeter of parks to reduce runoff to street.</td>
<td>Install paths at a total of seven parks, one facility every year.</td>
</tr>
<tr>
<td>Install low water use landscaping where appropriate.</td>
<td>Number of facilities where xeriscape is added/installed. The goal is three facilities in the next five years.</td>
</tr>
<tr>
<td>Educate employees in plant science so that plants are cared for properly, without excess fertilizer or water.</td>
<td>Annual training of all full-time employees through community college program.</td>
</tr>
<tr>
<td>Reduce turf areas where appropriate.</td>
<td>Number of square feet converted to xeriscape from irrigated turf.</td>
</tr>
<tr>
<td>Use short (syringe) cycles of watering instead of heavier water programs to eliminate runoff into streets and arroyos.</td>
<td>Number of runoff events reported at the facility by the public or by staff.</td>
</tr>
<tr>
<td>Use reduced pressure on irrigation system to reduce over-spray and misting.</td>
<td>Number of runoff events reported at the facility by the public or by staff.</td>
</tr>
<tr>
<td>Provide training and orientation to new employees through an employee handbook.</td>
<td>Develop and distribute orientation packet to new employees.</td>
</tr>
<tr>
<td>Train employees in irrigation repair, installation and operation.</td>
<td>Annual training of all involved employees through community college program.</td>
</tr>
<tr>
<td>Utilized licensed journeymen irrigation specialists when appropriate.</td>
<td>All supervisors must have JMS-6 license.</td>
</tr>
<tr>
<td>Provide additional trash containers at park facilities.</td>
<td>New containers provided, and tonnage of trash collected.</td>
</tr>
<tr>
<td>Provide on-site lift dumpsters at park facilities.</td>
<td>New containers provided, and tonnage of trash collected.</td>
</tr>
<tr>
<td>Install enclosed trash containers.</td>
<td>New containers provided, and tonnage of trash collected.</td>
</tr>
<tr>
<td>Pick up trash daily from park facilities.</td>
<td>Tonnage of trash collected.</td>
</tr>
<tr>
<td>Improve grades on turf areas to eliminate runoff into streets and arroyos.</td>
<td>Complete one retrofit per year for the duration of the permit or until project is completed.</td>
</tr>
<tr>
<td>Install silt boxes and cobblestone at runoff exits into arroyos.</td>
<td>Complete the two required retrofits.</td>
</tr>
<tr>
<td>License/certify employees in 3-B herbicide spraying, including sprayer calibration, solutions and concentrations, laws and ethics through Dept of Agriculture program.</td>
<td>Certify 90% of staff that might be involved in herbicide application annually.</td>
</tr>
</tbody>
</table>

Given the County's extremely limited resources, these measurable goals were selected based upon the total population impacted and the low cost and ease of implementation.
Glossary

**Benthic communities** – Communities of organisms that live in or on the sediment or bottom surfaces of a water body.

**Best management practices (BMPs)**—“Means schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of "waters of the United States". BMPs also include treatment requirements, operating procedures and practices to control site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage”. (USEPA 1991)

**Impervious**—Impermeable, or not allowing water to penetrate.

**Separate Municipal Storm Sewer (MS4)**—A stormwater conveyance system which is owned or operated by a public body and is not a combined sewer or part of a Publicly Owned Treatment Works

**Water Quality Parameters**

**Total Suspended Solids (TSS)**—All organic and in-organic particulates that are suspended in water.

**Total Kjeldahl Nitrogen (TKN)**—Named after the analytical test procedure that measures both ammonia (NH₃) and organic forms of nitrogen.

**Biochemical Oxygen Demand (BOD)**—An indirect measure of biodegradable organic matter in water. BOD is measured in terms of the amount of oxygen required by microorganisms to oxidize the organic matter to carbon dioxide.

**Nitrate + Nitrite**—A measure of total inorganic nitrogen

**Nitrate (NO₃)**—An oxidized ion of nitrogen

**Nitrite (NO₂)**—An intermediate ion in the oxidation process of nitrogen. Causes “Blue Baby” syndrome in children.

**Chemical Oxygen Demand (COD)**—Measures the consumption of oxygen from an introduced oxidizing chemical agent. COD measures the maximum possible oxygen demand

**Copper (Cu)**—A common natural metallic element. It is reddish, ductile, and malleable.
Total Phosphorus (TP) Includes all Phosphorus including those forms which are not readily available to the biologic community plus all soluble Phosphorus.

Lead (Pb)- A naturally occurring metal that has had various industrial uses, solder, alloys, and gasoline additive.

Soluble Phosphorus (SP)- includes mostly Orthophosphate which is the form most readily available to the biologic community and a fraction of organic Phosphorus.

Zinc (Zn) - Naturally occurring metal used in galvanizing processes. Has been found in highest concentrations in runoff from roofs believed to be from gutters.

Acronyms

BCPWD - Bernalillo County Public Works Division
BMP-Best Management Practice
CWA-Clean Water Act
DEM-Digital Elevation Model
GIS-Geographic Information System
LIDAR-Light Detection And Ranging
LPDB-Los Padillas Detention Basin
NPDES-National Pollutant Discharge Elimination System
NURP-National Urban Runoff Program
MS4- Separate Municipal Storm Sewer
SWQMP-Storm Water Quality Management Plans
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U.S. Environmental Protection Agency, 1995. Storm Water Discharges Potentially
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ARCGIS 8.1 Desktop Help

Huaguo Xiao and Xiaoyong Zhan, TOPAGNPS tool Visual Basic 6.0 Script
http://arcscripts.esri.com/

**Personal Communications**

Loren Meinz, Albuquerque Metropolitan Flood Control Authority, 2003

Todd Kelly, United States Geological Survey, 2003

**Web Sites**


**GIS shapefiles, Coverages, and Grid data,**

**Existing Coverages**

LIDAR Digital Elevation Model Grid Coverage  
Bernalillo County Roads  
Bernalillo County Irrigation Ditches  
Bernalillo County Parcels

**Created Coverages**

Adobe Acres Storm Drain Inlets  
Adobe Acres Basin