Integrating GIS and Capital Improvement Program: Quantifiable Prioritization Process

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Abstract

Bernalillo County New Mexico regularly updates its Capital Improvement Program (**CIP**) to plan major capital projects through the coordination of citizen and departmental requests.

The Department of Infrastructure Planning and Geo-Resources implemented a sophisticated system for prioritizing projects based on two levels of attribute scores, weights and a multiplier. First level attributes apply to all projects (service area, neighborhood support, previously committed funds, etc.). Second level attributes are comprised of socio-economic, transportation and planning factors. Scores at the second level are calculated using GIS tools, empirical factors and Visual Basic of Application code. A project multiplier was created to address additional public needs issues such as public health, safety, and economic development. This system helped identify projects of highest benefit to the public.

The resulting solution leveraged ARCGIS, SQL Server and ASP.NET to create a powerful system capable of objective, repeatable project prioritization based on quantifiable data.

Introduction

Bernalillo County is located in central New Mexico covering over 1,100 square miles, stretching east from the Volcano Cliffs, across the Rio Grande River Valley, over the Sandia Mountains, to the East Mountain area. It is home to more than half a million residents and includes the City of Albuquerque, the University of New Mexico (**UNM**), Sandia National Laboratory and Kirtland Air Force Base.
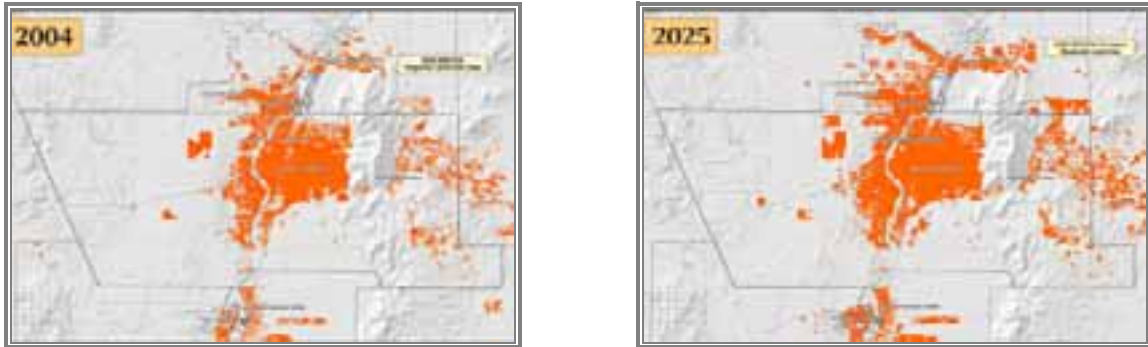
Bernalillo County and the surrounding region are experiencing rapid growth. The County's population increased by over 14.5% (60,877 additional people) between 1980 and 1990, and gained an additional 15.8% (76,101 people) between 1990 and 2000. This is higher than the national growth rates of 10% and 13%, respectively. Forecasts for 2010 predict a total population of 613,839.[1]

A growing population, a larger labor force and longer commutes all have contributed significantly to increased congestion and occurrences of traffic exceeding roadway design capacity.

Within the unincorporated portion of Bernalillo County, floodplains cover approximately 11,115 acres, affecting about 4,500 properties. As growth occurs in an area that experiences flooding, more of the population becomes subject to hazardous flooding conditions and the increasing cost of flood insurance.
Population growth and economic development significantly contribute to the increased needs to provide additional infrastructure for public safety,

protection of public health and emergency preparedness for the Bernalillo County residents.

Population Growth Pattern by Mid-Region Council of Governments

To ameliorate conditions brought about by this population increase, capital projects must be developed and undertaken in an organized fashion. Limited funds force projects to compete for priority.

Every two years, the Bernalillo Board of County Commissioners updates its Six-Year Capital Improvement Program (**CIP**) and Two-Year General Obligation Bond Program to include new projects that reflect public investment priorities. The process of updating the CIP includes gathering and evaluating ideas from citizens, neighborhood groups and departments. The public is encouraged to submit requests for projects at any time. However, in preparation to update the CIP, County Commissioners actively request input from the public through community meetings scheduled over two months, leading to a request deadline. After the deadline has passed, Bernalillo County Public Works Division (**BC PWD**) actively develops and integrates their department and public project requests into a prioritized package. Every Bernalillo County division then submits their package for further evaluation and selection. Ultimately, some projects are chosen by the Board of County Commissioners to be completed using funds derived from General Obligation Bonds which are voted on by county citizens during the next general election.

The nature of public requests dictates that BC PWD categorize, estimate and prioritize a vast variety of projects seeking inclusion in the CIP, in a very short time frame - one month. To do this efficiently and fairly, a quantifiable prioritization process had to be developed that could be applied to the 600 plus projects requested through BC PWD.

Methodology
BC PWD, through a collaborative effort of GIS, planning, engineering and maintenance staff, developed a sophisticated ranking system based on project attributes including:
- having been identified in a developed or approved master plan;
- volume to capacity ratio in the transportation network;
- data analysis zones population growth trends;
- public safety;
- public health;
- economic development; quality of life;
- service delivery

Each attribute was assigned a range of points and a weight, based on its importance.

For each project, points were assigned automatically during processing, by analysis or by department managers' consensus for each attribute and then weighted to obtain a project's raw score. This raw score was then adjusted according to the public needs addressed by the project. Projects were given a final priority based on this adjusted score.

Due to the diversity of CIP projects in BC PWD, project attributes were divided into two levels. The first level is comprised of general attributes that can be determined for all projects. Points at this level were assigned either automatically or by evaluation and consensus among department managers. The following list summarizes the criteria at this level (weights in parentheses):

- Committed Funds (5)
- Schedule (3)
- Service Area (2)
- Neighborhood Submittals (2)
- Operating Budget Impact (3)
- Department Request (2)
- Type of the project (4)
- Legal Requirements (3)

The second level of project attributes included socio-economic, transportation and planning factors for the different projects. If a certain factor was not applicable to a particular project, no points were assigned for that factor. The scores for this level were automatically calculated using GIS tools. This level included the following empirical factors:

- Inclusion in a master planned facility
- Project proximity to the vital facilities (schools, hospitals, and sheriff and fire stations)
- Metropolitan Transportation Plan lanes change trends
- Volume to Capacity ratio on transportation network
- Roadway functional class
- Intersection Capacity
- Number of acres removed due to flood plain impact
- Number of properties removed due to flood plain impact
- Land Use Patten in the project area
- Number of households in project area
- Traffic Analysis Zones population growth trends

In addition to the ranking criteria, a multiplier was created to address public needs issues. The following categories were used by managers to determine the multiplier for each project (range of points possible in parentheses):

- Public Safety: provides public safety (0-5)
- Public Health: provides for the public health and welfare (0-4)
- Economic Development (0-3)
- Quality of Life: provides for quality of life facilities (0-2)
- Service Delivery: provides for more efficient and effective service delivery to the public (0-1)

Based on the range of points for each category, the highest total multiplier is fifteen and the lowest is zero. This kept a project's total score at zero until a multiplier was calculated, regardless of any other points assigned. This structure allowed projects with a higher value to the public to rank higher than those which addressed fewer public needs.

CIP Ranking Matrix

Architecture Overview

SQL Server 2000 and ASP.NET provided the framework required to store, rank and display request information. Legacy Excel based CIP project requests were imported into the SQL database. New requests were entered through a user friendly intranet application. Every project was assigned a unique ID by the database and put into a group (roughly designed around department) based on project type; infrastructure planning, technical services, drainage, asphalt paving, etc.

A polygon feature for each CIP project was created in ArcMap GIS software containing the corresponding ID from the database. GIS analysis was performed on the CIP layer to assign points based on the second level of project ranking criteria. Visual Basic for Applications (**VBA**) scripts were written to calculate these points for each factor. GIS data from different agencies such as Mid-Region Council of Governments (**MRCOG**), City of Albuquerque (**COA**), and U.S. Army Corp of Engineers (**CORPS**) were acquired and utilized for GIS analysis.

The GIS score information was imported into the SQL Database and linked back to the individual requests through the IDs. This allowed GIS scores to be available to users of the intranet application.

Final project scoring and evaluation was done through consensus among department managers and entered into the SQL Database using the intranet application. The prioritized list was then extracted into individual Excel based requests and submitted as BC PWD's package for further evaluation and selection along with all other divisions' requests.

Intranet Application Details

This aspect of the project was implemented using ASP.NET web forms written in C#. A three tier design was utilized to provide data security, to reduce the amount of code required and promote code reuse.

A database provided not only data storage, but also handled the details of calculating scores and ranks when data changes were made. Stored procedures controlled access to the data and served to centralize the logic of scoring and ranking.

A data access layer interfaced the display layer with these stored procedures. This layer also provided data input transformation and final error checking before executing the stored procedures. Changes could be made at this layer to isolate the display layer from any modifications that needed to happen at the database level.

Finally, the display layer provided facilities to search, sort, and modify request information. Data security was further enhanced at this layer through the use of some pages restricted by user credentials. At the lowest level of security, anonymous users could peruse the data by project grouping, keyword search or by ID. At a higher level, user names and passwords were created for each group of projects. Department directors and section managers were given the credentials that corresponded to their areas of responsibility. This allowed permissions to be managed at a level higher than individual users while still retaining a degree of data protection. These users could create, update or drop existing requests from their group of projects. The ability to assign scores was restricted to a single administrator account.

Intranet Application

First level point details
The first level of project attributes is comprised of general criteria that can be applied to all projects. Each attribute has maximum and minimum points possible, with some having intermediate points as well. Points were assigned either automatically or by managers' consensus after evaluation. This section explains how this was done.

<u>Automatic Scoring</u>
These attributes had points assigned automatically based on information contained in the application:

> <u>Committed Funds</u> – Points were assigned based on the percent of a projects expected cost that had already been committed to the project. The higher the percent, the higher the points awarded:
> - 1 to 24% Committed – 1 point
> - 25 to 49% – 2
> - 50 to 74% – 3
> - 75% or more – 4
>
> <u>Schedule</u> – This measures the number of years a project needs funding to be completed. Generally, shorter projects received more points. The exception was ongoing projects, as funding should be continued in these cases:
> - More than two years – 1 point
> - Two years – 2
> - One year – 3
> - Ongoing – 4
>
> <u>Service Area</u> – Projects could impact one or more County Commission districts. Projects that effected more districts received more points. One point was assigned per district, up to five.
>
> <u>Neighborhood Submittals</u> – Requests for projects often come directly from the public. Sometimes, different groups or people make a request that is similar to others. Each of these duplicates was noted on the original request form. Projects were assigned points based on the number of times it was requested (including duplicates) up to a maximum of three points.
>
> <u>Operating Budget Impact</u> – Projects could create an ongoing financial responsibility for the County. Points were assigned based on yearly operating budget:
> - $5000 or more – 1 point
> - Between $1000 and $4999 – 2
> - Less than $1000 – 3

<u>Scoring by Evaluation</u>
Information in the applications did not provide the details necessary to allow points to be assigned automatically for the remaining attributes of this level. These points were assigned by managers' consensus using the Intranet application:

> <u>Department Request</u> – Either high (2 points) or low priority (1)

Type of the project – A project either creates something new (1 point) or it replaces or protects something already existing (3)

Legal Requirements – Projects could be the result of a legal requirement being imposed on the county by either the State or Federal governments. Having such requirements resulted in one point, otherwise zero.
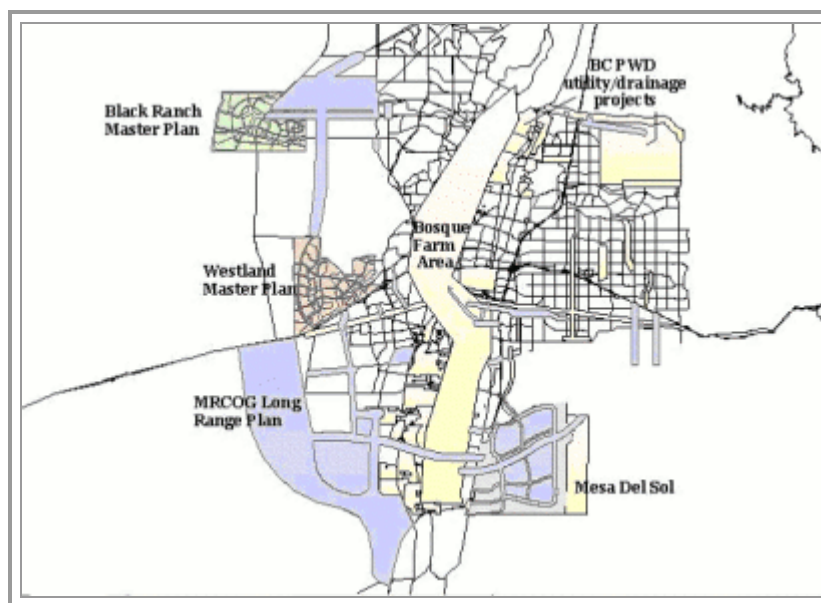
GIS Analysis Details
BC PWD selected a number of socio-economic, transportation and planning factors to be part of ranking process. Their selection was based on the role played by each factor in project area development, service delivery to the public as well as upon availability of the data. If a certain factor were not applicable to a particular project, no points were assigned for that factor. The GIS analysis was performed in ArcMap customized with VBA scripting. This section details what factors were analyzed and how points were assigned.

Inclusion in Master Planned Facility
The awareness of existing regional plans is an important element in the CIP ranking process. This knowledge is vital in coordinating efforts between county departments and other local agencies. The CIP layer was spatially overlaid with the master planned facility layer to find out whether a project's geographic location lied in an area of a master planned facility. If it did, one point was assigned, otherwise zero. The following datasets were used to perform GIS analysis:
- COA boundaries for the West Land, Mesa Del Sol and Black Ranch areas
- CORPS boundary of Bosque Farm Area
- BC PWD utility and drainage projects boundaries, recreational trails corridors
- MRCOG Long Range Plan Transportation Corridors and Major Streets Network

Master Plans Boundaries

Proximity to Vital Facilities

Public Safety and Health are the biggest concerns in delivering service to the public. Any capital improvement which had a positive impact on accessibility to any vital facility received additional points. The vital facilities included hospitals, nursing homes, schools, sheriff and fire stations. Three different buffer zones were created around these facilities to determine a project's proximity. The CIP layer was spatially overlaid with these buffer zones to distinguish which projects were closer to vital facilities than others. Points were awarded by the number of miles:

- Projects lying less than one mile from a vital facility – 3 points
- Those located between one an two miles – 2
- Any project more than two miles – 1

Buffer Zones

Transportation

An area's transportation network is a key element in providing sufficient conditions for economic development, population growth, and public safety and quality of life improvements. There are a number of parameters to measure the efficiency of an existing transportation network and forecast capacity and changes of the future one. These parameters were analyzed and computed by MRCOG in the Metropolitan Transportation Plan (**MTP**). BC PWD used this information in the CIP ranking process for projects related to transportation network improvements. Below is the description of each parameter and how it was used in GIS analysis.

MTP lane changes

Changes in a roadway network are expected to address growth of population and employment. Changes in number of lanes were projected for 2005, 2010, 2015 and 2025. The CIP layer was spatially overlaid with the MTP lanes layer to find out whether a project's geographic location will be affected by future changes. The changes to the number of lanes were calculated for each forecast year as the ratio between the projected
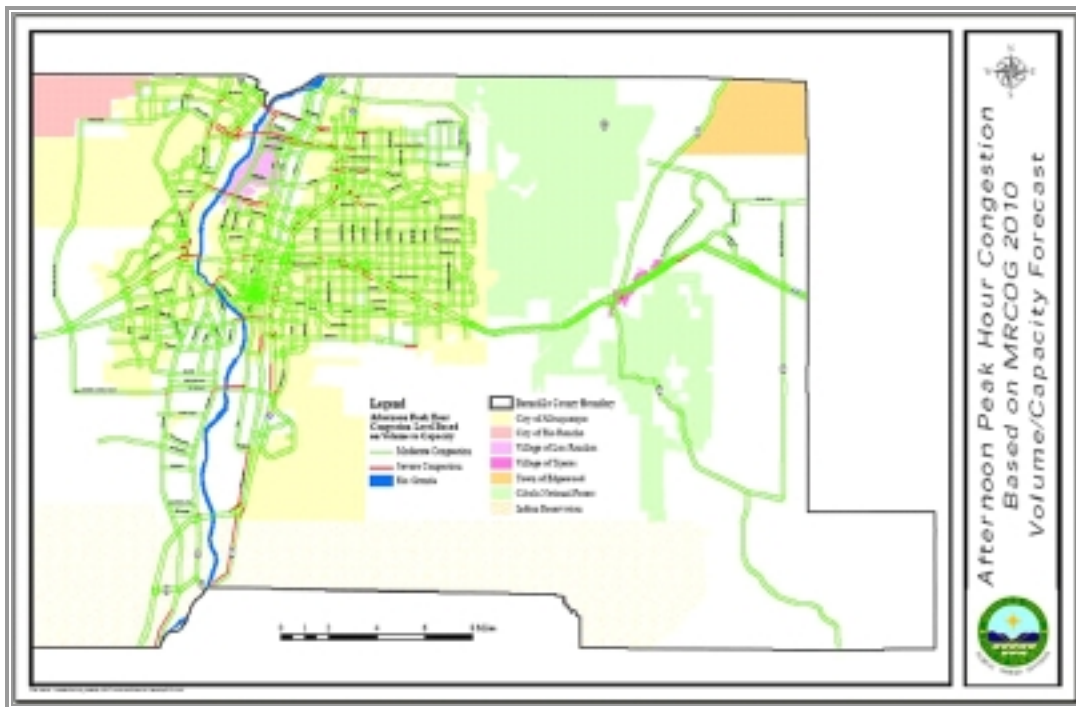
numbers of lanes to the existing number of lanes in 2002. This ratio was used to assign points:
- If ratio was less than one (lane reduction) – 1 point
- Ratio was exactly one (no change) – 2
- The ratio was greater than one (lanes added) – 3

Volume/Capacity (**V/C**)

A V/C ratio is a parameter which defines the level of traffic congestion. A V/C ratio is computed by dividing the volume of traffic during peak hour on a certain section of roadway by its hourly capacity (vehicles per hour). A V/C ratio of 1.0 represents the middle range of congestion; speeds start to decline, limited ability to maneuver, minor incidents can result in stopped traffic. A V/C ratio of 1.1 or greater represents the severe range of congestion. This is the level where stop-and-go traffic conditions would be expected to occur. A V/C ratio was projected for years 2010, 2015 and 2025. The CIP layer was spatially overlaid with the V/C ratio layer to find out how a project's geographic location will be affected by the level of traffic congestion. The CIP transportation projects in the area of severe congestion received the highest score. Points were assigned based on the V/C ratio as follows:
- V/C less than one – 1 point
- V/C equal to one – 2
- V/C greater than one – 3

Afternoon Peak Hour Congestion

Roadway Functional Class

Arterials carry the highest amount of travel. The CIP projects in the close vicinity of an arterial will have the highest impact on public safety and health. On the other hand, the majority of the county roads are local (about 87% of all Bernalillo County maintained lane miles), so they don't carry much of the travel. The CIP layer was spatially overlaid with the

County's roadways layer, to find out the functional class of the route in a CIP project's area. The score values were:

- Arterial – 3 points
- Collector – 2
- Others – 1

Intersection Capacity

BC PWD staff created the Intersection Capacity dataset for county maintained intersections. This data is a rough estimation of congestion based on previously done transportation studies and common knowledge of existing problems. The higher the level of congestion, the higher the number of points awarded for a related CIP intersection project. The levels of congestion and their values:

- Sever congestion – 3 points
- Moderate congestion – 2
- No congestion – 1

Flood Plain Impact

Number of Acres removed

Bernalillo County is a member of the National Flood Insurance Program and, as such, all property within the unincorporated portions of Bernalillo County is subject to FEMA requirements and the 2003 Flood Insurance Rate Maps that delineate floodplains. For each project that includes drainage infrastructure, the drainage basin was identified and spatially overlaid with the floodplain layer to determine the number of acres of FEMA floodplain that will be removed through the construction of the project. The ranges of floodplain removed and their values are:

- Over 50 acres removed – 3 points
- 11 to 50 acres removed – 2
- 1 to 10 acres removed – 1

FEMA designated Flood Plains

Flood area drainage problem

Number of properties removed

When a drainage project removes floodplain, individual affected properties will have the requirement to maintain flood insurance eliminated; thus recognizing a financial gain through not paying for flood insurance. Similar to the previous category, the project drainage basin was spatially overlaid with the parcel layer to determine the number of properties that will be

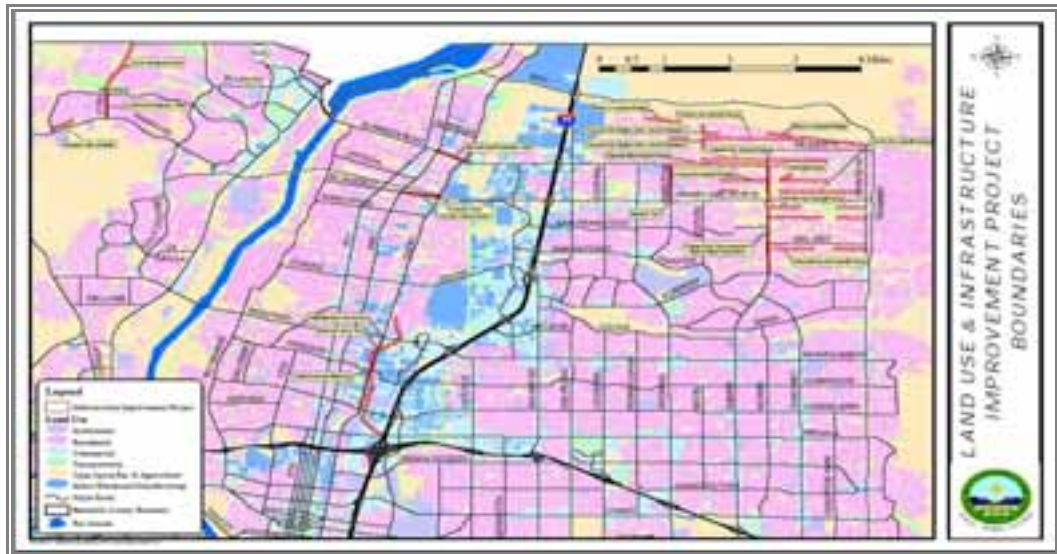removed through the construction of the project. The ranges of properties removed and their values are:
- Over 100 properties removed – 3 points
- 21 to 100 properties removed – 2
- 1 to 20 properties removed – 1

Socio-Economic

Land Use Pattern

Land developments are affected by the availability of services such as roadways, sewer and water. On the other hand, the land use type (for example, residential or commercial) affects the kind of infrastructure and transportation services that are needed (new roadways, increased bus service or additional recreational trails). The CIP layer was spatially overlaid with the Land Use layer to find out what land use pattern covered each CIP project. In the case where multiple patterns occurred, the land use with highest available score was assigned to the project. The types of land use and their points are:
- Institutional – 5 points
- Residential – 4
- Commercial – 3
- Transportation – 2
- Parks & Open Space – 1

Land Use Distribution

Number of Households covered by project

Improving services for the public is the goal of the Capital Improvement Program. Therefore, the number of households affected by the CIP project is an important element in the ranking process. Only residential properties were selected from the parcel layer for GIS analysis. The parcel layer was spatially overlaid with the CIP layer to count the number of affected properties for each CIP project. Projects which affect more residential properties (e.g. households) scored the most points, as follows:
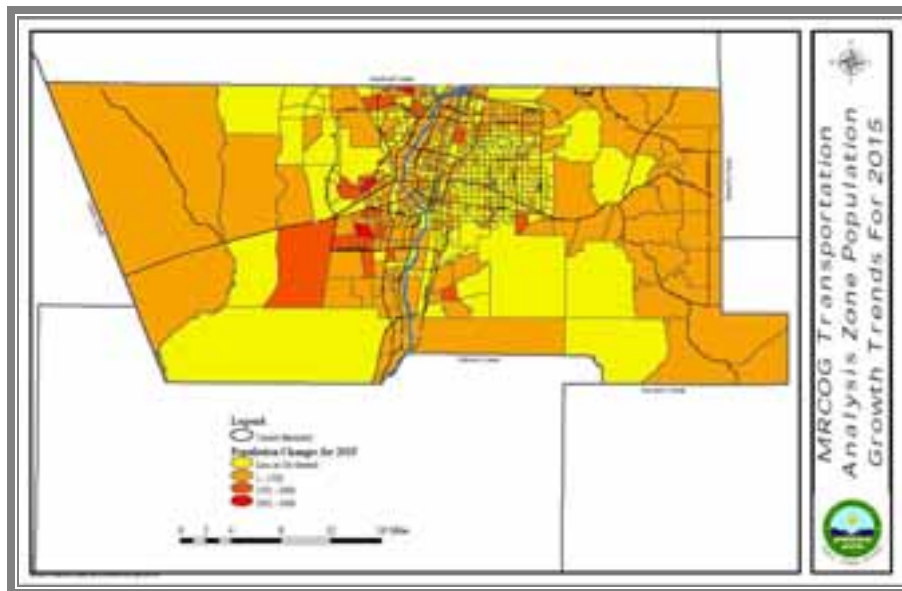- More than 30 households – 4 points

- 10 to 29 households– 3
- 5 to 9 households – 2
- 0 to 4 households – 1

Traffic/Data Analysis Zones (**TAZ/DAZ**) Population Growth
Estimates of county-level population statistics were generated by UNM's
Bureau of Business and Economic Research. These forecasts (produced
by MRCOG) are then disaggregated to smaller areas called Traffic or Data
Analysis Zones using MRCOG's Land Allocation Model. The Population
Growth Trends information is an important factor for understanding
community needs and providing sufficient transportation services and
accessibility to both major employment sources and vital facilities.
Population Growth Trends and forecasts are important criteria for the CIP
ranking process. The 2000, 2010, 2015 and 2025 Population Growth
trends were used in GIS Analysis. The trends for year 2000 were
computed using 1990 statistics as base, and other years' trends were
computed using 2000 statistics as base. Each TAZ layer was spatially
overlaid with the CIP layer to calculate population changes in the area of
each project. If the project intersected with more than one TAZ, then the
simple calculation of the mean population changes was performed. The
score values were:
- Growth was more than 3000 – 4 points
- Growth was in the range of 1501-3000 – 3
- Growth was in the range of 1-1500 – 2
- No growth occurred or a reduction of population took place – 1

Population Growth Forecast for 2015

Conclusion
There are still some enhancements to be made and further integration with other
BC PWD business process to be implemented:

1. Upon completion of a CIP cycle, create a dynamic ARCIMS website for
   viewing and querying CIP Projects. This will include accessing information
   in the SQL Database and identifying funded or unfunded projects. The

GIS CIP dataset will also be hyperlinked to photos of funded project areas. This tool should be available to the public for visualization and project status tracking

2. Create an ArcGIS extension for calculating all GIS related scores, making run time selection of different databases possible. This also will include outlining the update process for the GIS datasets involved in GIS analysis

3. Develop an interface between the CIP database and BC PWD financial database. This will provide funds tracking capabilities and project status information for management and PWD staff

Developing the BC PWD CIP database is a step toward rational, long-range capital planning and budgeting. Integration of GIS, Web and SQL database tools resulted in the implementation of a quantifiable prioritization process. This provides for more objective project selection and prioritization. The system allows for better project coordination, public request tracking and improves labor efficiency under limited time frame conditions.

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Appendixes
Summary of Acronyms

CIP - Capital Improvement Program
BC PWD - Bernalillo County Public Works Division
VBA - Visual Basic for Applications
MRCOG - Mid-Region Council of Governments
COA - City of Albuquerque
CORPS - U.S. Army Corp of Engineers
MTP - Metropolitan Transportation Plan
TAZ/DAZ - Traffic/Data Analysis Zones
V/C - Volume/Capacity

End Notes

[1] Mid-Region Council of Governments, Population Trend and Forecast, 1960 – 2025: http://www.mrcog-nm.gov/Bernalillo_county.htm Sources: U.S. Bureau of Census for 1960 - 2000, UNM BBER for 2010 and 2025 Forecasts.

References
MRCOG 2025 Metropolitan Transportation Plan (MTP) is a long range transportation plan, adopted in Spring 2004: http://www.mrcog-nm.gov/mtp.htm

City of Albuquerque, Council Planned Growth Strategy Report
http://www.cabq.gov/council/pgs.html

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