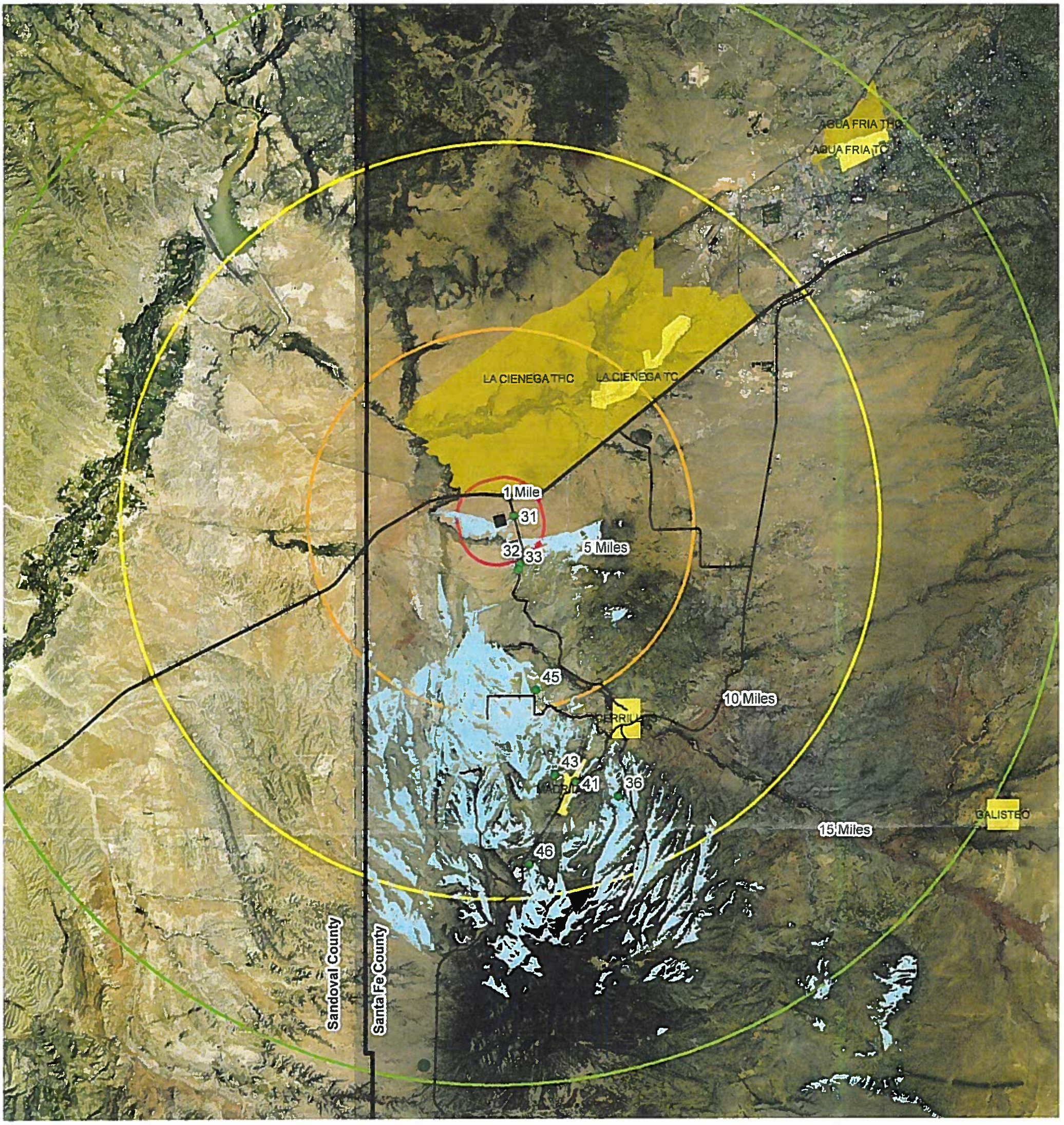

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Legend

- Photo Sites
- Proposed Mine
- Main Roads
- Traditional Community – County Regulations
- Traditional Historic Community – State Designation
- Can See Proposed Mine
- 1 Mile
- 5 Miles
- 10 Miles
- 15 Miles

Rockology Proposed Mine
Locations of Photos

July 30, 2014

#31

JUL 24 2014

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#33

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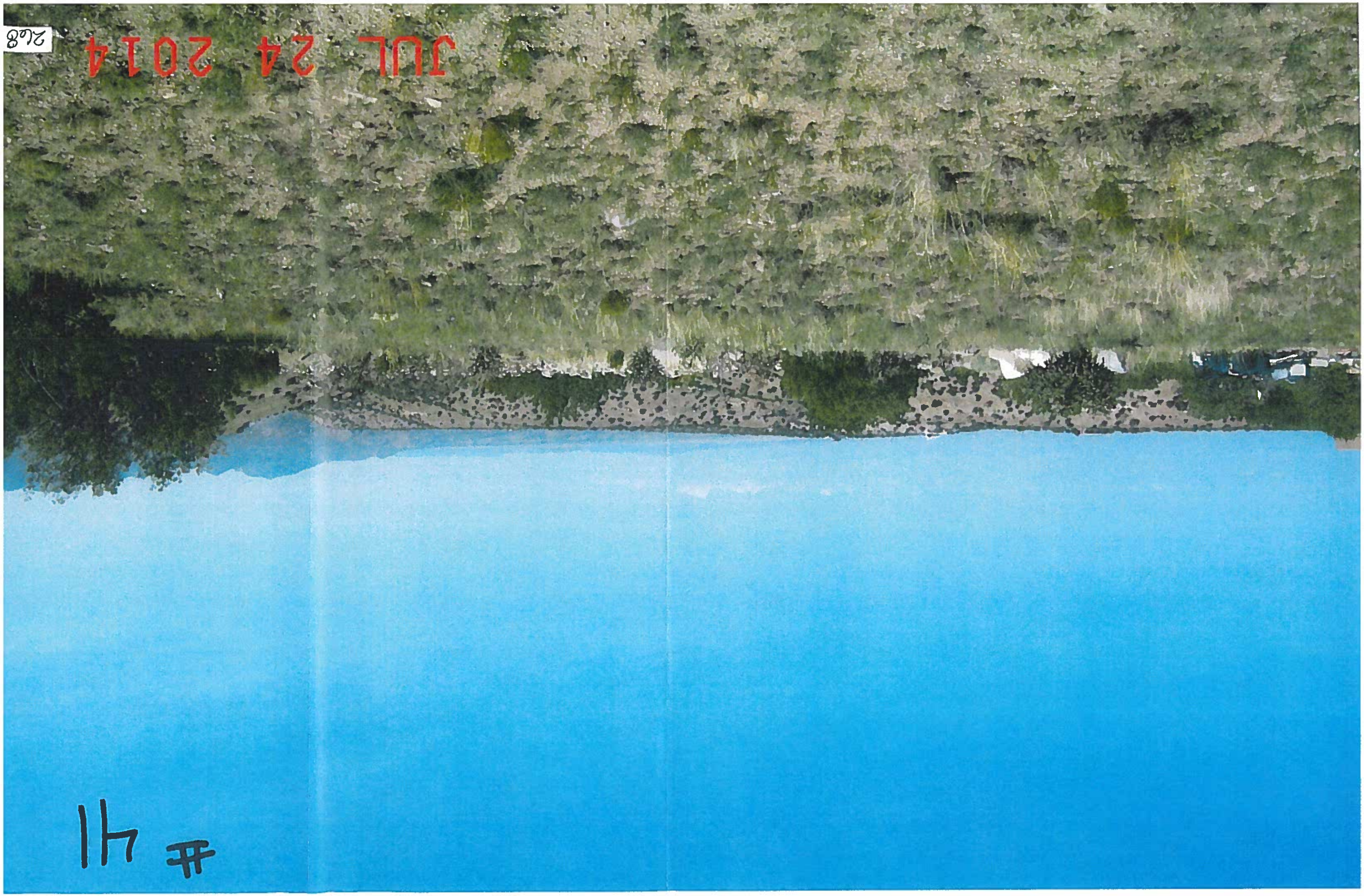
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DATE: July 31, 2014

TO: Jose Larrañaga, Development Review Team Leader

FROM: Karen Torres, County Hydrologist

VIA: Adam Leigland, Public Works Director

RE: CDRC Case # ZMXT 13-5360 Buena Vista Estates, Inc & Rockology LLC

At the request of the Public Works Director a review of the water budget for the subject development was performed. It should be noted this review is limited to the water budget only and should not be considered a comprehensive review for technical accuracy and compliance with the Santa Fe County Land Development Code.

Dust Control Water Budget:

The applicant is proposing to use 2.19 acre-feet per year for dust control associated with a mining operation to crush basalt into aggregate for construction purposes. The proposed supply of water is treated effluent which will be purchased from the City of Santa Fe wastewater treatment plant in combination with potable water from the County Bulk Water Facility and subsequently hauled to the site.

A monthly schedule of water use was presented but no methodology of how these figures were derived is included. It is presumed that the primary dust abatement will be associated with a water spray system specific to the mining equipment that will be used, for wetting of the disturbed areas and/or for use on the proposed haul road.

Industry standards (see attachment) indicate that a small rock-crushing operation will generally use between 10 to 50 gallons per minute. Extrapolating this out to 8 hours per day, 5 days a week, 50 weeks a year results in an annual water use of 3.5 acre-feet to 18 acre-feet per year. The County's road maintenance operation uses approximately 0.4 gallons per square yard when it applies water to dirt roads for grading purposes; dust control on disturbed areas and on any roads could be assumed to require similar application rates.

In short, without more specific information on the proposed mining operation, namely, duration of crushing operation and area involved in dust control, it is not possible to determine if the proposed water budget for dust control is reasonable.

EXHIBIT 10

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Reclamation Water Budget:

Water use is also proposed for necessary reclamation of the mine and is proposed to occur in 3 phases. An annual water budget for re-vegetation of disturbed areas with grass is proposed for each phase. The duty of water used for reclamation to establish grass indicated in the proposed water budget of 7.48 gallons per square foot is less than OSE Tech Report 48- Appendix C which estimates 14.91 gallons per square foot for buffalo grass irrigated through flood irrigation or sprinkler in Santa Fe County. Additionally summer precipitation cannot be counted on to reduce water demand as the duty of water used by the OSE takes evaporation and precipitation into account with the exception of rainwater catchment. It appears amount of water proposed for re-vegetation purposes may not be sufficient to meet the water demand grasses in this area. It should also be noted that irrigation of non-food crops with effluent can be done by flood application only; spray irrigation is prohibited by NMED.

If you have any questions, please feel free to call me at 992-9871 or email at ktorres@co.santa-fe.nm.us.

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Guidance for Controlling Silica Dust from Stone Crushing with Water Spray Technology

Stone crushing has long been associated with exposure to airborne crystalline silica dust to both workers and those residing in close proximity to these operations. Water spray dust control measures are effective at reducing levels of respirable crystalline silica dust. Studies have reported reductions in the range of 60% to 86% for respirable silica and dust in various applications including stone crushing, construction, mining, and manufacturing industries.

Health Effects of Crystalline Silica

Occupational exposure to respirable crystalline silica can cause silicosis, an irreversible and potentially fatal lung disease. Occupational silica exposure is also a risk factor for lung cancer, severe mycobacterial or fungal infections, such as pulmonary tuberculosis, chronic bronchitis and emphysema, and may be associated with renal disease and autoimmune diseases like scleroderma and rheumatoid arthritis. Freshly fractured crystalline silica particles are considered the most fibrogenic as they are capable of entering the gas-exchange regions of the lungs, thus increasing the importance for the control of respirable silica dust generated from stone crushing units.

Figure 1. Stone crushing operations create large quantities of respirable dust. Workers exposed to respirable silica dust have an increased risk of developing lung diseases such as silicosis or tuberculosis.

Engineering Controls

Reductions in respirable dust in stone crusher mills can be accomplished through engineering controls including process enclosures or containment, dust collection or local exhaust ventilation, and water spray systems. Water spray systems are generally thought to be the

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less expensive alternative and are therefore the focus of this guidance. However, additional measures may also be required to adequately lower silica exposure levels.

Water spray suppression techniques include the application of water, surfactants or foam at the crusher, conveyor feed and at other discharge points. Systems may be pressurized or rely on available water pressure. Wet methods can also control dust exposures downstream of the initial application if a high enough volume of water is applied to adhere to larger rock particles. Basic systems without pressurization and chemical additives are effective at significantly reducing respirable silica.

Water Spray System Design

The spray nozzle is the most important component of a water-spray system because it determines the physical characteristics of the spray, including droplet size, velocity, spray pattern and angle. In addition the available water pressure will dictate the selection of nozzles to achieve the desired spray characteristics. A general discussion of these factors is below, with specifics available from the manufacturer. Below is a general discussion of these factors, but product specific information must be obtained from the manufacturer.

Droplet and Orifice Size: Droplet size is the most important variable for proper dust control and is determined by the orifice size and available pressure. Droplet size decreases as operating pressure increases. The smallest droplets are generated by air atomizing nozzles using either compressed air or high-pressure water.

Droplet Velocity: Normally, higher droplet velocities are desirable for dust suppression control. Information on the droplet velocity, based on the available water pressure, can be obtained from the nozzle manufacturer.

Spray Pattern: Nozzles are categorized by the spray patterns they produce. The following table describes the different spay nozzles used in dust control.

Nozzle Selection & Characteristics

Solid-Cone	Hollow-Cone	Flat-Spray	Air Atomizing/Fogging
• Round spray pattern • High velocity over distance • Provide optimal surface area coverage for non-pressurized spray systems • Provide best coverage if water pressure available	• Circular ring spray pattern • Smaller droplets than other types of nozzles • Useful for operations with widely dispersed dust	• Rectangular, even spray pattern • Larger droplets • Useful for wetting rock material as it is being crushed	• Requires pressurized system • Very effective where airborne dust particles are very small • Nozzles can be located in close proximity to dust source

Spray Angle: The spray angle determines the width of the cone-shaped spray pattern produced by the nozzle. The appropriate spray angle needed to cover a specific surface area would depend on the distance the nozzle is placed from the material.

Flow Rate: The rate at which water flows through a nozzle depends on the operating pressure and orifice size. A pressurized system with a typical full-cone nozzle orifice diameter of 4 mm and an operating pressure of 80 psi (pounds per square inch) delivers a flow rate of 19 lpm (liters per minute). A non-pressurized system with the same nozzle orifice diameter delivers a flow rate of 5 lpm at 10 psi. Increased water pressure improves mist delivery and may allow for the installation of fewer nozzles to achieve the same dust reduction. It is also important not to apply too much water to the material as the finer particles can become muddy and sticky, which may cause equipment problems.

Number of Spray Nozzles

Depending on mill design and coverage area, a minimum of 8 – 11 nozzles are usually needed in small crushing units. The essential nozzle placements are given in the table below.

Essential Nozzle Locations	No. Nozzles
Top of crusher	1
Delivery point of crushing material	2–3
Each side of crushed material	1 pair
Vibrator/Rotary Screen (bottom)	1-2
Storage hopper	2–3

Additional nozzle locations may include: 1 at delivery point of raw materials and 1 at the bottom of the dust hopper.

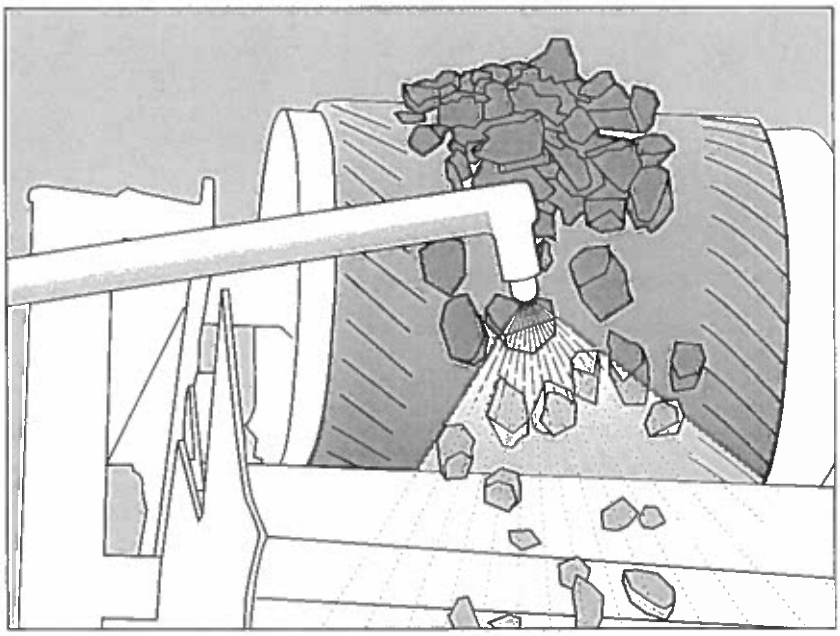

Figure 2. Spray nozzles help reduce the formation of respirable dust.

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Placement of Nozzles

Nozzles should be placed upstream of transfer point where dust emissions are produced and located to allow maximum time for water droplets interaction with airborne dust. Distance to crushing material depends on nozzle type, spray angle and water pressure (see Figures 3 and 4).

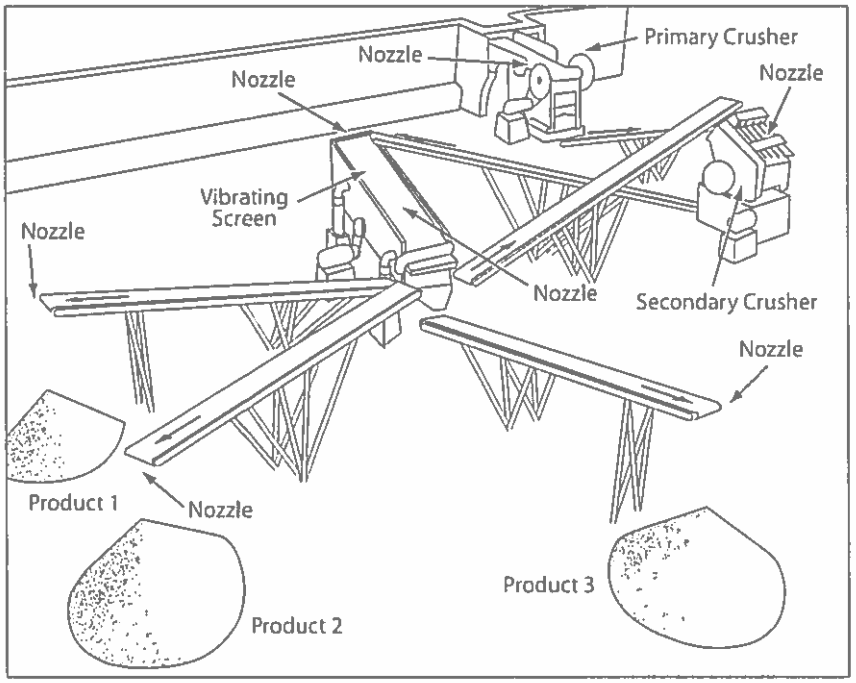

Figure 3

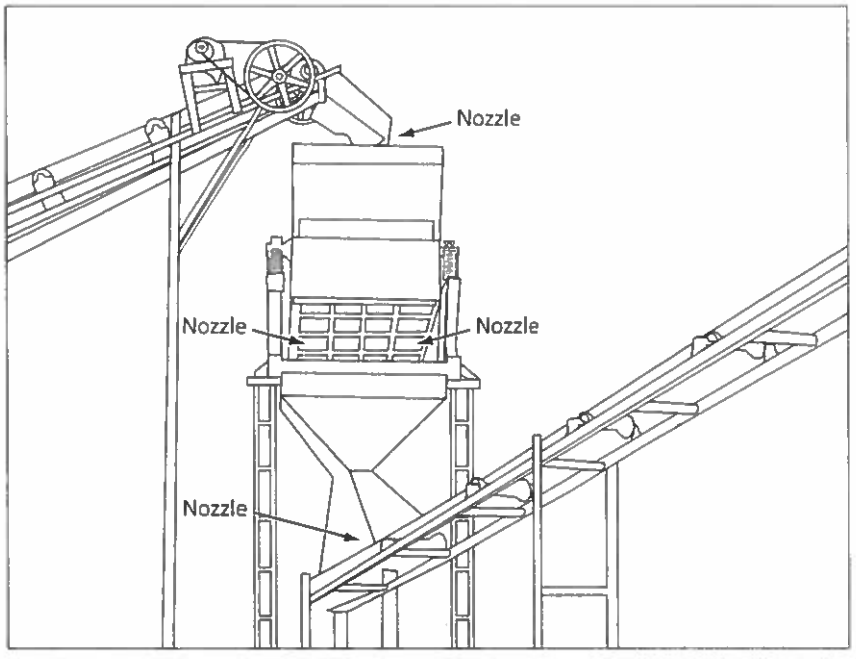

Figure 4

Water Consumption

A typical nozzle consumes 5 to 20 lpm of water (per nozzle) depending on pressure, with total water use dependent on the crusher unit size and number of nozzles needed.

Water Quality

Spray systems can rely on a variety of water sources that do not have to meet drinking water quality. In some cases, in-line filtration may be needed to avoid clogging nozzles.

For nonpotable water sources, careful consideration should be taken with respects to microbiological contaminants in the water, as they may constitute an inhalation hazard. Contaminants may include bacteria such as *Legionella* and *Mycobacterium*, viruses such as Hepatitis A or Hepatitis E, or even protozoa or helminths such as *Giardia* and *Schistosoma*.

Road Sprinklers

Sprinklers may be used to stop the spread of dust previously settled on the roadways and on waste materials. Road sprinklers are intended to reduce the amount of fugitive airborne dust generated by wind or vehicles. Commercially available spray equipment can be used without regard to nozzle orifice size. However such systems typically consume considerably more water than the fine mist nozzles, but they may also be operated intermittently.

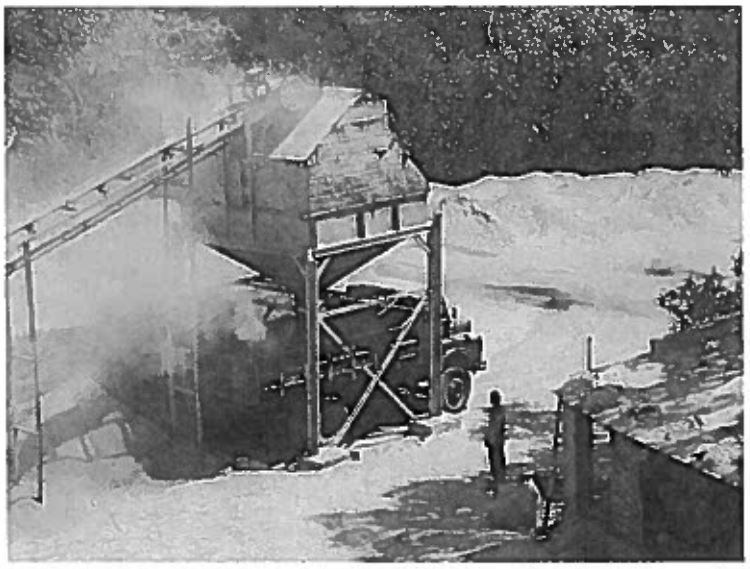

Figure 5. Dust being released during the loading of fine waste materials.

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Figure 6. Sprinkler systems along roadways help to reduce dust created by trucks entering and leaving the facility.

Estimated Costs for Water Spray System

Costs for purchasing and installing this equipment will vary and largely depend on the availability of water. Equipment costs for pressurized systems or those using chemical surfactants are higher than nonpressurized water spray equipment and will also have higher operating costs. Rainwater harvesting and other sources of reclaimed water can also lower operating costs.

Below are some examples of the cost for equipment and installation of dust suppression technology at two different stone crusher units. The cost for a site with 21 spray nozzles and a crusher capacity of 35 tonnes per hour (tph), and another site with 30 spray nozzles and a crusher capacity of 50 tph is approximately $2,120 and $2,815 respectively (Table 1). Smaller systems can be purchased and installed for approximately half these costs.

Table 1. Cost Estimate for Dust Suppression Technology Unit[1]

Description	Total Site A	Total Site B[2]
Well Bore Drilling Cost	$900	$1,400
Well Depth (meters)	60	91
Well pump (electric) cost	$300	$420
Water Storage Tank cost	$120	$120
Water Consumption per Day	3500 L/day	5000 L/day
Spray Equipments cost	$800	$875
Number of Nozzles	21	30
Crusher Capacity	35 tonnes/hr	50 tonnes/hr
Motor and Pump capacity (water)	1.5 H.P. (6500 lph -50 m head)	2 H.P. (7500 lph -60 m head)
Total Costs (USD)	$2,120	$2,815

[1]All cost are approximated in US dollars.

[2]Consists of two crusher units sharing one well.

Note

The above information has been provided as a general guideline for implementing a water spray system. However, the silica content of rock varies greatly and other environmental conditions such as temperature and humidity will impact the effectiveness. It is recommended that stone crusher mill operators consult with water spray specialists to properly design a system suited for their dust control needs.

Limitations

Although water spray systems are very cost-effective in significantly reducing the risk of silica dust exposure in stone crusher units, they do not eliminate the risk of silicosis or other related disease among exposed workers. Additional engineering controls and respiratory protection, may be required depending upon the crystalline silica content in the stone.

INDEX to DOCUMENTATION

RELEVANT TO COMMISSIONERS' INFORMATION REQUESTS DURING THE PUBLIC HEARING

At the June 11, 2014 hearing, the County Commissioners asked for more information during the public testimony and at the conclusion of the hearing. Recognizing the large volume of testimony and submissions, this index is provided as an aid to staff in documenting factual and published data responsive to the Commissioners' questions.

The Index was created to allow easy navigation to desired materials. Clicking on any blue underlined text in the document will bring you to the material referenced.

The Index is organized around the questions posed at the hearing. A list of the questions addressed in the Index is found on p. 3.

Clicking on any of the questions will bring you to a table citing relevant references and source material to address that question. Clicking on any blue underlined text within those tables will either bring you to the attached source material or link you directly to the source online.

If at any point you wish to return to the beginning of the document, press Ctrl + Home on your keyboard to return to this cover page.

FORMAT OF THIS INDEX

Each question from the BCC Hearing is underlined.
The list of questions (next page) can be clicked to go directly to a specific question.

- **Responsive factual published documents** are listed below each question.
- "**Submittal Item**" column: refers by page number to documents submitted to the record:

CRDC packet	package for CDRC March 20th
BCC packet	package for BCC June 11th
doc@CDRC	document submitted at CDRC hearing, March 20
doc@BCC	document submitted at BCC hearing, June 11
CDRC transcript	transcript of hearing
BCC transcript	transcript of hearing
App-CDRC	document originally submitted by applicant (in CDRC packet)
APP-modified	recalculations by applicant for BCC hearing; numbering per BCC packet
Real Estate Ad	Online commercial real estate ad, CB Richard Ellis. Key pages are attached. This material can be directly accessed at http://www.cbre.us/o/albuquerque/properties/la-bajada. However, some of the web pages seem to have been modified. Excerpts from the application time are shown in Attachment #12.
Land Dev Code	Santa Fe County Land Development Code, 1996
NM Mining Act	New Mexico Mining Act of 1993
Attachment #X	Refers to an Attachment to this Index

- "**Published source**" column: Citations refer to the original source of the published document (books, web page URLs, and County and City reports).

Questions Addressed in this Index

1. Is basalt from applicants' site uniquely superior to other road-base sources? 3
2. Can tax and employment benefits be expected from a new mine? 4
3. What conflicts exist between State and County mining definitions, and within County codes? 5
4. How does "contested water" (per Rep. Stephanie Garcia-Richards) affect County potable and City effluent supplies? 6
5. Is the water budget estimate reliable? 7
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10. What viewshed analysis methods are standard? 11
11. From what locations have visual analysis been mapped? What other viewpoints need to be mapped concerning this mining application? 11
12. What is the history of land ownership and real estate transactions for this site? 12
13. Where is this property listed as "5200 acres of aggregate for mining" 12
14. Are application documents correct and complete? 13

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1. Is basalt from applicants' site uniquely superior to other road-base sources?

Relevant document	Submittal Item	Submittal Page	Published Source
Caja del Rio Basalt lab test records, SFSWMA, show that CdR product meets FHWA, NMDOT, City, BIA, and FAA standards for aggregate.	Attachment #1	p. 1	Letter, June 24, 2014, from testing lab Western Technologies Inc, 8395 Washington Pl. NE, Abq 87113-1670.
Average specific gravity of basalt is 2.8 to 3.0	On-line Reference	-	EduMine, Professional Development and Training for Mining and the Geosciences, http://www.edumine.com/xtoolkit/tables/sgtables.htm
Applicant represents LB basalt as having specific gravity of 2.55-2.65 (lower than average).	Attachment #12 from Real Estate web site	p. 1-2	Oct. 10 2003 letter, on Buildology letterhead, signed by Steven A. Hooper P.E. No testing lab cited.
Applicant stated that LB basalt is especially dense (this means high specific gravity) and impermeable.	BCC transcript		During applicant's sworn testimony. (Page number unknown until transcript is posted.)
Evidence regarding the soundness and suitability of LB basalt	Attachment #2	p. 11, item 16	"Gross Receipts Tax and Economic Impact Analysis of proposed Buena Vista - Rockology basalt aggregate operation" by L. Graeser, Chief Economist (ret.), NM Taxation & Revenue Dept (1986-2001), and NM Dept. of Finance & Admin. (2006-2010); International economic consultant (1998-present), specializing in analysis of tax revenue impacts of economic proposals
La Bajada & Caja del Rio are the same homogenous geological formation.	BCC packet	NBB-1090	Map provided by Dr. Kirt Kempter, geologist and Fullbright Fellow.

2. Can tax and employment benefits be expected from a new mine?

Relevant document	Submittal Item	Submittal Page	Published Source
Expert witness testimony, economics and taxation: Laird Graeser	doc@BCC	-	Laird Graeser, Chief Economist (ret.), NM Taxation & Revenue Dept (1986-2001) , and NM Dept. of Finance & Admin. (2006-2010); International economic consultant (1998-present), specializing in analysis of tax revenue impacts of economic proposals
Gross Receipts & Economic Impact Analysis	doc@BCC, Attachment #2	pp. 1-7	"Gross Receipts Tax and Economic Impact Analysis of proposed Buena Vista - Rockology basalt aggregate operation" by L Graeser, 2014
Exclusion of Caja del Rio basalt production from Applicants' estimates distorts actual production and market data.	Attachment #2	p. 2	(above)
Caja del Rio cost structure makes profitability and tax liability of proposed BV/R mine questionable.	Attachment #2	pp. 3-5	(above)
Applicants estimate 50% of sales GRT taxable; historically, Caja del Rio sees between 3% and 10% taxable sales.	Attachment #2	p. 5	(above)
Existing in-county suppliers, including CdR, have existing stockpiles sufficient for over 10 years' demand, and capacity to expand production.	Attachment #2	p. 6	(above)
Applicants' job projections of 7 full-time workers with benefits, plus 6 contract truckers, does not match production (projected BV/R, or actual CdR)	Attachment #2	p. 7	(above)

3. What conflicts exist between State and County mining definitions, and within County codes?

Relevant document	Submittal	Submittal Page	Published Source
LDC is internally inconsistent on applicability: Art III, section 5.1.1, Applicability, does not exempt gravel; but Art III, 5.1.2.D states that none of Article III applies to sand and gravel.	Land Dev Code (LDC)	III.5.1.1 & III.5.1.2.D	Santa Fe County Land Development Code, 1996
LDC is ambiguous in defining sand, gravel, etc. Art. III definitions, esp. that of "mineral," have been referenced to Art. XI	Land Dev Code	III.5.2	Santa Fe County Land Development Code, 1996
Art XI was written to exempt the gravel industry from nearly all zoning and environmental regulations applicable to every other residential or commercial or industrial land-user, and applied to gravel when under Art. III. This violates the clear intentions of the Code as a whole.	Land Dev Code	Art. III , Sec A.3 through A.7	LDC Art III.5 (mining) requirements include a multi-disciplinary review board, BCC-set limits on volume or duration of operation, review of past performance by operator at any site worldwide, and compliance with all State and Federal permits.
Article XI exempts sand and gravel from every part of the LDC except Article XI: XI.1.7.2 "Except as provided in this Ordinance, mining uses shall not be subject to the Code." XI.1.1.2 makes any conflicting provision in the LDC "precluded by this Article XI."	Land Dev Code	XI.1.7.2 & XI.1.1.2	Santa Fe County Land Development Code, 1996
County Land-Use Code definitions for "mine site", "mineral", and "mining use" (established in Art X) all specifically apply ONLY to Art XI. However, Art. XI governs sand and gravel exclusively, so these definitions are all self-contradictory.	Land Dev Code	Art X, 1.83 to 1.86	None of these definitions excludes or exempts sand or gravel, and in fact, none even mentions sand or gravel in specific. Yet each definition is clearly stated to apply ONLY to the Article (XI) that governs sand and gravel mining.
Article XI defines extracted construction materials as "stone, sand, gravel, aggregate, and other naturally occurring materials" and excludes them from the Article on Mining (Art IISec5).	Land Dev Code	Art XI, 1.1	Santa Fe County Land Development Code, 1996
NM Mining Act 69-36-3 in defining "mineral" and "mining," excludes sand, gravel, and related soil-like substances.	Attachment #13	69-36-3	New Mexico Mining Act, 1993

4. How does "contested water" (per Rep. Stephanie Garcia-Richards) affect County potable and City effluent supplies?

Relevant document	Submittal	Submittal Page	Published Source
The Board of County Commissioners in Dec 2011 formally requested the City utility to prioritize release of effluent for use in irrigation by La Cienega, Cieneguilla & La Bajada	Dec 13, 2011 BCC minutes; Attachment #3	pp. 25-29	SF BCC Resolution No. 2011-191, A Resolution Requesting that the **City of Santa Fe Release Additional Effluent** into the Santa Fe River **to Support the Historical Agricultural Needs of the Village of La Cieneguilla and The Village of La Bajada** (Introduced by Commissioner Anaya) Resolution approved by unanimous [4-0] voice vote. santafecountynm.gov/documents/agendas/minutes/12-13-11.pdf
City effluent is over-allocated by min. 40%	BCC transcript; Attachment #4	pp. I, 22	*City of Santa Fe Reclaimed Wastewater Resource Plan*, April 2014, pp. I, 22
Code requires rights certified by State Engineer	Land Dev Code	pp. 249-250	Santa Fe County Land Development Code, 1996, Article XI, Zoning for Extraction of Construction Materials, Sec. 1.7, Reviews for Mining Uses
Water rights face adjudication throughout NM; the Santa Fe River system/basin was 74% adjudicated in 2010. "There is no debate that [the Middle Rio Grande, from Cochiti south] is the most significant area of the state where an adjudication suit has yet to be filed."	Attachment #5	p.12	*The Future of Water Adjudications in New Mexico,* GC Ridgely, Office of State Engineer **Especially fig. 2, p 12.** http://wrri.nmsu.edu/publish/watcon/proc55/ridgley.pdf

5. Is the water budget estimate reliable?

Relevant document	Submittal	Submittal Page	Published Source
Water estimate as initially submitted in the application is unsubstantiated. The "Water Budget for Reclamation" section of the application does not actually provide a water budget. Instead, it mentions three phases of reclamation whose surface area is provided in square feet, then provides calculations showing that 270,431 gallons of water will be required to reclaim each acre of land.	App-modified; CDRC packet	p. 19; NBB-31	Cites no methodology, source of data, nor explicit assumptions (e.g. hours of operation)
The three phases described in this Water Budget for Reclamation section total only 592,376 square feet, or 13.6 acres of land. However, Sheet 16 of the Materials Extraction Plans, entitled *Reclamation Plan, Phase III*, shows all 50 acres reclaimed. Since no actual water budget is provided, it is impossible to determine which plan is accurate and what condition the mesa would be left in when mining is complete. Nor do we know whether the process will have consumed 3,677,862 gallons of water (to reclaim 13.6 acres) or 13,521,550 gallons (to reclaim all 50 acres.)	APP-modified	Sheet 16	
Applicants' estimates of water requirements increased by 13,521,550 gal between CDRC and BCC hearings	APP-modified	p.21, NBB-33; Sheet 16	Total additional water quantities not cited, but required gallons per acre for reclamation, partial acreage calculations, and a plan (sheet 16) showing 50 acres of planned reclamation are provided.

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6. Is a groundwater discharge permit required?

Relevant document	Submittal	Submittal Page	Published Source
NM Environment Department regulations require Groundwater Discharge Permitting.	Attachment #6		NMED Water Quality Control Commission Regulations, 20.6.2.1201, Environmental Protection: Water Quality – Ground and Surface Water Protection http://www.nmcpr.state.nm.us/nmac/parts/title20/20.006.0002.htm
City of Santa Fe *Reclaimed Water Use Requirements* state unequivocally: "Dispensing of reclaimed water for application to any Area on an **ongoing basis**, rather than temporary or intermittent, **shall require a ground water discharge permit,** pursuant to the New Mexico Water Quality Control Commission Regulation 3104.	BCC packet	NBB-87	*City of Santa Fe, Wastewater Division, Reclaimed Water Use Requirements.* These rules, regulations and requirements are legally attached to the Reclaimed Water Use Agreement and Permit (see page NBB-82), and include the provision that failure to follow these requirements may result in revocation of the agreement to provide effluent.
Applicants' submission (pp. NBB-9 through NBB-146) contains no reference to any Groundwater Discharge Permit.	BCC packet	not found	
County Code requires applicant to provide evidence of planned compliance with laws, rules, regulations and permits.	Land Dev Code		Santa Fe County Land Development Code, 1996, Article XI, Zoning for Extraction of Construction Materials, Sec. 1.7, 2 Environmental Review

7. Does Code require sufficient water for full duration of project?

Relevant document	Submittal	Submittal Page	Published Source
County Land-Use Code, re: gravel extraction. "The applicant shall submit evidence that the applicant has obtained an **adequate** supply as evidenced by appropriate **permits issued by the State Engineer's Office**/ Interstate Stream commission of New Mexico." (Emphasis added. "Adequate" clearly means meeting proposed usage, and strongly implies that usage be met for the full term of the project.)	Land Dev Code	Art. XI	Santa Fe County Land Development Code, 1996, Article XI, Zoning for Extraction of Construction Materials, Sec. 1.7, Reviews for Mining Uses
County Land-Use Code, applicable **ONLY** to community water systems. [where] "existing utility companies are proposed as the source of water supply, the applicant shall submit a water availability assessment which includes... a letter of intent from the utility that they are ready, willing, and **able to supply the maximum annual requirements** for the development. The letter must also state any requirement for the applicant to provide water rights." (Emphasis added. Applicant is not proposing a community water system, but has claimed that a ready-and-willing letter is sufficient evidence for a mining operation.)	Land Dev Code	Article VII, 6.4.4a	Santa Fe County Land Development Code, 1996, Article VII, Environmental Requirements
Neither utility letter (from County or City) meets the requirement to guarantee "to supply the maximum annual requirement for the development." In fact, both utilities state that supply may be curtailed under emergency conditions.	BCC packet	NBB-79 through NBB-88	
The City of Santa Fe is submitting a letter to BCC elaborating on limits to access to effluent water sources. These limits mean that County potable water will be used much *more* extensively than implied at the BCC hearing.			To be supplied

8. Does the submitted traffic analysis represent standard estimating methods for industrial traffic counts?

Relevant document	Submittal	Submittal Page	Published Source
Applicants' traffic analysis was limited to "rush hour" on a road where there is no rush hour, and where maximum usage is driven by production schedules, not arrival or departure of workers.	App-CDRC; doc@BCC	NBB-34 & NBB-35	Neither in written application nor in sworn testimony did applicant cite any methodology or reason for focus on commuter peak hours.
Standard method(s) must differentiate trucks from other traffic, and consider daily, weekly, and monthly statistics.	Attachment #7		"Evaluation of Different Methods to Calculate Heavy-Truck VMT" University Transportation Centers, US Dept of Transportation MTC Project 2002-02.
Average Daily Traffic must be based on 48-hour count during midweek; minimum, with extrapolation, 24-hour count.	Attachment #8		"2014 Project Traffic Forecasting Manual" Florida Department of Transportation www.dot.state.fl.us/planning/statistics/trafficdata/ptf.pdf

9. Are County facilities such as Caja del Rio ever obligated to obtain County zoning permits?

Relevant document	Submittal	Submittal Page	Published Source
For Caja del Rio, which is a joint agreement between City and County of Santa Fe, landfill permits were obtained by the City. These are State and Federal (EPA) regulations, and are more stringent than State gravel mining permit requirements, especially concerning air and water impacts.	Attachment #2	p. 2	"Gross Receipts Tax and Economic Impact Analysis of proposed Buena Vista - Rockology basalt aggregate operation" by L Graeser, 2014

10. What viewshed analysis methods are standard?

Relevant document	Submittal	Submittal Page	Published Source
Visual impact analysis or viewshed analysis today is primarily automated, using GIS and publicly available digital map data.	doc@BCC Attachment #9	p. 1	" Viewshed Mapping and Visual Impact Analysis" D. van Doren, 2014
Visual impact from Camino Real was evaluated by Rick Wessel, NMDOT archaeologist, based on National Elevation Dataset.	doc@BCC	pp. 3-4	(above)
Visual impact from five locations along I-25 (not evaluated by Applicant) were evaluated using transect analysis and public data, by Van Doren.	doc@BCC	pp. 6-7	(above)

11. From what locations have visual analysis been mapped? What other viewpoints need to be mapped concerning this mining application?

Relevant document	Submittal	Submittal Page	Published Source
Viewpoints submitted by applicants/staff were limited to two on I-25 on either side of the Waldo interchange, and others on Waldo road close to the interstate.	App-CDRC	NBB-132 to NBB-141	Field photos of 3-foot wide flags on 20-foot poles representing mine location
Wessel documented views from the Juana Lopez segment of the Camino Real de Tierra Adentro passing close to the proposed mine.	doc@BCC Attachment #9	p. 3-4	"Viewshed Mapping and Visual Impact Analysis" D. van Doren, 2014
Transect analysis by van Doren covered 5 sites on I-25; see location map.	doc@BCC	p. 6	(above)
Other viewpoints of concern include locations on the Turquoise Trail National Scenic Byway (NM 14), NM 22 and NM 57A, and Cerro Chato Road. This is not a comprehensive list.	doc@BCC	p. 5	(above)
No viewshed analysis was conducted from locations south and east of the proposed mining zone. However, photographs from some of these locations show that the entire proposed operations will be visible, not hidden in an extraction pit. Because of the slope of the land, the Application diagrams show that the "pit" has no sides to the south. This fact is also shown in the elevation diagrams in the application.	App-CDRC, doc@BCC Attachment #9	pp. 6-7	"Views of Proposed Mine Site from Five Locations Along I-25"

12. What is the history of land ownership and real estate transactions for this site?

Relevant document	Submittal	Submittal Page	Published Source
pre-1970s sale by John Simms to Ernest Cummins	doc@BCC		Santa Fe Reporter, May 18 1978, page 1- 15
Sept. 9, 1975 'round-robin' sales between Naumburg, Cummins, and Peppler increased value 400%	doc@BCC; Attachment #10		Santa Fe Reporter, May 18 1978, page 3 "*From $300 to $1200 per Acre in One Day*"
1978 Consent Decree against Cummins, Naumburg, and Peppler			District Court Case # SF 78-2566, Toney Anaya vs. Ernest Cummins. Several decisions handed down Dec 20 1978; Oct 3, 1979: Required restitution of $475,000 to investors.
1980 transfer from Cummins to Buena Vista. J. Geist is mentioned as an investor in BV, but Naumburg is conspicuously absent at the time of this transfer. As of 2014, he is a major (if not the major) owner in BV.	App-CDRC	NBB-38 to NBB-53	District Court ruling on restitution escrow required by consent decree, above, ruling May 26, 1980. Because the escrow for restitution was not funded, Cummins was allowed to give the land to newly formed Buena Vista to ensure funding for restitution.
Buena Vista Inc. was required under the terms of the District Court ruling to abide by State and County laws concerning development.	App-CDRC	NBB-46 (orig p. 10, sec. 13)	"Buena Vista Estates Inc intends to develop [the land surrendered by Cummins] but will comply with the New Mexico Subdivision Act 70-5-1 et seq NMSA and the Santa Fe County Subdivision Regulations prior to subdivision or sale of said land."

13. Where is this property listed as "5200 acres of aggregate for mining"

Relevant document	Submittal	Submittal Page	Published Source
International real estate ad for "5200 acres of rich aggregate for possible mining."	doc@CDRC and doc@BCC; Attachment #12	p. 3	http://www.cbre.us/o/albuquerque/properties/la-bajada First posted ca. 2007; most recent update July 2014.

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14. Are application documents correct and complete?

Relevant document	Submittal	Submittal Page	Published Source
Coefficient of Runoff "CN" for existing soil is unrealistically high (82%).	Application plan drawings: NBB-90 to NBB-106	Sheet 9	Transportation Department standards for NM and five other states show max. CN for vegetated soil at 60% (10-year storm); max for soil in 100-year storm, 75%
Coefficient of Runoff "CN" for exposed basalt unrealistically low (84%).	Application plan drawings	Sheet 9	Applicant testimony (BCC) states basalt at this site is highly impervious (impervious surfaces CN = 90-95%)
Resulting calculation estimates only 2% increase in runoff from soil to solid impervious rock.	Application plan drawings	Sheet 9	
Recalculation using soil CN = 75% and basalt CN = 95% results in retaining pond undersized by rough factor of 2 (31K cf versus 54K cf).	Attachment #11		Spreadsheet table "**Recalculation of BV/R Runoff using more realistic coefficients**"
Contours at pond cross each other (contours can never cross)	Application plan drawings	Sheet 9	Impossible to ascertain whether pond size as drawn matches mathematical estimate.
18-inch silt fence used for dust control (ineffective and non-standard specification)	Application plan drawings	Sheet 11	Zigzag line on plan; detail "Silt fence Installation" clearly indicates use for filtering runoff, not dust)
Topsoil stockpiles are extremely large: drawn at approx. 300 x 175 ft (Phase I) and 200 x 50 (Ph. 2+3I). Topsoil amounts are not proportional to pile sizes: 17,000 c.y. (Ph. 1), 11,000 c.y (Ph.2), and 6,000 c.y. (Ph 3).	Application plan drawings	Sheets 9,12,15	Per plans: **Phase 1:** 17,000 cu. yds; plan footprint = 300 x 175 ft. (5833 sq. yds base area). If uniform height, this would be 9 feet tall, but as a cone, much taller. **Ph.2:** 11,000 c.y. on 200x50 ft (1,111 sq. yd) If uniform height, 30 ft tall; actually much taller. **Ph.3.:** 6,000 c.y. on 200x50 ft (1,111 sq. yd.). If uniform height, 16 ft tall; actually much taller.
Industry standards indicate that soil stockpiles taller than 4 to 6 ft or held for more than one month result in dead soil organisms; soil is no longer viable, and will disperse as dust.	Standard sources listed		P. Craul, *Urban Soil in Landscape design,* 1992,Wiley, p. 290-91; *Sustainable Landscape Construction,* 2nd Ed. 2007, Island Press; page 88-89.
"Area to be reseeded" (shaded on applicants' plans) is completely inconsistent with volume of topsoil stockpiled per phase.	Application plan drawings	Sheets 10, 13, 16	**Phase 1:** 17,000 c.y. over area of less than 20,000 sq. yds. (shaded on plan)= ***2.5 ft*** **depth of topsoil.** **Ph.2:** 11,000 c.y. over area est. 21,000 sq. yds = ***1.5 ft*** **depth of topsoil.** **Ph. 3:** 6,000 c.y. over area 134,000 sq. yds. = about ***1.5 INCHES*** **topsoil depth** - *insufficient to sustain vegetation, especially over bedrock.*

NPDES general permit requires "areas inactive for more than 14 days be temporarily stabilized, unless construction will resume within 21 days." **No such temporary stabilization is indicated** on plans, yet applicant has testified that quarry will be inactive for months within the proposed 25-year operation.	Application plan sheets	Sheet 18 re-produces text of NPDES regulation	For details of the NPDES **(National Pollution Discharge Elimination System)** see http://cfpub.epa.gov/npdes/. NPDES applies to all projects disturbing one acre or more. BV/ R drawings reference a superseded version of the NPDES regulations.
Code requirement to provide evidence of planned compliance with laws, rules, regulations and permits	Not provided		Santa Fe County Land Development Code, 1996, Article XI, Zoning for Extraction of Construction Materials, Sec. 1.7, 2 Environmental Review
Reclamation acreages inconsistent throughout application	App-modified	p.21, NBB-33; Sheet 16	The partial acreage listed is incorrectly calculated and also inconsistent with the 50 acre reclamation plan shown on Sheet 16.

ATTACHMENTS

Attachment #1: Letter affirming repeated AASHTO testing of Caja del rio aggregate meeting NMDOT and all other agency standards for base course and other uses

Western Technologies Inc.
The Quality People
Since 1953

8305 Washington Place N.E.
Albuquerque, New Mexico 87113-1670
(505) 823-4488 • fax 821-2963

June 24, 2014

To Whom It May Concern

RE: Delhur Industries - Caja Del Rio Aggregate Pit - Santa Fe, New Mexico

Western Technologies Inc. is an accredited *AMRL* laboratory by the American Association of State Highway and Transportation Officials (AASHTO) doing business in the greater Albuquerque area since 1984. We have provided quality control and materials acceptance reports on many of the products produced out of the Caja Del Rio Pit for many years. As such, we can attest that the materials produced out of the pit have been tested and acceptable by many agencies that specify aggregates for highway, bridge, and building materials. We have tested and produced reports for the following agencies:

- New Mexico Department of Transportation (NMDOT)
- Bureau of Indian Affairs(BIA)
- Federal Highway Administration(FHWA)
- City of Santa Fe Public Works
- Private Contractors and subcontractors.
- Federal Aviation Administration (FAA)

The aggregate pit is a basalt flow crushed material that meets the aggregate index required by the NMDOT for concrete, asphalt, and base course materials. In addition, the aggregates meet the durability requirements of the FHWA section 703, for concrete, asphalt, base course, and RIP RAP materials. The coarse aggregates have been used for concrete on Santa Fe Public Works projects for years and meet all requirements of ASTM C-33.

Respectfully Stated,

WESTERN TECHNOLOGIES INC.

Andrew L. Cuaderes, SR. - Managing Director/Vice President

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Attachment #2: Gross Receipts Tax and Economic Impact Analysis

Gross Receipts Tax and Economic Impact Analysis
of proposed Buena Vista - Rockology basalt aggregate operation

Executive Summary of Testimony and Analysis by Laird Graeser

Chief Economist (ret.), NM Taxation & Revenue Dept (1986-2001)
and NM Dept. of Finance & Admin. (2006-2010)
International economic consultant (1998-present)
specializing in analysis of tax revenue impacts of economic proposals

Sworn testimony provided at June 11, 2014 BCC hearing, Santa Fe NM

- The application by Buena Vista/Rockology (hereafter, BV/R or Applicant) claims that creating a new mining zone and permitting it to blast, crush and sell basalt aggregate would have economic benefits including tax revenue increases for Santa Fe County. Analysis shows these claims to be dubious.
- The BV/R application contains a number of misstatements due to completely excluding the amounts of basalt produced and sold by the Caja del Rio quarry (hereafter CdR). Excluding CdR quantities makes it appear that there is less existing basalt production in Santa Fe County than in fact is produced, and that therefore a profitable market could exist for new production. Analysis that includes CdR shows that there is no shortage of suitable construction aggregates in the mid-County area.
- The BV/R application claims that aggregate from CdR and other existing in-County producers is inferior to what applicant proposes to produce, allegedly giving the proposed mine a market advantage. However, CdR's product has repeatedly been tested and shown to meet the standards of NMDOT, FHWA, BIA, and City and County of Santa Fe (see Attachment #1, letter from Western Technologies lab, June 24, 2014). CdR aggregate is widely accepted and used for base course, construction, ready-mix, and landscaping purposes. Analysis does not support claims of higher quality, or advantageous marketability based on such claims.
- The cost structure of CdR Rock Quarry, operated by Del Hur Industries, allows it a competitive advantage compared to the BV/R proposal and to other existing producers. If BV/R must lower prices to compete, their profitability, and thus economic benefits and tax liability to the County, would be questionable.
- Because production currently fulfills and meets demand, even if BV/R captures part of the market, it will be at the expense of "cannibalization" of existing operations, including CdR. If existing operations lose profits and/or workers, the potential impacts on the County's economy and tax base are negative, especially since BV/R is headquartered outside the County.

Understatement of Production and Overstatement of Market

There is a substantial market throughout Santa Fe County for aggregate of all grades, but the market is currently satisfied by production within the County. Applicants' exclusion of production by CdR distorts the actual relationship between supply and demand.

- Caja del Rio produces aggregate as a adjunct to blasting that creates pit space for its main purpose, as the regional landfill. Sale of basalt removed from the pits recovers something approaching half of the costs of blasting, a significant saving to County taxpayers for whom the landfill is operated. CdR aggregate production is operated by Del Hur Industries.
- Aggregate production at CdR is governed under its landfill permit (with stricter air and water protections than are usual for gravel mine permits), and as such is not reported to the NM Department of Energy, Minerals and Natural Resources, which permits and tracks ordinary gravel operations.
- Hereafter, gravel operations that obtain their permits from and report production and sales statistics to the NM EMNRD are referred to as "State gravel-permitted" operations. Other legal production comes from "adjunct-permitted" operations, whose permits allow gravel production secondary to a main purpose, such as landfill at CdR; and from "temporary permit" operations, usually specific to borrow pits for road construction. Neither adjunct nor temporary production should be thought of as operating without any permit.
- By relying on EMNRD statistics on gravel production only from state gravel-permitted operations, the applicant has understated actual production for Santa Fe County and overstated potential markets by 50,000 to 160,000 tons. This under/overstatement also distorts the Applicant's estimates of costs, sales, and margins.

The following chart shows the recent volume and value of aggregate for Santa Fe County as reported to NM EMNRD, 2008-2012. Production by Caja del Rio is not included by EMNRD in their statistics. However, Caja del Rio currently has a stockpile of 1.6 million tons of basalt extracted from the landfill cells that can readily be processed into gravel.

Note that even without the CdR production, there was an excess supply of aggregate in the County for the period reported. This excess is much larger when CdR production and sales are properly accounted for.

Existing Aggregate Production/ Sales/ $Value - Santa Fe County NM EMNRD statistics 2008-2012 (as reported by operators)				
AggregateType	Amount Sold	Amount Produced	Production Value	Price per Ton
	Short Tons	*Short Tons*	*$*	*$/Short Ton*
Base Course Total	516,283	550,797	$10,585,457	$19.22
Crushed Rock Total	79,595	80,626	$249,800	$3.10
Gravel Total	348,262	420,973	$11,364,937	$27.00
Riprap Total	65,778	65,778	$1,217,715	$18.51
Totals - existing production	1,009,918	1,118,174	$23,417,909	
Average Total Annual	201,984	223,635	$4,683,582	
Excess Supply Annual		21,651		
Caja del Rio aggregate (annual) *not* **included in EMNRD stats**		250,000 to 500,000		
ACTUAL EXCESS SUPPLY FOR ALL EXISTING COUNTY AGGREGATE (ANNUAL)		271,651 (min) 521, 651 (max)		

Note: NM EMNRD statistics for fill dirt production have been excluded from this chart. For SF County during the above years, the pattern of supply slightly exceeding demand held for fill dirt as well as gravel products.

Cost Structure, Profitability, and Impacts to Taxpayers

The cost structure of the CdR operation allows a competitive advantage compared to existing aggregate producers and to the proposed BV/R mine. CdR blasts and excavates basalt to create landfill cavities. This excavated basalt is stockpiled, ready for crushing and screening. This stockpile is currently 1.6 million tons. Del Hur pays the Agency $1.50 per ton for the excavated basalt. This includes a fair-market payment of $0.95 per ton to BLM, owners of rights to minerals including the basalt. Thus, the County nets $0.55 per ton for re-purposing what would otherwise be a waste byproduct of the landfill operations.

Concurrently, Del Hur realizes a cost advantage over other mining operations. The cost of blasting and excavating prior to crushing is estimated at $2.87 per ton. Because Del Hur pays only $1.50 per ton, they have a $1.37 per ton cost advantage.

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Current prices of gravel products produced under NM-EMNRD permits in Santa Fe County (previous chart) range from $18 to $27, except the significantly smaller and cheaper crushed rock.

The following chart shows current prices for comparable products from the Del Hur operations at Caja del Rio.

Caja Del Rio Quarry Rock Sales Price List		
	Freight on Board (FOB)	Delivered
ROCK TYPE	PRICE PER TON	PRICE PER TON
¾" minus – driveway base	$5.95	$10.95
¾" NMDOT type 1 base	$7.45	$12.95
Chips* -- (#57, 67, 7, 8, ¾")	$8.95	$13.95
3/8" minus – crushed fines	$8.95	$13.95
Rip rap	$15.00	$20.00
¾" minus – general fill	$3.75	$8.95

Note that CdR price for NMDOT type 1 base and chips (used for concrete and asphalt manufacture, and comprising the bulk of CdR's contract sales) average $8.20. This is approximately 10% lower than the $9 per ton estimated by BV/R for proposed production.

Based on their incorrect assumption that the County market is under-supplied, Applicants have argued that delivery from sources outside the County was significant in driving up local prices. (From the BV/R application: "*Reduced cost of materials: The location will reduce transportation costs for aggregate from Albuquerque sources by an estimated $4-$5/ton.* ") This is based on the assumption that it is necessary to deliver from Albuquerque (which is where Rockology is based). However, CdR delivers at $5 per ton, exactly the amount used by BV/R in its own estimates.

Thus, while BV/R might be able to undercut the prices of NM-EMNRD-permitted operations in mid-Santa Fe County, it is unlikely that the proposed mine could undercut the CdR operation. Only by cutting prices below production costs could the operators of the proposed La Bajada mine develop a market for their product. Since this is not a sound business model, it suggests that the application to rezone the property for mining may not be directed at actual mining, but at manipulating the price of the Applicant's holdings in the area.

As noted earlier, in a market that is already adequately supplied, a new operation would result in cannibalization of profits, Gross Receipts tax revenues, and jobs, which would merely move from existing locally-owner businesses to Albuquerque-based BV/R.

In addition to these cannibalization effects, analysis suggests two other negative fiscal impacts are likely:

Any production at the proposed mine on La Bajada that displaces sales from the Caja del Rio operation will cost the citizens of Santa Fe County (landfill users and taxpayers) $0.55 per ton of base course, chips or crushed rock. Any displaced sales would also cost the BLM nearly $1 per ton.

Thus, County residents, as citizen taxpayers of both of the County and the US, will sustain an economic loss of $1.50 for every ton of aggregate produced by the proposed mine. Given the Applicant's assumption of 250,000 tons per year over 25 years, and assuming that all BV/R sales displace CdR sales, these losses would total $375,000 annually, and $9,375,000 over the next quarter century.

Gross Receipts Tax impact

Applicant assumes 250,000 tons/year sales at an average of $9 per ton. Gross revenue is calculated as $2,250,000 per year; costs of production, deductible form other types of tax rates but not from GRT, are not accounted for. Haulage (at $5/ton, identical to CdR's actual haul rate) is added to the applicants' calculations, giving a claimed annual total for material and haulage of $3,500,000. Analysis (above) shows that BV/R's assumptions about ease of capturing market in the County are overstated, which would mean that the applicants' revenue estimates would also be unreliable.

The applicants' claims of economic benefits also include the assumption that 50% of the product + haulage would be non-taxable. The Director of CdR, by contrast, states that historically only about 10% of CdR gravel sales have been taxable, and that this is going to decrease to 3% in the near future because of a large new contract. Further, the applicants' calculations imply that the County receives 100% of any GRT collected. In fact approximately 75% of GRT revenue goes to the State, and only 25% benefits the County directly.

Gross Receipts Tax for the kinds of aggregate likely to be sold from the proposed operations is charged at point of use, not at the mine location. Therefore, any sales outside of Santa Fe County would generate no GRT for the County. In sworn testimony, the Applicant has stated that they consider the La Bajada site optimal because of access to I-25 and the ability to serve markets to the South (Albuquerque and beyond) and North (Las Vegas, Raton, and beyond). If, as this analysis concludes, profitable entry into the Santa Fe market may not be easy, a business strategy of selling in, for instance, the Albuquerque market may be what the Applicants are relying on. Given Rockology's existing sales facility in Albuquerque, it seems very likely that

much or all of the product of a La Bajada mine would be sold and taxed in Albuquerque, not Santa Fe County. In the extreme case, this could result in no additional GRT for the County.

Even if the proposed mine's products were to be sold in Santa Fe County, there would be no increase in GRT. The taxes are collected where the aggregate is used irrespective of what mine produces the material. Therefore GRT would be generated because of the project, not because of this new mine.

The net result of these corrections to the applicants' estimates is that there will be little, if any, increase in GRT.

Future Capacity

The capacity of the CdR operation to provide gravel and base course from its existing stockpile (estimated by director Mr. Kippenbrock at 1.6 million tons) and from future expansion is on the order of 250,000 to 500,000 tons per year, even if no additional landfill cells are excavated. An additional 125,000 tons per year for at least four years is expected to be generated by the most recent new cell, 5B.

Applicant has stated that each US citizen uses 22,000 pounds (11 tons) of gravel per year. New Mexico EMNRD statistics for Santa Fe County, 2008-2012, show a similar rate of consumption: 10 tons per person per year. Applicant also states that, as a national average, building a new modern home uses 400 tons of aggregate.

The Santa Fe County Sustainable Growth Management Plan predicts 12,195 homes to be built between 2010 and 2030. The bulk of these (9,425) are expected to be built in the El Centro and Galisteo areas in the middle of the county. Given widespread and pro-active "green building" in Santa Fe, it might be predicted that homes here would use less than the 400 tons national average. Even assuming that each house requires 400 tons, and that the projections for new construction are accurate, the average annual demand for aggregate for residential construction will be about 189,000 tons for the central portions of the county. Existing sources, including Caja del Rio, can more than meet this demand for many years to come even without expansion of the CdR facility. Given that growth in residential numbers generates increased need for landfill space, expansion of Caja del Rio's primary purpose should generate additional basalt as an adjunct to landfill, continuing the cost-saving re-use of excavated material and the resulting cost competitiveness of CdR products.

Future demand appears likely to be reduced by trends in construction material recycling. The use of recycled concrete as a substitute for "virgin" aggregate, as well as use of recycled glass aggregate, and in-situ recycling of asphalt (which effectively recycles the aggregate already contained in the original asphalt) are all gaining acceptance among engineers and builders, and

are increasingly cost-effective options. Many such recycled products drastically cut the cost of transportation, which makes them increasingly viable as fuel costs rise. Thus, such options must be considered as likely increasing competition for any gravel operation, and especially for one that relies on energy-intensive blasting and crushing.

Jobs

Applicant states that it anticipates "*7 full-time employees at average wages of $40,000 + benefits.*" In addition, Applicant states they would hire "*6 independent haulers at average hourly rate of $75/hour.*"

However, the Caja del Rio Del Hur operation has only one permanent employee, plus four members of a crusher operations crew that moves around among three or four del-Hur operated quarries as needed to meet demand for product. Typically, the crew conducts operations at Caja del Rio about three times per year, crushing enough to fill anticipated orders. For the near future, this involves about 80 hours work per year for the four person crew, producing approximately 160,000 tons.

BV/R has, in sworn testimony, pictured their operation as on-again-off-again, as demand requires, and that this is typical of the gravel industry as a whole. These arguments have usually been presented in the context of attempting to downplay concerns about constant noise, dust, or traffic. However, they appear quite inconsistent with claims that seven people will be employed full-time, plus truckers, to produce 250,000 tons per year. Assuming the use of 500 ton per hour equipment, this annual production would require crusher operations only 50% to 60% of the working year, plus blasting which the Applicant has repeatedly characterized as infrequent.

Employment estimates are not binding upon an applicant. There are many ways in which total actual employment could be reduced below the threshold that differentiates full-time from part-time. These include failure to capture market, reduced demand (whether from slow construction or from increased sustainable practices and alternative materials), and logistical changes in hours of operation. If any of these occur, some or all of the staff would be reclassified as part-time workers, and would not receive the benefits asserted in the application. This would substantially reduce the value of the claimed job creation, both to individual workers, and indirectly to the economy and tax base of the County.

White Paper –

Factual Background on the Caja del Rio Landfill

and associated crushed basalt gravel operation

Prepared by Laird Graeser

Based on comprehensive interview (Thursday, June 26, 2014) with Randall Kippenbrock, P.E., Director of the Caja Del Rio landfill

and on a legal analysis document prepared by Holland and Hart for SFSWMA (Aug. 4, 2010), supplied by Randall Kippenbrock, P.E.

1. The Santa Fe Solid Waste Management Agency (SFSWMA or Agency), a joint authority of the City of Santa Fe and Santa Fe County, was created in 1995. The purpose of SFSWMA was to create, maintain and operate a modern, fully EPA-certified landfill[1] for use by residents of the City of Santa Fe and Santa Fe County. The old landfill located on the site of the current Buckman Road Recycling and Transfer Station, was at the end of its useful life. Under the initial joint agreement, the City was tasked with obtaining the necessary landfill permits and the County with obtaining the real property for the new landfill. SFSWMA began operations at the new Caja del Rio landfill in 1997.
2. The original plan for Caja del Rio called for soil cover from each disposal cell to be removed and stored for use in the daily, intermediate and final covers of compacted solid waste. The basalt bedrock was to be blasted into lumps that could be excavated with heavy equipment, loaded into heavy mining dump trucks and transported to a storage waste (tailings) pile located next to

[1] http://www.sfswma.org/about-us/caja-del-rio/cell-5b-construction/
The requirements and technology for modern landfills is both complicated and expensive. The webpage cited includes the following description of elements required for Cell 5B.
"The Caja Del Rio Landfill is continuing the construction of its next solid waste disposal cell, Cell 5B. A total of 25 successful blast events occurred from October 7, 2013, to February 21, 2014. The blasting and excavation of 279,000 cubic yards of basalt rock is complete. The subgrade soil will be prepared for the installation of a geosynthetic liner. The liner is a low permeable barrier which is constructed under the landfill before disposal to contain leachate and prevent groundwater contamination. The liner system includes a layer of a low-permeability, geosynthetic clay (GCL) liner on the bottom. The GCL liner acts as a primary seal at a specified moisture content to provide additional protection for the liner system. Over this layer, a 60-mil, high-density polyethylene (HDPE) secondary plastic liner is installed to cover the bottom and sides of the landfill cell. The HDPE liner is smooth on the landfill bottom and textured on the landfill sides to increase friction and prevent slipping. The liner, which is resistant to chemicals and damage, is then welded together and tested to ensure a continuous seal in accordance with regulatory requirements. A blanket of geotextile fabric, composed of synthetic fibers, is laid above the liner and a geonet made of mesh-like plastic is added under the geotextile on the sides of the landfill to prevent fine clay particles from clogging the leachate collection layer and promote removal of leachate from the liner surface. Normally, the entire leachate collection layer would be comprised of two feet of basalt gravel on the liner that collects leachate and allows it to drain by gravity to the leachate collection pipe system, but this cell is different. For the first time in New Mexico, glass cullet from bottles processed at the Buckman Road Recycling and Transfer Station will provide a beneficial use as a portion of this drainage layer. The liner installation of the new cell is scheduled to begin in September of 2014 and completed by December. The new cell will have a surface area of approximately 10 acres with a disposal capacity of 4 years. Estimated cost of building the new cell is $3.6 million with $1.6 million of this for the blasting and removal of basalt. The Agency has contracted CDM Smith of Albuquerque, NM to design and prepare the technical plans and specifications for the liner installation."

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the landfill disposal area (cells). For many years, this waste pile was not considered an asset, but a waste product. Both the soil cover and the underlying (waste) basalt were blasted, excavated and stored in the planned manner.

3. Randall Kippenbrock, P.E., has been the director of the Santa Fe Solid Waste management Agency that oversees the Caja del Rio landfill since June 2004. Early in his tenure as executive director, in consultation with the Agency's Joint Powers Board and others, he determined that the basalt could be crushed and sold as aggregate. Currently, there are a number of markets for the product (see Appendix B price list), including DOT-certified base course and aggregate for road building, repair and maintenance; landscape use; and as a component of pre-cast concrete.
4. Beginning October 7, 2013, Caja del Rio Landfill began construction of its next disposal space for solid waste, referred to as cell 5B, which will hold approximately 600,000 tons of solid waste over a useful life of four years. Like previous cells, creation of this cell or pit required blasting, which occurred 25 times between Oct. 7, 2013 and Feb. 21, 2014, an average of. Approximately 590,000 tons of basalt were excavated from the cell, roughly equivalent to 279,000 cubic yards. The cost of blasting and excavating for cell 5B is public information, and was $1.6 million. From this reported information, it is possible to calculate the per-ton cost of blasting and excavating Caja del Rio basalt at $2.87 per ton.
5. Caja Del Rio operates under EPA and State standards for landfills, and has a valid landfill permit. The CdR Rock Quarry operates as a extension of the landfill permit. Landfill permits are generally more stringent that gravel permits, and have stronger focus on clean water and clean air. The overall landfill permit is, in many ways, more comprehensive for the public welfare than a mining permit.[2]
6. Gravel, and other types of mining, are generally regulated and monitored by the State of NM's energy Minerals and Natural Resources Department, Mining and Minerals Division, which issues mining permits and collects and publishes production and sales statistics. Caja del Rio, because it operates under a stricter type of permit, is not required to be permitted by EMNRD. Because of this, CdR's production and sales are not reported to EMNRD's Mining and Mineral's Division and therefore the quantity of materials produced and sold are not included in EMNRD's data either at the County level or State level.
7. Crushed basalt generally is an acceptable material for road building and concrete manufacturing pursuant to ASTM C33 / C33M - 13.[3] However, crushed basalt is relatively expensive to produce in competition with gravel excavated, screened and washed from typical loose gravel-bed locations. Standard geotechnical textbooks indicate that crushed stone – particularly crushed basalt – is a perfectly acceptable aggregate, but is not particularly popular because other acceptable aggregates are available at lower cost.[4]
8. Contrary to assertions by Buena vista/ Rockology in their mine application and sworn testimony, Caja del Rio basalt is not an inferior construction material. CdR basalt has been repeatedly tested by Western Technologies; a letter confirming that the product meets all standards for NMDOT, FHWA, FAA, BIA, City and County of Santa Fe, and private contractors is attached. EMNRD statewide data does not separately collect data for crushed basalt, but lumps it together

[2] A case in point is that SFSWMA has installed a $1 million landfill gas collection system to deal with methane and non-methane gases generated in the depths of the landfill by digestion and fermentation of organics included in the solid waste.
[3] http://www.astm.org/Standards/C33.htm

[4] http://www.ce.memphis.edu/1101/notes/concrete/PCA_manual/Chap05.pdf ... Chapter 5, Aggregates for Concrete

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in the "aggregates" category. The proposed La Bajada mine would be classified in the same category, and is believed to be part of the identical geological formation as Caja del Rio.

9. As a result of this incident, the SFSWMA management has recently negotiated an eight-year contract with Del Hur Industries. Del Hur, in turn, has an exclusive aggregate supply agreement with Associated Asphalt and Materials of Espanola, NM to provide 110,000 tons of aggregate materials annually. This will be DOT- acceptable aggregate for use in road building, repair and maintenance.
10. There is some legal controversy about whether crushed basalt is defined as a mineral, the extraction and/or production of which is covered by the state's Mining Act. Rock used in construction is often regulated differently than rock which is the matrix of metal ores, for example. If the basalt – raw or crushed – is a mineral, then the owner of the material is owed a royalty; there is no set rule for how that royalty should be calculated. Based on a memo from Holland & Hart, dated August 4, 2010, the Agency is paying $.95 per ton of crushed basalt to the Bureau of Land Management (BLM), the presumed owner of the material in the name of the United States. This level of royalty payment to the US is consistent with an average price of about $7.50 per ton of extracted material and 1/8th royalty. According to Mr. Kippenbrock, the BLM is recalculating this royalty amount, since the value of the material in situ is virtually negligible. It is the value added from the blasting, excavating, crushing and screening ("beneficiation") that creates the market value. Based on other information[5], the payment to the BLM for gravel and sand is the fair market value as determined by appraisal. Thus, the old calculation (sales price times 1/8th royalty) is not valid. Mr. Kippenbrock estimates that the production costs, including amortization of the embedded blasting and excavation costs are about $5.00 per ton. Thus, an estimated fair market value of $.95 per ton for the in-situ material is quite reasonable assuming an average price after beneficiation is about $7.00. However, the BLM is authorized to permit production for governmental purposes free of charge. If 30% of the production has been consumed by government funded projects (e.g., NMDOT and Santa Fe County), then the royalty rate could be legitimately reduced to $.65 per ton while preserving the fair market value principle.
11. Mr. Kippenbrock said that the annual budget of the Agency is about $7 million. The enterprise is self-funded through landfill user fees and sales of crushed basalt. (Loss of basalt sales due to the proposed BV/R mine could jeopardize SFSWMA's self-funded status.)
12. The processing of basalt at CdR is operated by Del Hur Industries, a Port Townsend, WA, firm with quarries in 17 Western states. SFSWMA sells basalt, excavated to create landfill cells but otherwise unprocessed, to Del Hur, which crushes the material. For each ton of crushed basalt, Del Hur Industries remits $1.50 per ton to the Agency which includes $0.95 as a fair-market royalty payment to the BLM (the mineral owner, see note 11 above).
13. The net $0.55 per ton retained by the Agency represents recovery of the contract costs to blast and excavate the previous cells, beginning in 2006. Mr. Kippenbrock estimates about 1.6 million tons of uncrushed basalt is stockpiled on site. $0.55 per ton represents the previously incurred costs of blasting, excavating and stockpiling the basalt, but not the overburden, from the cells. Thus, the net value of the stockpile is about $880,000 to SFSWMA. Basalt sales significantly offset the $7 million needed annually to operate the landfill.
14. According to Del Hur the basalt aggregate materials are not subject to NM gross receipts taxes due to resale. Del Hur does not sell any material to landscapers or non-contractor individuals

[5] http://www.blm.gov/pgdata/etc/medialib/blm/wo/MINERALS__REALTY__AND_RESOURCE_PROTECTION_/non-energy_minerals.Par.48557.File.dat/sand.pdf

15. Because the Caja del Rio Quarry is not registered or permitted through EMNRD, Mr. Kippenbrock does not know if the minimal severance taxes and resource excise taxes are required on gravel and other aggregates .
16. Mr. Kippenbrock had two comments regarding the Buena Vista/ Rockology Application for Mining Permit on La Bajada:
    a. A first lab report was prepared by Western Technologies (the same lab used by SFSWMA) on 9-21-07 based on a sample provided by Rockology owner Steven Hooper. The only relevant data included in that report was an absorption % of 1.4. This single number was used and reported in the Application. It would have been more appropriate to have the testing laboratory send a tech to the field to draw samples, but, in this case, the sample was provided by the client.
    b. A second lab report is dated October 4, 2007. This sample is described as "base course." The project name is "Rail Runner Phase 2" and the sample source is "Buena Vista Pit." This analysis reported an absorption of 2.2, with an apparent specific gravity of 2.868 for the coarse (only) fraction. There is no estimate of crush strength or any other relevant data to substantiate Buena Vista's application declaration that, *"The basaltic material is a durable, sound aggregate,..."* Nor does it match the specific gravity of 2.64 cited in the application (on page NBB-22 of the BCC packet).
17. Del Hur's Caja Del Rio Rock Quarry has only one permanent employee. His duties include loading trucks on site and arranging delivery when required.
18. The Agency weighs trucks unloaded and loaded and provides these tickets to Del Hur Industries for use in billing accounts. Invoices are prepared, as needed, by Del Hur Industries' home office accounting department.
19. Caja del Rio crusher operation has the capacity of 200 tons per hour. This is about average for permanently installed equipment. Some gravel operations use mobile equipment with a capacity of 100 tons an hour. Mr. Kippenbrock estimates that Del Hur has about $2.0 million in equipment. In addition to the crusher, screens and conveyors, there is a big payloader, a mining dump truck, a water truck and a construction trailer used as a sales and fulfillment office. Since Del Hur offers delivery, there may well be several 12 or 18-yard dump trucks. The price sheet indicates at least one pup (delivery trailer) is also on the premises.
20. The Del Hur crusher operations crew consists of three specialists and a foreman. The foreman has stated that a total of four specialists was very thin for running a complex, fixed base crusher operation. This crusher crew moves around among a number of Del Hur's operations in the Western states. Typically, the crusher crew conducts operations at Caja Del Rio about three times a year. They crush enough to fulfill anticipated orders. The number of crew hours is about to rise, due to the large contract mentioned in note 10, above. Adding that order to the existing workload, it will take about 80 days of work for the four-man crew. This is equivalent to about 1.3 FTE. Including 1.0 FTE for the permanent loader operator and 0.2 for invoicing and weighmaster services, total employment equivalent at this quarry operation is 2.5 FTE, equivalent to 1 FTE per 64,000 tons produced. At this rate, the proposed production of the BV/R mine, 250,000 tons per year, would require 3.9 FTE. (These figures do not include blasting, which is done by a specialist contractor, and in the case of CdR, was completed under the landfill's budget and recouped by sales to del Hur.)
21. Del Hur estimates that water consumption for the crusher operation alone is about 3 gallons of water per ton of material produced. In addition, Del Hur uses additional water to settle the dust on the roads and on the soil piles. During the windy months of March through June, the rock quarry uses about 5,000 gallons of water a day to moderate windblown dust from the gravel

and topsoil piles and the quarry roads. Treated effluent water is piped from the City wastewater treatment plant located a few miles from the Quarry.

Caja Del Rio Quarry Rock Sales Price List

	Freight on Board (FOB)	Delivered
ROCK TYPE	PRICE PER TON	PRICE PER TON
¾" minus – driveway base	$5.95	$10.95
¾" NMDOT type 1 base	$7.45	$12.95
Chips* -- (#57, 67, 7, 8, ¾")	$8.95	$13.95
3/8" minus – crushed fines	$8.95	$13.95
Rip rap	$15.00	$20.00
¾" minus – general fill	$3.75	$8.95

* Chips are sold for subsequent use in manufacturing concrete and asphalt. This is the bulk of the contract sales.

7 ton or 5 yard minimum purchase required on delivered loads. Delivered prices are within a 10-mile radius from the Quarry. Beyond that radius, deliveries will be charged at FOB price plus truck time.
Dump Truck Rates: $75.00 per hour – solo; $85.00 per hour – truck and pup

Jobs involving substantial volumes will be quoted on an individual basis.

Attachment #3: Santa Fe County Board of County Commissioners Meeting Minutes for December 13, 2011

BCC MINUTES
PAGES: 164

COUNTY OF SANTA FE)
STATE OF NEW MEXICO) ss

I Hereby Certify That This Instrument Was Filed for Record On The 2ND Day Of February, 2012 at 09:52:08 AM And Was Duly Recorded as Instrument # 1659253 Of The Records Of Santa Fe County

Witness My Hand And Seal Of Office
Valerie Espinoza
Deputy _____ County Clerk, Santa Fe, NM

SFC CLERK RECORDED 02/02/2012

SANTA FE COUNTY

BOARD OF COUNTY COMMISSIONERS

REGULAR MEETING

December 13, 2011

Virginia Vigil, Chair – District 2
Liz Stefanics, Vice Chair – District 5
Robert Anaya – District 3
Kathy Holian – District 4
Danny Mayfield – District 1 [excused]

SANTA FE COUNTY

REGULAR MEETING

BOARD OF COUNTY COMMISSIONERS

December 13, 2011

This regular meeting of the Santa Fe Board of County Commissioners was called to order at approximately 2:00 p.m. by Chair Virginia Vigil, in the Santa Fe County Commission Chambers, Santa Fe, New Mexico.

Employees of the Community Services Department led the Pledge of Allegiance and State Pledge, following roll call by County Clerk Valerie Espinoza and indicated the presence of a quorum as follows:

Members Present:	Member(s) Excused:
Commissioner Virginia Vigil, Chair	Commissioner Danny Mayfield
Commissioner Liz Stefanics Vice Chair	
Commissioner Kathy Holian	
Commissioner Robert Anaya	

V. INVOCATION

An invocation was given by Renee Sandoval.

VI. APPROVAL OF THE AGENDA

A. Amendments
B. Tabled or Withdrawn Items

CHAIR VIGIL: Ms. Miller.

KATHERINE MILLER (County Manager): Madam Chair, yes, there's a couple of tabled or withdrawn items. Under "Special Presentations" IX. B that has been tabled. We have a long agenda and the next item is on page 5, item IVX, F. 1, that item is also tabled and then on that same page item IVX, I.2 is withdrawn. Under the "Public Hearing" item XV A. 3 is tabled.

COMMISSIONER STEFANICS: Madam Chair.

CHAIR VIGIL: Commissioner Stefanics.

COMMISSIONER STEFANICS: I move approval of the amended agenda.

COMMISSIONER HOLIAN: Second.

The motion passed by unanimous [4-0] voice vote.

VII. APPROVAL OF CONSENT CALENDAR

CHAIR VIGIL: Are there any consent calendar withdrawals? Commissioners?

COMMISSIONER HOLIAN: Madam Chair, I move approval of the Consent Calendar.

COMMISSIONER STEFANICS: I'll second.

The motion passed by unanimous [4-0] voice vote.

XIII. CONSENT CALENDAR

A. Miscellaneous

1. **Resolution No. 2011-184, a Resolution Requesting an Increase to the Corrections Operations Fund (247) to Budget the Fiscal Year 2011 State Criminal Alien Assistance Program (SCAAP) Award Received for Expenditure in Fiscal Year 2012 / $15,258 (Corrections Department)**

excise tax on alcohol and any other kind of liquor. I was just at the Revenue and Stabilization Tax Committee this morning and they did pass the resolution that we supported that allows for the current distribution of local liquor taxes to go to drug courts. So that will redivert some dollars from the general fund which receives the excess dollars that don't go to counties that were originally intended to go to counties and so that bill was supported by Tax and Rev. It still has to go to the legislature. This may or may not succeed in the legislature. Part of the problem that it creates is there's a barrier there to moving it forward based on the fact that the industry argues that the current distribution was intended to go for the purposes that this option would create. And I know that Commissioner Anaya is familiar with that. He and I actually worked on this through the legislature. And I think and I'm not sure if it might even be considered germane but I think we should constantly keep this at the forefront of our legislators. I think for the most part they are sympathetic to try and look for dollars to deal with these critical issues.

I recommend that we enact this resolution and bring it to the consciousness of our legislators and move for approval.

COMMISSIONER STEFANICS: I'll second.

CHAIR VIGIL: Motion and a second. Any comments?

COMMISSIONER STEFANICS: Madam Chair, I think that we need to continue to put forward – there is emphasis on the use of these dollars and it will ultimately be left to the state legislators to decide but if we don't speak to what is important in terms of services or in terms of what the County desires it'll never be considered. Thank you very much.

CHAIR VIGIL: Thank you. Any other comments?

COMMISSIONER ANAYA: Madam Chair, having worked directly with this as you stated for several years I actually agree with the sentiment of some of the industry when they speak to the use of the current liquor excise tax. I think that the tax that we currently pay is not being utilized as it was intended to be utilized. In this resolution, this resolution supports giving the local entities the option to pursue through a voter referendum a tax that doesn't impose a tax. I couldn't speak at this time due to the economics of increasing any new taxes but I don't think this resolution does that. I think it just gives our other local entities an alternative. But I do strongly advocate that more of the money that goes into the current tax be distributed for it's intended purpose instead of being diverted to other areas so those are my comments. Thank you, Madam Chair.

CHAIR VIGIL: Okay, I have a motion and a second.

The motion passed by unanimous [4-0] voice vote.

E. Resolution No. 2011-191, A Resolution Requesting that the City of Santa Fe Release Additional Effluent into the Santa Fe River to Support the Historical Agricultural Needs of the Village of La Cieneguilla and The Village of La Bajada (Commissioner Anaya)

CHAIR VIGIL: Commissioner Anaya.

COMMISSIONER ANAYA: Madam Chair, Commissioners, the public and the community I think we've heard a couple of resolutions today that link very closely to this resolution that I have before you today. The resolution of supporting buying local and being creative with purchases as well as the resolution relative to the farm bill priorities and the regional food system ties closely with what the Village of La Bajada and the Village of La Cieneguilla have done for hundreds of years and that's take care of the livelihood of their families and grow agricultural crops for the community and for their living expenses and to survive.

In this current year because of drought conditions and other issues that have arisen associated with beavers and other issues in the river, in the Santa Fe River, many of those communities include La Cieneguilla and La Bajada were not able to grow their crops because there was no water. And I think that goes contrary to the two resolutions that we previously approved that we want to encourage people to grow their crops. We want to encourage agricultural use but if there's no water getting to those communities it's a little difficult to do that.

With that I also heard today that there was some discussion on Public Radio today associated with what the City may or may not do associated with this water use and effluent and that they potentially might not release more water.

I would strongly publicly ask for the Mayor of the City of Santa Fe and the entire City Council to seriously review and consider the contents of this resolution. This resolution isn't about a brand new project. This isn't a resolution about a new business in a community or creating a problem in a community. This resolution is about sustaining a community and sustaining multiple communities for agricultural purpose and use.

So with that said, a resolution requesting that the City of Santa Fe release additional effluent into the Santa Fe River to support the historical and current agricultural needs in community villages of La Cieneguilla and La Bajada.

Whereas, Santa Fe County has been experiencing severe drought conditions including above normal temperatures with little or no precipitation; and

Whereas, numerous streams including the Santa Fe River have experienced decreased water levels. Whereas, the village of La Cieneguilla and La Bajada encompass a segment of the Santa Fe River which also conveys water that is released from the City of Santa Fe's wastewater treatment plant; and

Whereas the villages of La Cieneguilla and La Bajada are traditional acequia-based communities that utilize the Santa Fe and whose culture and heritage are intrinsically tied to water and agriculture; and

Whereas, the County is experienced increased urbanization and development that is contributing to the loss of water in the Santa Fe River and whereas there is a critical need for the villages of La Cieneguilla and La Bajada to maintain a traditional and sustainable local small farming and ranching economy that is essential to the health and economic well being of the County residents.

Now, therefore, be it resolved that the Board of County Commissioner of the County of Santa Fe request that the City of Santa Fe release additional effluent water into the Santa Fe River to continue to support the historical and current agricultural needs in the downstream community villages of La Cieneguilla and La Bajada.

Madam Chair, I would first move for approval.

COMMISSIONER STEFANICS: Second.

COMMISSIONER ANAYA: And with the second, Madam Chair, I would just further emphasize that as we consider other uses of rare water from the Buckman Direct Diversion project that we also in addition to this request to the City of Santa Fe should consider releasing water for agricultural purposes from the Buckman Direct Diversion project into the aquifers and into the streams to further assist with the agricultural historical uses that exist through Santa Fe County.
Thank you, Madam Chair.

COMMISSIONER HOLIAN: Madam Chair.

CHAIR VIGIL: Commissioner Holian.

COMMISSIONER HOLIAN: Thank you, Madam Chair. Thank you, Commissioner Anaya for bringing this forward. As you know food security is a really, really big issue with me. And I think that we're talking about organizing a water summit perhaps in a few months, and I think a good issue for that water summit would be how La Bajada can not only have a water source but some back up water sources as well. So I just wanted to ask you if they also use ground water for their agricultural activities?

COMMISSIONER ANAYA: Madam Chair, Commissioner Holian, they use some limited groundwater of which we're trying to provide them more access as you know to a larger well to augment their service, but many of the residents frankly didn't – weren't able to perform their agricultural duties, if you will, and generate revenue to feed their families and had to do alternative things to just get by.

COMMISSIONER HOLIAN: Thank you, Commissioner. I think that this really illustrates why you need not only a water source but you need back up water sources as well. Especially if you're really going to take agriculture seriously. Thank you.

CHAIR VIGIL: Commissioner Stefanics.

COMMISSIONER STEFANICS: Thank you, Madam Chair. And, thank you, Commissioner, for bringing this forward. I certainly support this particular resolution. In regards to BDD I think that you would want to discuss with your constituents whether or not they could be paying customers because right now the BDD is not in a position of providing water services without some compensation. So I totally support this and as you go forward you might just want to discuss that with them as well. Thank you.

COMMISSIONER ANAYA: Madam Chair, on that point if I could. Madam Chair and staff can further clarify this but my understanding that we have access to water within the diversion project both treated through the diversion plant and raw untreated water and that annually we could utilize some of that raw so I think there might be a compromise because many of these communities and the residents therein probably don't have the mechanisms to sustain being part of a utility but if we have water that we could divert and flow through our communities for this purpose that is uncommitted water within our utility I think that might be – Ms, Miller, is that something that you'd like to comment on and Mr. Ross?

MS. MILLER: Madam Chair, Commissioner Anaya, I think the issue would be how we can deliver it. Based on the agreement that was done with Las Campanas that if there was excess capacity with the well water there it could get incorporated to their agreement that we could use it elsewhere, it would be how we can convey it to elsewhere and then and then also whether there's any opportunity to do anything at the [inaudible] plants at the State Pen and how we could convey that water also.

COMMISSIONER ANAYA: Madam Chair, I appreciate the comments and the feedback and we'll continue to work in progress. But I very much would appreciate the support of the Commission.

CHAIR VIGIL: I think you have the Commission support. I certainly support it. I think this is a timely resolution. I think in all fairness to our city sister, there is no doubt in my mind that if they have the ability to release water and keep the water flowing that they would. Santa Fe River is one of the top ten endangered rivers in the nation and the Mayor has created a river board of some kind, I'm sorry the name doesn't come to me right away, but there are representatives from Agua Fria Village who would also benefit from this and they have had much issue with what kind of water would flow down. They're concerned about effluent water and so the issue has been quite dynamic and discussed for quite some time as far as I know. It might alert the City to better inform us as to why that doesn't occur. It might alert the City – I mean what I've learned as being sort of piece by piece they do have a scheduled release and it's dependent on their reservoir and they're advised by their own experts and those kinds of things. But what I like about this resolution is that it says, look at other resources to see if we can work something out at this point in time. And I think that's moving in the right direction for these communities.

So with that I think we can move forward on the vote.

The motion passed by unanimous [4-0[voice vote.

XI. F. Proclamation in Memoriam of Gerald González (Commissioner Anaya)

COMMISSIONER ANAYA: Madam Chair, it is an honor and a privilege to do this along with yourself as the chair and the entire Commission. I'm going to read the proclamation, Mr. Ross and I are going to read the top part of the proclamation and let you help us finish it Madam Chair and then I'd like to allow Mr. Ross to make some remarks and anyone else that would like to outside of the Commission, if that's okay with you, that would like to as well.

A proclamation honoring the life of Gerald T. E. González.

Whereas, former County Manager Gerald T.E. González, passed away Tuesday, November 1, 2011 at the age of 68;

MR. ROSS: Whereas, Gerald lived an extraordinary life, beginning in his birthplace of Las Vegas, New Mexico, and continuing through his formative years in

Attachment #4: City of Santa Fe Reclaimed Wastewater Resource Plan

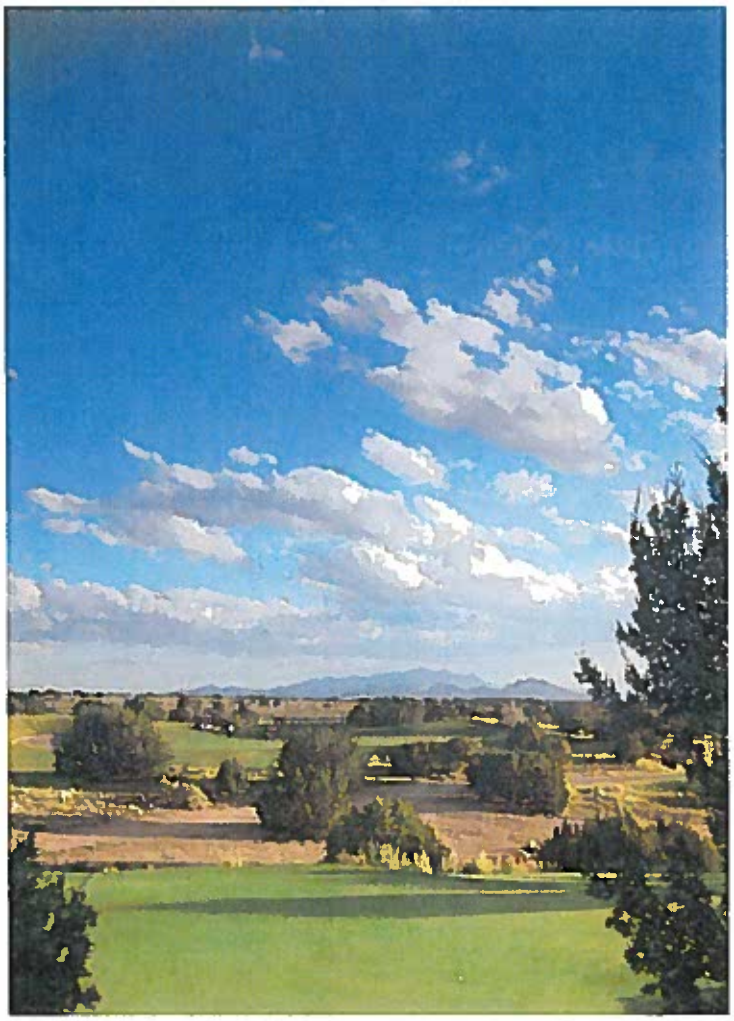
REPORT

City of Santa Fe

Reclaimed Wastewater Resource Plan

SELECTED PAGES RELEVANT TO EXISTING OVERCOMMITMENT OF EFFLUENT

April, 2013



Executive Summary

Reclaimed wastewater (RW) is a vital and valuable water resource that helps the City of Santa Fe meet its current water supply needs; it can also play a critical role in meeting future potable water supply demand. Since the adoption of the previous RW plan, the Treated Effluent Management Plan (TEMP) in 1998, the quantity of available RW has been reduced by 29% because of the City's comprehensive indoor water conservation programs while RW use has more than doubled (Figure 3). This Reclaimed Wastewater Resource Plan (RWRP), developed with the assistance of the "Working Group" members identified on the cover page, prioritizes current RW uses and identifies strategies and implementing actions to optimize current and future use of the resource. This analysis concluded that RW availability is currently limited during the peak summer irrigation months and that the shortfall will increase in the future with new RW uses anticipated by the City. The methodology used for prioritizing RW uses herein can be applied in the future to new circumstances; thus, this plan serves not only as a blueprint for RW use today, but also serves as a roadmap for the future.

This RWRP considers the City's current and projected RW needs through the 2020s. RW availability is projected 40 years in to the future through 2052. Based on the City's average RW production of 1,887 million gallons/yr (5,790 af/yr) over the past five years, this RWRP assumes that 1,825 mg/yr (5,600 af/yr) and 152 mg/mo (467 af/mo) of RW is available (Section 4) at a steady daily and monthly rate for the 40-year planning period. The difference (62 mg/y; 190 af/yr) between the RW produced and the amount allocated in this Plan is reserved to accommodate for changes in use, metering uncertainty, and/or changes in future conditions.

The RW use options considered in this analysis include current uses: direct sale for dust control and other construction purposes; irrigation of municipal recreational fields at the Municipal Recreational Complex (MRC) and the infield at Santa Fe Downs; irrigation of the Marty Sanchez Links de Santa Fe and the Santa Fe Country Club golf courses; dust control at the regional landfill; watering livestock on the Caja del Rio; irrigation of the education-scape at the New Mexico Game and Fish facility; and for Santa Fe River flows downstream of the City's wastewater treatment plant to support the river/riparian ecosystem and local agriculture (Section 5). The analysis also includes potential future uses: irrigation of the turf at the Santa Fe Equestrian Center (also a previous use); irrigation of the Southwest Area Node Park; irrigation of turf at schools, the library and other open space along the Southwest Sector effluent pipeline; offsetting the surface water depletions in the La Cienega area caused by the City's pumping of the Buckman well field; piping RW upstream to the Santa Fe River; and future potable water supply (Section 5).

For this analysis, an annual, monthly and maximum peak daily RW budget for all of the current and potential future RW uses was determined, either based on past usage, contracts, requests, or estimates (Section 6). The demand for monthly and daily RW is great. The combined monthly demand for all the options, except RW for potable water supply, is 213 mg/d (Table 2), 40% more than the RW available; the combined daily demand of all the options (except RW for potable water) supply is 6.9 mg/d (Table 2), 38% more than the available amount. Hence, RW demand is greater than available supply under

current average conditions, which will only worsen under drier hotter drought and projected climate change-impacted conditions.

The RW options were ranked according to criteria and methodology (Section 5) approved in May 2012, by the City's governing body. Using the ranking methodology and then prioritizing uses that are non-discretionary (long-term contracts and permit requirements), the RW options were prioritized; the first three options retain equal ranking, because no distinction is made within these uses required by permits versus long-term contracts):

1. Buckman Well Field Permit Compliance- 33 mg/yr; 100 af/yr
1. US Forest Service Livestock Water – 2.3 mg/yr; 7 af/yr
1. Santa Fe Country Club Golf Course- 130 mg/yr; 400 af/yr
4. Municipal Recreation Complex – 54 mg/yr; 165 af/yr (65 mg/yr requested)
5. On-demand Sales for Dust Control, Construction– 31 mg/yr; 95 af/yr (65 mg/yr in 2007)
6. Dust Control at Regional Landfill – 6 mg/yr; 17 af/yr (12 mg/yr requested)
7. Marty Sanchez Links de Santa Fe Golf Course– 168mg/yr; 517 af/yr (196 mg/yr requested)
8. Recreational Infield at Santa Fe Downs – 43.5 mg/yr; 134 af/yr
9. Future Potable Water Supply – approximately 717 mg/yr; 2,200 af/yr
10. Southwest Area Node Park - 19 mg/yr; 57 af/yr
11. New Mexico Game and Fish Educational Landscape – 1 mg/yr; 4 af/yr
12. Southwest Area Irrigated Parks and Open Space – 48 mg/yr; 149 af/yr
13. Downstream Santa Fe River – 600 mg/yr; 1,843 af/yr
14. Upstream Santa Fe River – 177 mg/yr; 543 af/yr
15. Santa Fe Equestrian Center – 41 mg/yr; 127 af/yr
16. Urban Food Production (originated from 2nd public meeting; no RW budget developed)

These options and their monthly RW budgets were then compared to the available RW (Section 7) to see how much of the RW needs could be met. The assessment was performed in three different time frames - 'current', 'near-future', and '2020s', including only those projects relevant to the different timeframes (Section 7). For example, since potable use of RW will likely take a decade to implement, the use is shown to first come 'online' in the 2020s analysis.

This analysis showed that all but two of the 'current' RW options can be met with the available RW at this time (Figure 12 and 13); the exception is that there are insufficient flows to fully meet the Downstream Santa Fe River 3 mg/d, target flows in June and the Santa Fe Equestrian Center RW request in May, June and July. In the near future (approximately 2018), the shortfall in RW will be even greater: using the Plan's criteria and ranking method, the Downstream Santa Fe River, the Santa Fe Equestrian Center, and the Upstream Santa Fe River option do not have adequate supply during the summer months (Figure 14). By the 2020s, when the infrastructure and permits to use RW for potable supply may be ready, no RW is available for the SF Equestrian Center or the Upstream Santa Fe River, and there continues to be insufficient RW to meet the 3 mg/d target flows for Downstream Santa Fe River in June (Figure 15). By the 2020s, using the RW that is not

1. MRC: RW is used at the Municipal Recreation Complex (MRC) to irrigate playing fields for baseball, soccer, football, rugby, and other recreational play. RW is piped from the WWTP via the "northern purple pipeline" to a storage pond just north of the MRC. From this pond, RW is metered, pumped and used on the MRC irrigated fields. A City resolution from 1995 permits up to 2 mg/d for use by Marty Sanchez Golf Course and the MRC via the "northern" RW distribution system. Since the installation of the pipeline, three additional users (US Game & Fish, Caja del Rio Landfill and USFS) are also supplied by the pipeline. City Parks Division pays its share of the electric costs to pump RW from the WWTP to the storage pond.

   - **RW budget**: Annual: 54 mg/yr (165 af/yr); Peak month: 11 mg/mo (34 af/mo); Daily maximum: 360,000 g/d. The annual value of the RW is $163,000. **[Requested annual RW budget is 65 mg/yr (200 af/yr)]**

2. SF Downs: RW at the Downs of Santa Fe is used both for irrigating the race track infield (approximately 92%) and for irrigating trees and other landscaping. The infield is made available for recreational sport play like soccer and football. An agreement signed between the Pueblo of Pojoaque and the City defines that Pojoaque will pay $2.59/1,000 gallons for any RW **not** used to irrigate the infield and generated approximately $9,000 in revenue in 2011. The City pays Pojoaque $1 for the use of the infield playing area.

   - **RW budget:** Annual: 43.5 mg/yr (133.5 af/yr); Peak month: 8.2 mg/mo (25 af/mo); Daily maximum: 400,000 g. The annual value of the RW that is traded to the Downs for use of the turf sports fields is approximately $121,000.

3. SWAN Park: The design for the planned Southwest Activity Node (SWAN) Park identifies one large, natural-grass, irrigated recreational area: the Field Sports Area. The area is designed to accommodate organized sports groups like soccer, football, rugby, lacrosse and Ultimate Frisbee. RW will be used to establish some park landscaping during start-up (5-7 years), while other areas (orchards) will continue to receive RW irrigation for the long term. The Field Sports Area is planned to be constructed during Phase II (possibly finished 2016). The sole source of irrigation water for the park is via a proposed RW pipeline from the WWTP and a 200,000 gallon on-site RW storage tank. As currently designed, RW will be pumped into the RW pipeline using the same lift station that also pumps RW north toward the MRC and Marty Sanchez GC. For this analysis, the SWAN Park RW budget is assumed to be constant into the future, beginning in 2014, even though the park's development is phased and the xeric landscaping may require less water in the long term once established. The working

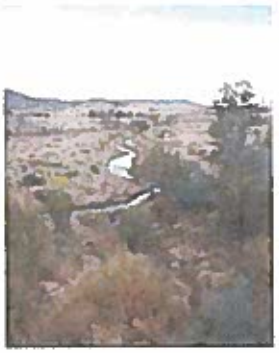
assumption is that City Parks Division will pay for the pumping costs and annual O&M costs associated with the RW pipeline.

- **RW budget:** Annual: 19 mg/yr (57 af/yr); Peak month: 4 mg/mo (11 af/mo); Daily maximum: 120,000 g. The annual value of the RW is $56,000.

4. SW Irrigated Parks: The 12-inch RW pipeline designed for SWAN Park has excess capacity than the water needs of the planned park. The entire RW pipeline (identified as the Southwest Effluent pipeline in City capital improvement projects) has a similar capacity to the RW pipeline that supplies the "northern" uses (MRC, Marty Sanchez GC, etc.) and will share the RW lift station of the northern RW pipeline. The pipeline's planned route extends near public facilities (e.g. Capital High School, Southside Library, Cesar Chavez Elementary School, Ortiz Middle School) that could use RW for irrigation. However, since the exact RW uses along the "southwest RW pipeline" have not been determined, an overall RW budget for the pipeline, excluding SWAN was developed by allocating approximately the same RW budget as is currently used by the MRC. Because the pipeline shares the lift station with the "northern" pipeline, it is likely that additional RW storage on the system is needed. The combined budget of SWAN Park plus this option of 0.39 mg/d is less than one-sixth of the 2.0 mg/day pipeline capacity. The working assumption is that City Parks Division will pay for the pumping costs and annual O&M costs associated with the RW pipeline.

   - **RW budget:** Annual: 48 mg/yr (149 af/yr); Peak month: 10 mg/mo (30 af/mo); Daily maximum: 330,000 g. The annual value of the RW is $146,000.

5. Downstream SF River: The Santa Fe River downstream of the WWTP currently receives over 70% of the RW produced and constitutes all but storm flows in the reach of the Santa Fe River between the WWTP and the springs that emerge at La Cienegilla. The RW flows through the Santa Fe's Rural Protection Zone (RPZ, City property west of the Santa Fe Airport), then land owned by Santa Fe County, the Bureau of Land Management, and private land owners. The stream flow is used for irrigation by land owners in La Cienegilla, El Cañon Ranch, Tres Rios Ranch, and the village of La Bajada. The City Attorney's office l opinion is that the City currently has no legal obligation to deliver RW to water right holders downstream, because cities control the use of artificial waters under the City of Roswell court case and the New Mexico statute, NMSA 1978, § 72-5-17. A decade of restoration in the RPZ has created a thriving beaver population, lush riparian vegetation, and wetland areas. It is unknown how much water is needed to support the restored areas and the needs of the downstream agricultural needs.



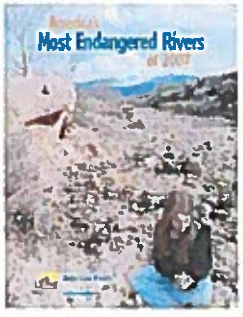
The irrigators of approximately 100 acres of land downstream of the WWTP and the Santa Fe County Commissioners have requested that the City release "sufficient

reclaimed water to the downstream users of La Cienegilla, La Cienega, the Village of La Bajada and the Pueblo of Cochiti for historic and agricultural traditions" (Board of County Commissioners of Santa Fe County 2011 and 2012 Resolutions (Appendix E). The State Legislature approved similarly worded memorials in 2011 and 2012 (Appendix E).

For this analysis, the Working Group assumed a minimum flow ranging from 0.5 mg/d in the winter season to three mg/d during the peak irrigation months. The 3 mg/d summer target flow value is based on a broad-brush understanding of stream flow conditions and downstream agricultural needs. This option assumes that within the annual water budget, the RW from the WWTP can be patterned to accommodate irrigation needs. The budget for this option may need to be revised in the future, after more stream flow data has been collected and analyzed. This option has no ongoing O&M or distribution costs.

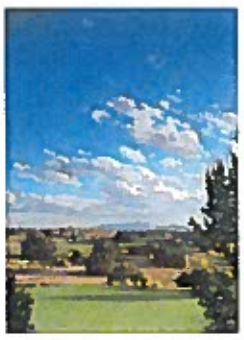
- **RW budget:** Annual: 600 mg/yr (1,843 af/yr); Peak month: 93 mg/mo (285 af/mo); Daily maximum: 3,000,000 g. The annual value of the RW is $1.82 million.

6. Upstream SF River: This option involves pumping water from the WWTP upstream to a currently unspecified point and delivering about 0.5 mg/d (0.75 cubic feet per second) of RW to the Santa Fe River daily. The pattern of release could be altered, but may be constrained during the summer months by other RW demands. The purpose of the option would to create another "living" river reach along the Santa Fe River. The quantity of water would probably provide surface water flow for about 1-3 miles, depending upon weather and river channel conditions. The City would need to pay for the capital costs to install the pipeline and pumping equipment and be responsible for the continued pumping and O&M costs.



- **RW budget:** Annual: 177 mg/yr (543 af/yr); Peak month: 15 mg/mo (45 af/mo); Daily maximum: 500,000 g. The annual value of the RW is $536,000.

7. Marty Sanchez GC: The Marty Sanchez Links de Santa Fe golf course currently uses exclusively RW to irrigate the golf course and other facility landscaping. RW is piped from the WWTP via the "northern purple pipeline" to a storage pond just north of the MRC. A City resolution from 1995 permits up to 2 mg/d for use by Marty Sanchez Golf Course and the MRC via the "northern" RW distribution system. From there, RW is pumped to a series of ponds around the golf course before being distributed by the irrigation system. City Parks Division pays its share of the electric costs to pump RW from the WWTP to the storage pond, and then to the golf course.



- **RW budget:** Annual: 168 mg/yr (517 af/yr); Peak month: 27 mg/mo (83 af/mo); Daily maximum: 900,000 g. The annual value of the RW is $536,000. **[Requested annual RW budget is 196 mg/yr (600 af/yr)]**

8. SF Country Club GC: Under the existing contract, the Santa Fe Country Club has been irrigating its golf course with RW since the 1950s.

RW is pumped during the day from the WWTP to two on-site storage ponds, and then applied to the golf course during the evening and early morning hours. The RW budget presented herein is based on actual use, not the existing, in-perpetuity contract, which allows the SF Country Club GC to use up to 700,000 gpd all year long (an equivalent of 256 mg/yr or 784 af/yr). SF Country Club GC maintains the conveyance pipeline and pays its share of the electric costs to pump RW from the WWTP to its storage ponds. In exchange for allowing the public to play on the golf course, the Club does not pay for the RW.
   - **RW budget:** Annual: 130 mg/yr (400 af/yr); Peak month: 20 mg/mo (77 af/mo); Daily maximum: 700,000 g. The annual value of the RW is $395,000.

9. SF Equestrian Center: The Santa Fe Equestrian Center used RW from the City to irrigate the equestrian polo fields through 2006; no RW contract currently exists between the parties. The irrigated fields are used for the center and also rented by local sports clubs. Currently the fields are irrigated with groundwater from RG-590 (e.g. Hagerman well) with water rights leased from Santa Fe County. The water budget herein originates from a 12/5/2011 letter from a SF Equestrian Center representative to the City stating interest in securing at least a 10-year agreement with the City for effluent. In the past, SF Equestrian Center maintained the conveyance pipeline and was responsible for the electric costs to convey RW from the WWTP to its facility.

   - **RW [Requested] budget:** Annual: 41 mg/yr (127 af/yr); Peak month: 12 mg/mo (38 af/mo); Daily maximum: 400,000 g. A RW agreement with the SF Equestrian Center could generate $125,000 annually.

10. On-demand Sales: The WWMD has a stand pipe to provide RW to customers for construction, dust control and other similar uses. The City's water conservation ordinances require the use of RW for all appropriate construction purposes. On-demand sales have declined in recent years. During fiscal year 2011/2012, the sales from the standpipe equaled approximately $90,000. The RW budget for on-demand sales used in this analysis is 5% greater than actual use of the past three years, but is not as high as 2007 use.

- **RW budget:** Annual: 31 mg/yr (95af/yr); Peak month: 4 mg/mo (14 af/mo); Daily maximum: 140,000 g. The stand pipe sales will generate up to approximately $94,000 annually. **[Amount sold in 2007: 40 mg/yr (123 af/yr)]**

11. NM Game & Fish: The New Mexico Department of Game and Fish has their headquarters on One Wildlife Way off Caja del Rio Road. The agency uses RW for a small pond and native vegetation that is all part of an on-site wildlife educational center. Water is pumped to NM Game & Fish from one of the storage ponds at Marty Sanchez GC. Relative to other uses, very little RW is used. The annual contract with NM Game & Fish allows the agency to use up to 1.6 mg/yr (4 af/yr).

- **RW budget:** Annual: 1.6 mg/yr (4 af/yr); Peak month: 0.23 mg/mo (0.55 af/mo); Daily maximum: 10,000 g. The City will collect about $5,000 under this contract in 2013.

12. Landfill: Caja del Rio Landfill uses RW for dust control and rock crushing/screening during landfill operation. Use has varied between 2 to 9 mg/yr (7- 18 af/yr).

- **RW budget**: Annual: 6 mg/yr (17 af/yr); Peak month: 1.3 mg/yr (4 af/mo); Daily maximum: 40,000 g. RW use by the Landfill generates approximately $17,000 per year. **[Requested annual RW budget is 12 mg/yr (37 af/yr)]**

13. BW Permit Compliance: The Buckman Well Field Permit Compliance option is a way for the City to fulfill to a New Mexico Office of the State Engineer (OSE) permit condition associated with pumping the City's Buckman wells (RG-20516 et al). The OSE annually calculates impacts from Buckman well groundwater pumping on the surface waters, including the springs in the La Cienega area using a groundwater model. The City is currently seeking recognition from the OSE that the release of water from the WWTP has mitigated the impacts over the past decades and that future offset calculations need to include RW released to the river. Other downstream discharges, like Option 5, could likely also to be counted toward permit compliance. The RW budget presented herein is preliminary. This budget assumes a constant pattern of release over the course of a year, although the OSE may ultimately require a different flow schedule.

- **RW budget:** Annual: 33 mg/yr (100 af/yr); Peak month: 3 mg/mo (8 af/mo); Daily: 90,000 g. The annual value of the RW use is $99,000.

14. USFS Livestock Water: Historically, US Forest Service well RG-29725 supplied livestock and wildlife water on the Caja del Rio. Among other difficulties, the drop in groundwater levels from Buckman well field pumping reduced the viability of the deep well, which currently only has a 17-foot water column. When water supply is interrupted, the livestock seek water from the Santa Fe River or the accessible portions of the Rio Grande. To increase water supply reliability, the City has been providing RW as a replacement supply for livestock and wildlife on the mesa since 2006. By providing the water to the USFS, the City's impacts on the well are offset and livestock intrusion into sensitive riparian areas can be reduced. The RW, pumped from the 500,000 gallon pond at the Landfill, reaches the stock tanks on the mesa through approximately 26 miles of small-diameter, above ground PVC lines. The budget herein is based on the expired RW agreement between USFS and the City. Actual use has reached 2.9 mg (9 af) in one year.

   - **RW budget:** Annual: 2 mg/yr (6 af/yr); Peak month: 0.4 mg/mo (1 af/mo); Daily maximum: 15,000 g. The annual value of the RW is $6,400.

15. Future Potable Supply: RW is a viable supplement to the City's other potable water supply sources. This could be accomplished in one of at least three ways: 1) returning the water via a pipeline to the Rio Grande and diverting an equal amount from the river at the Buckman Direct Diversion; 2) direct potable reuse (DPR) via the Buckman Regional Water Treatment Plant (WTP); or 3) by recharging the groundwater with RW and then extracting it in the future. "Direct potable reuse (DPR) projects benefit public water supplies, agriculture, the environment, and energy conservation" (NWRI, 2012). This RWRP proposes a separate work effort to evaluate the merits of the three approaches or to pilot a project analyzing the need for RW pre-treatment before mixing it with the raw Rio Grande water at the Buckman WTP. Herein the quantity of water available for potable water supply is estimated by using the RW available during the non-irrigation season.

   - **RW budget:** Annual: approximately 717 mg/yr (2,200 af/yr). No monthly or daily maximum is identified since this option uses what remains after other obligations are met. The annual value of the RW is $2.17 million.

16. Urban Food Production: RW could be a valuable source of water to produce food in the areas served by the RW distribution system. Much of the landscaping at SWAN Park, for example, includes orchards. The production of local food to increase the region's food security is emphasized in the Sustainable Santa Fe Plan. Because this option was added to the Plan from comments provided at the public meeting on January 24, 2013 after the analysis was complete, this option has not been given a RW budget, scored or ranked in the following sections.

The *annual* RW demand of all the options combined equals 2,072 mg/yr (6,358 af/yr), which is 14% more than the 1,825 mg/yr (5,600 af/yr) conservatively projected to be available (Figure 9).

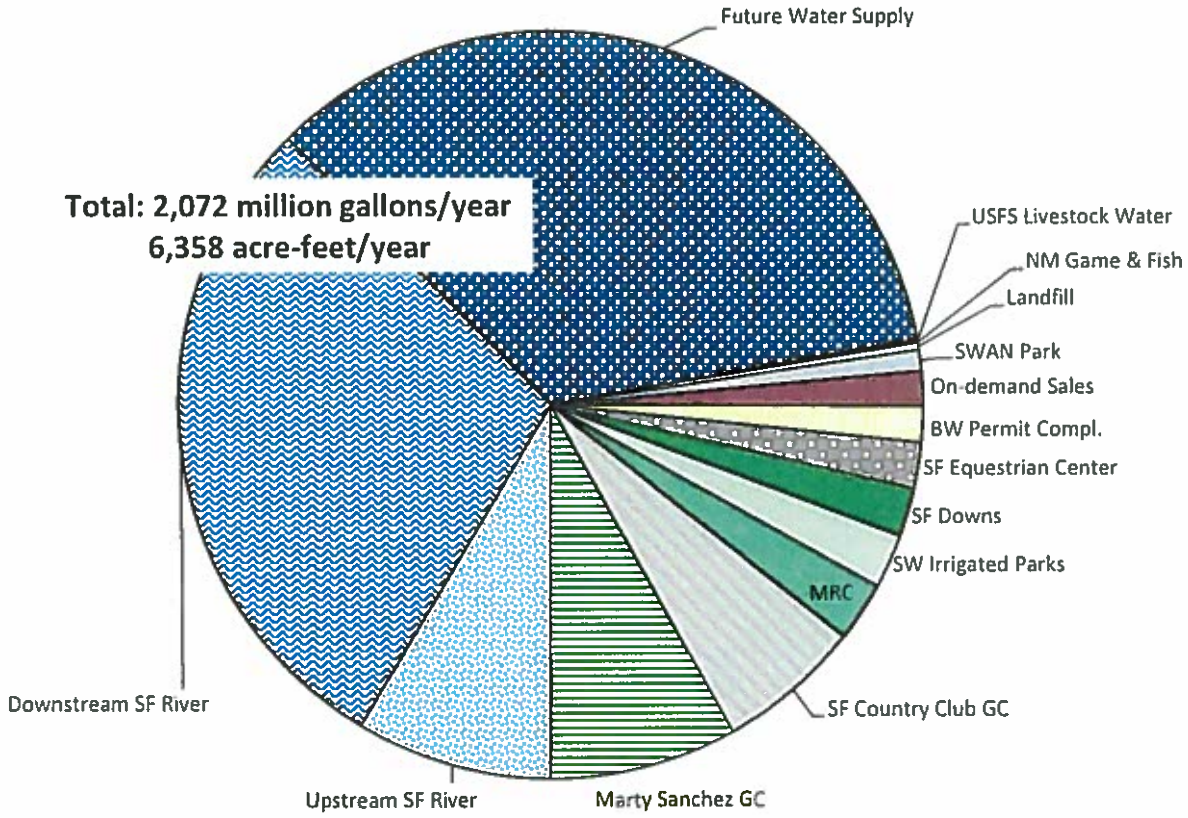


Figure 9. Annual total and relative proportion of all reclaimed wastewater use options combined

The demand for monthly and daily RW is even greater. The combined monthly demand for all the options except RW for potable water supply is 213 mg/d (Table 2), 40% more than the RW available and the combined *daily* demand of all the options (except RW for potable water) supply is 6.9 mg/d (Table 2), 38% more than the available amount. Hence, RW demand is greater than available supply under current average conditions, which will only worsen under drier hotter drought and projected climate change-impacted conditions, and become more pronounced during high seasonal demand.

5.4 Revenue Generation from Reclaimed Wastewater Options

As shown in Figure 10, only 2% of the City's RW currently generates revenue in the amount of approximately $121,000 annually. If all of the RW currently used were sold at the current rate of $3.03 per 1000/gallons, the resource could generate $1.4 million. Since 2012, one of the largest RW revenue sources, CLCI, no longer pays $300,000 to $400,000 annually to the WWMD.

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The Future of Water Adjudications in New Mexico

Gregory C. Ridgley, Office of the State Engineer

Greg is the Deputy Chief Counsel for the New Mexico Office of the State Engineer, where he coordinates the work of the hydrographic survey staff and Special Assistant Attorneys General of the OSE Litigation and Adjudication Program who represent the State of New Mexico in the 12 water rights adjudication suits currently pending in New Mexico's state and federal courts. During his 12 years at the OSE, he has worked with Indian Pueblos and Nations, federal agencies, local governments, acequias, and private individuals to resolve water right claims through negotiation or litigation. He received his BA from Harvard University in 1984, and his JD from the University of California, Hastings College of the Law in 1992. He lives with his wife and two spirited teenagers in Santa Fe. In addition to cheering for his kids on field and stage, he roots for the Boston Red Sox and San Francisco Giants.

Good morning. Before I start, I first would like to say a word of thanks to Judge Valentine. We just heard that the Judge is retiring at the end of the year, after presiding over the Lower Rio Grande water rights adjudication for over a decade. I have appeared before Judge Valentine myself many times. I have also worked with Judge Valentine on many matters relating to adjudications over the years, and I've always appreciated the strength of his commitment to improving adjudications in New Mexico, and his tireless efforts to do so. So I would like to thank him on behalf of all New Mexico water right owners – and all the citizens of the state – for his distinguished service in this challenging but very important field. Thank you, Judge.

As we all know, New Mexico state government is in an era of tight budgets. Today I will discuss what that means for water rights adjudications. The resources available to work on adjudications will be the most important factor in the next few years on how much progress we make in these cases. I will address four specific topics today: first, provide a brief overview of adjudications; second, review the budget of the Litigation and Adjudication Program (LAP) of the Office of the State Engineer (OSE) and what that means in terms of people and other resources available to work on adjudications; third, introduce the annual Rule 71.3 Report, which describes the State's priorities and resource allocations for pending water rights adjudications in the coming fiscal year; and finally, wrap up with a brief discussion of lessons we have learned from our experience prosecuting adjudications and how we can work smarter to achieve lasting incremental progress in adjudications.

Adjudications Overview

In the handouts we passed out you should have received a copy of this map (Fig. 1); on the back of the map you'll see there is a chart presenting some summary statistics (Fig. 2). These provide a very high-level overview of water rights adjudications in New Mexico. The map shows in red adjudications that over the years have been completed to a final decree, and in green the adjudications that are currently pending. There are 12 water rights adjudication suits pending today in the state and federal courts, half in the state courts and half in the federal courts.

Let me take a moment here to explain what a water rights adjudication suit is, because I don't think this is always clearly understood. Although adjudications get a fair amount of attention from the press and the legislature, the public is often unclear on the difference between adjudications and other litigation involving water rights. The State Engineer supervises the appropriation of the waters of the state largely through permits that he issues. If someone is unhappy with the permit they receive then they can request an administrative appeal before the State Engineer, and if they don't like that decision then they can appeal that to the district court. We have attorneys and hydrologists and other technical staff who work on those

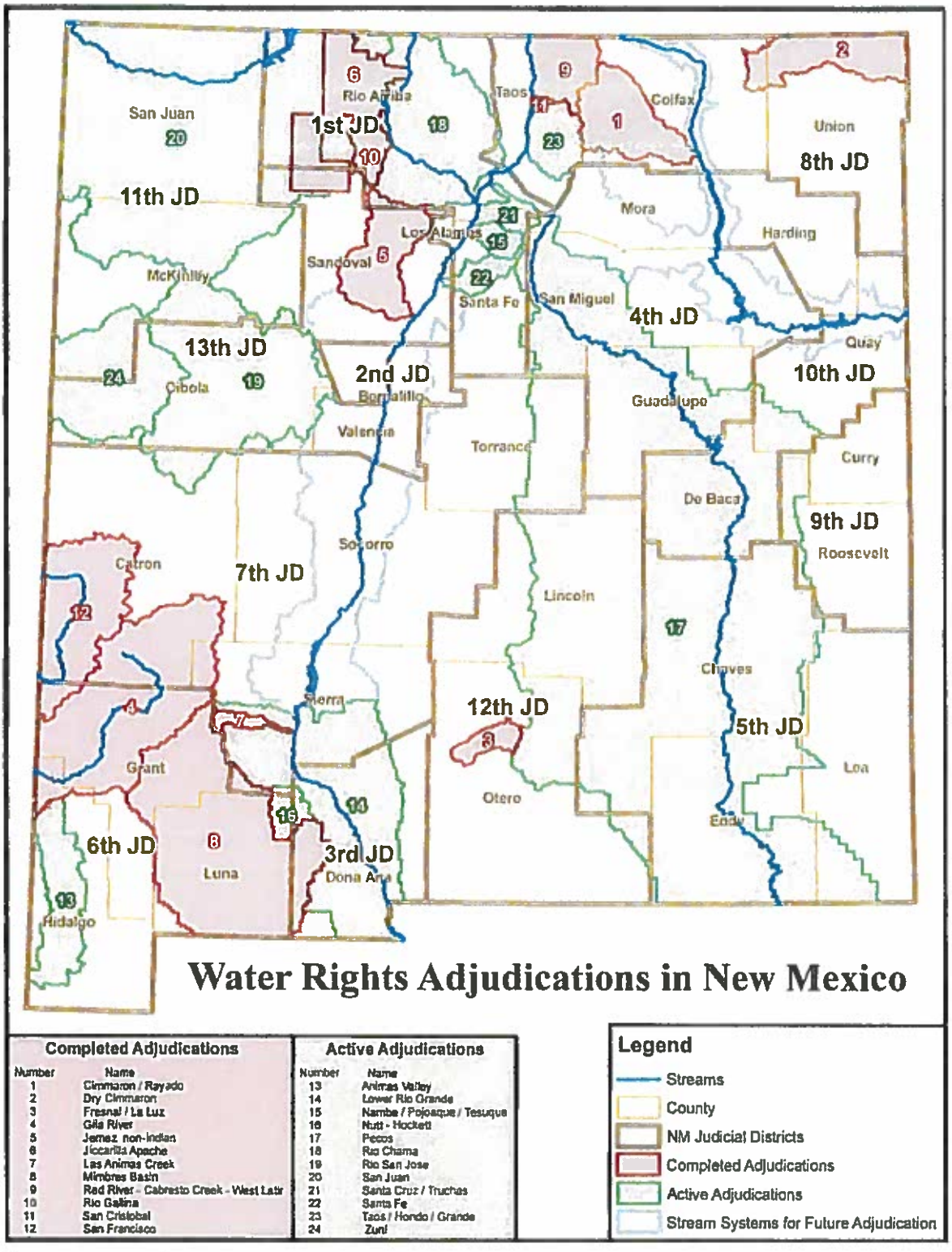

Figure 1. Map of New Mexico water rights adjudications

appeals from State Engineer permits, and those appeals can involve litigation in district court, but those suits are not adjudications. Adjudications are distinct, specialized legal proceedings in district court to comprehensively determine all water rights in a given stream system. Whereas the parties to an appeal of a State Engineer permit are typically the permittee, the State Engineer, and perhaps a handful of protestants, the parties to a water rights adjudication are the hundreds or thousands of owners of water rights in the stream system being adjudicated.

Figure 2 shows just how large these suits are: the 12 pending adjudications have a combined total of around 72,000 defendants. These are big and cumbersome cases, and they take a lot of time as a result. The Pecos is by far the largest in terms of geographic area, while the Lower Rio Grande has the largest number of defendants and water rights involved. Figure 2 shows the differences in the number of defendants in each of the 12 suits. These suits also vary greatly in terms of age – the Pecos adjudication has been pending for over 50 years, while the Animas, the newest, is only a few years old. The handout also provides statistics on the number of acres and subfiles adjudicated in each case that show the varying stages of completion of the different suits.

Figure 1 shows the locations and different geographic areas covered by the 12 pending adjudications. Probably the most notable thing shown on this map is something that Judge Valentine mentioned: there is no adjudication currently pending for the Middle Rio Grande. The area cross-hatched in blue on the map along the Rio Grande from Cochiti down to Elephant Butte shows the likely geographic scope of a future Middle Rio Grande adjudication. Periodically over the years we have heard calls to initiate this adjudication. There is no debate that it is the most significant area of the state where an adjudication suit has yet to be filed. When it is eventually started it will be the most challenging and resource demanding adjudication New Mexico has ever attempted. It is precisely because it will demand so many resources that the State Engineer and his Chief Counsel DL Sanders and I have consistently made clear in our public statements over the years that we need to finish several of the currently pending adjudications before we will have the resources available to be able to take on a new adjudication of the magnitude of the Middle Rio Grande.

When discussing the progress that New Mexico has made in adjudications, an estimate frequently cited is that about 20 percent of water rights in the state have been adjudicated. I think that estimate is too low. On the map in Figure 1, the completed adjudications shown in red cover about 20 percent of the geographic area of the state that needs to be adjudicated. Beyond these completed adjudications, the only geographic areas of the state left to be adjudicated are the 12 pending adjudications shown in green and the areas for future adjudication shown in blue cross-hatching. The 12 currently pending adjudications cover over 60% of the geographic area of the state that needs to be adjudicated. (Areas on the map that are not outlined in either red, green, or blue do not have significant numbers of water rights developed from surface water, and therefore will not need to be subject to a stream system adjudication suit.) The statistics in Figure 2 show that of the total irrigated acreage at issue in the 12 pending adjudications, about 67% has been adjudicated with a subfile order. So by that measure, at least, the 12 pending adjudications are about 2/3 complete. If we put that together with the adjudication suits that have already been completed to a final decree (shown in red on the map), I think a better estimate is that we have adjudicated between 40 and 50% of the state's water rights that need to be adjudicated.

Another gauge of progress in water rights adjudications in recent years is provided by the performance measures set by the legislature for LAP. The next two figures present these performance measures. Figure 3 shows over the last seven years how many people in the 12 pending adjudications have been served with what is known as an offer of judgment to determine their water right. Service of this document initiates the process before the court that culminates in an individual subfile order adjudicating a water right. Beginning in fiscal year 2004, a total of a little over 2,000 people had been served with an offer of judgment. Over the last seven years we have raised that total to 13,000. So in seven years, the adjudication process was initiated for 11,000 people who own water rights. Figure 4 presents our results for the performance measure that measures the number of subfiles in the 12 pending adjudications that have received individual subfile orders that adjudicate a water right. This figure shows the steady progress we have made over the last seven years; by this measure, by fiscal year 2010 close to 50% of all water rights in these pending suits have been adjudicated by final subfile order.

STATE OF NEW MEXICO
OFFICE OF THE STATE ENGINEER

Acres Adjudicated, Subfiles, and Defendants in Pending New Mexico Adjudications
Totals and Estimates as of June 30, 2010

NORTHERN NEW MEXICO ADJUDICATIONS

Stream System	Total Acres	Adjudicated Acres	% Acres Adjudicated	Subfiles	Defendants
San Juan	37,829	3,991	11%	9,000	11,400
Jemez	2,033	2,033	100%	1,011	1,095
Red River	12,185	12,185	100%	1,202	1,605
Zuni	980	-	0%	950	1,000
Rio San Jose	undetermined	-	0%	1,800	2,000
Rio Chama	34,889	34,329	98%	3,655	4,626
Taos/Hondo	13,756	13,692	100%	4,026	5,224
Santa Cruz/Truchas	7,218	7,218	100%	3,446	5,139
Nambe/Pojoaque/Tesuque	2,755	2,747	100%	3,430	5,598
Santa Fe	827	612	74%	1,284	1,550
Subtotals	112,472	76,807	68%	29,804	39,237

SOUTHERN NEW MEXICO ADJUDICATIONS

Stream System or LRG Section	Total Acres	Adjudicated Acres	% Acres Adjudicated	Subfiles	Defendants
Animas Underground	15,912	-	0%	300	500
Nutt Hockett	11,554	11,554	100%	43	73
Rincon Valley	21,964	17,180	78%	1,227	1,429
Northern Mesilla	20,032	3,493	17%	5,884	7,422
Southern Mesilla	53,923	10,140	19%	5,320	7,203
Outlying Areas	3,801	283	7%	1,233	1,738
Subtotals	127,186	42,650	34%	14,007	18,365

PECOS ADJUDICATION

Section	Total Acres	Adjudicated Acres	% Acres Adjudicated	Subfiles	Defendants
Gallinas	8,162	6,841	84%	1,680	1,994
Upper Pecos(Ground Water)	685	660	96%	99	92
Upper Pecos(Surface Water)	undetermined	-	0%	undetermined	2,000
Pecos Supplemental/Misc	4,651	365	8%	49	100
Hondo Basin	6,748	6,739	100%	588	657
FSID	6,500	-	0%	undetermined	480
Fort Sumner(Ground Water)	7,444	7,444	100%	80	44
PVACD	128,274	123,032	96%	1,900	2,522
River Pumpers	6,063	6,063	100%	19	22
Carlsbad Underground	11,350	320	3%	320	240
Carlsbad Irrigation District	27,053	26,912	99%	1,109	1,328
Penasco	undetermined	-	0%	undetermined	5,000
Subtotals	206,930	178,376	86%	5,844	14,479

ACTIVE GRAND TOTALS	446,588	297,833	67%	49,655	72,081

Figure 2. New Mexico adjudication summary statistics

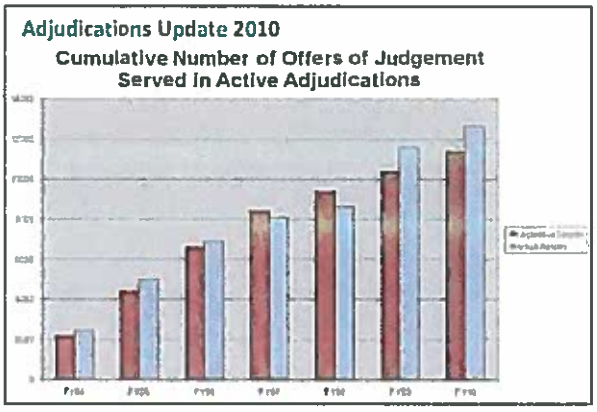

Figure 3. Offers of judgment served in 12 pending adjudications

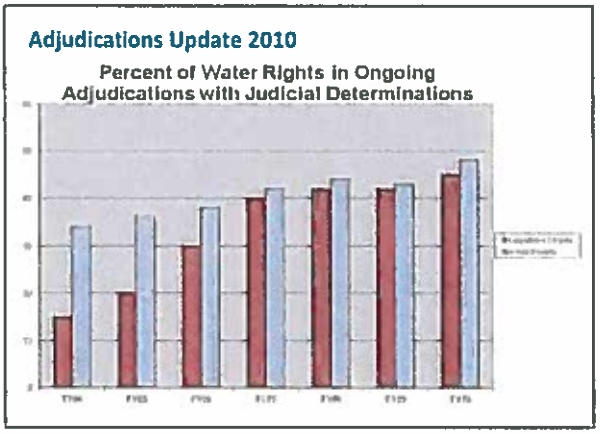

Figure 4. Percent of water rights adjudicated in ongoing adjudications

Figure 5 shows the progress we can make when we are able to focus resources on a single adjudication without interruption. The data are for sections 3, 5, and 7 of the Chama adjudication, where for the last ten years we have been able to dedicate a single attorney, supported by hydrographic survey staff, to move the suit forward. The darker blue bars show the total number of subfiles in these three sections of the adjudication, while the light blue bars show the subfiles that have been adjudicated by subfile order entered by the court. As you can see on the right side of the chart, subfile work is now almost complete, and this year and next we will be focusing on *inter se* proceedings and the entry of partial final decrees for these three sections of the Chama.

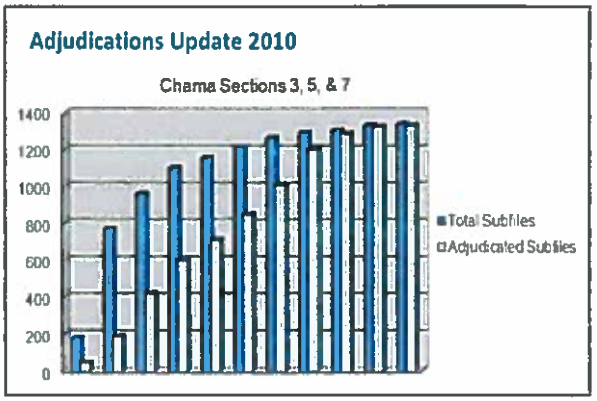

Figure 5. Subfiles adjudicated in Chama sections 3, 5, & 7

OSE LAP Budget and Resources Available for Adjudications

The difficult budget climate and its impact on LAP staffing levels is limiting our ability to make progress in adjudications, and likely will continue to do so in the next few years. But the resource problems we have encountered are more complicated than a simple matter of the dollar amounts budgeted by the legislature.

The budget amounts set by the legislature for the current fiscal year have not significantly affected the resources available to LAP for adjudication work. Figure 6 compares LAP's budget for the current fiscal year 2011, which began July 1, 2010, to our budget for the previous fiscal year 2010. The legislature appropriates LAP's budget in three basic areas: salary and benefits, contracts, and all other expenses. You can see that the budget amount for salary and benefits – the amount budgeted for LAP to pay employees – is basically flat. It was not reduced in FY 2011 from the amounts budgeted in FY 2010. You can also see that the amount budgeted to LAP for contracts was reduced in FY 2011 by 15% from the FY 2010 level. That has had an impact, because we employ contract attorneys to work on adjudications. The majority of our attorneys working on adjudications are salaried agency employees, but we do employ some contract attorneys with specialized expertise in areas like Indian water rights. The reduction in our contractor budget has directly reduced our ability to use contract attorneys to work on adjudications. But because LAP's salary and benefits budget has not been reduced, the overall impact of the budget reductions has been only moderate.

LAP Budget and Staffing

Budget Appropriation Amounts - FY11 compared to FY10

Salary & Benefits	Flat
Contractors	<15%>
All Other Costs	< 4%>

Figure 6. LAP budget - FY11 vs. FY10

Our real resource problem has been that even though we have enjoyed close to flat budgets on paper over the last two fiscal years, we have suffered significant shortfalls in actual funds received to pay those budgeted amounts, and these shortfalls have left us unable to fill vacancies when staff leave the agency. This problem started with House Bill 1110 passed by the legislature a few years ago. The idea of that bill was to provide additional funding from the water project fund to the OSE to work on adjudications, over and above our base general fund budget. Unfortunately, the moment that additional funding was added to our budget, the legislature took away an equivalent amount of general fund money. This left our overall budget flat, which doesn't sound so bad, but Figure 7 shows the real problem it caused. Our budget for salary and benefits in the current fiscal year was $4.86 million. Of that total, $3.4 million was appropriated from severance tax bond proceeds in the water project fund. But because those severance tax bonds only generated $2.7 million, we were left with a shortfall of $700,000.

LAP Budget and Staffing

- HB 1110
- FY11 LAP Salary & Benefits budget shortfall

Total Budget:	$4.86 M
STB Proceeds (Budgeted):	$3.40 M
STB Proceeds (Actual):	$2.69 M
Shortfall:	<$ 700 K>
(14.5% of $4.86M)	

Figure 7. LAP FY11 salary and benefits shortfall

Because of that $700,000 funding shortfall, we have not been able to fill vacancies as agency employees leave for other opportunities. Since November, 2008 the Governor has imposed a hiring freeze on state agencies. While there has been a lot of reporting in the press that this hiring freeze has been very porous, that has not been the case for LAP. Because of the $700,000 funding shortfall, we have not been able to request an exemption to the hiring freeze, and so we have not been able to fill any vacancies. Figure 8 shows the resulting impact over the last 18 months. On the left is fiscal year 2010 and the right is fiscal year 2011. These little icons represent the attorney and hydrographic survey positions in LAP. These are not all the positions in LAP, just the core technical and legal positions that are assigned to our four main adjudication bureaus. We have a total of 43 of these adjudication positions in LAP. At the beginning of fiscal year 2010, only four of these 43 positions were vacant – a nine percent vacancy rate. Those four vacancies are shown as the little "ghost" icons in gray on the end of the rows. Today, in the middle of fiscal year 2011, we have a lot more ghosts: 14 of the 43 positions are now vacant – a 33% vacancy rate. With 33% of our core adjudication technical and legal positions now vacant, our capacity to work on adjudications has been reduced by almost 25% over the last 18 months. That has had an unavoidable, direct impact on our ability to make progress in adjudications.

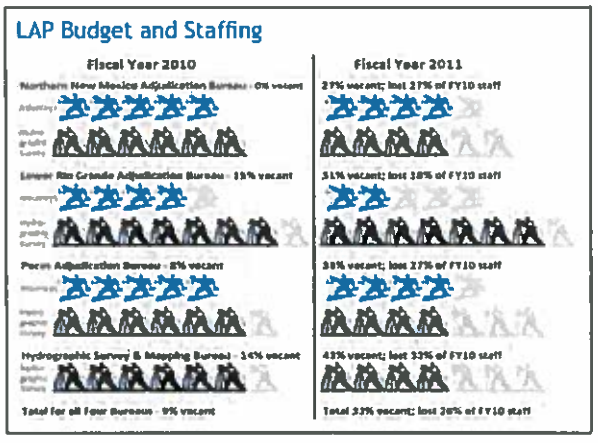

Figure 8. Vacancies in LAP technical and legal positions

Rule 71.3 Report

Rule 71.3 is a rule of civil procedure recently adopted by our Supreme Court. It requires all the state court judges presiding over adjudications and the attorneys representing the state in those suits to get together once a year for a working session. The purpose of the working session is to discuss the state's resources available to prosecute adjudications and the state's priorities for adjudication work in the coming fiscal year. For this meeting the state's attorneys prepare a report that outlines all the resources we have to work on adjudications and how those resources are going to be allocated in the coming fiscal year. Figure 9 shows a sample of a page from that report. This report is the most detailed description we provide every year on resources and the prioritization of adjudication work. It is an essential tool for communicating these matters to the public and the courts.

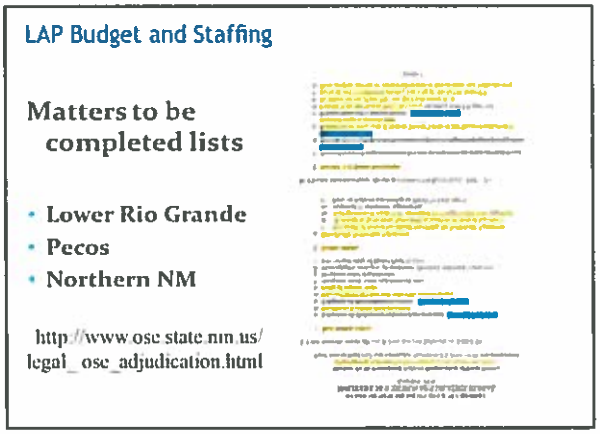

Figure 9. Rule 71.3 report

Of course, things change, and at the time the report is compiled at the beginning of the fiscal year we cannot anticipate every development during the year. For example, we received some wonderful good news this week. On Tuesday, November 30, 2010, the House of Representatives passed the legislation authorizing and funding the federal portion of the Aamodt and Taos Pueblo Indian water rights settlements. (On December 8, 2010 President Obama signed the bill, the Claims Resolution Act of 2010, into law as Public Law 111-291). This is wonderful news for New Mexico and an extraordinary achievement by our congressional delegation. But it is also one of those "be careful what you ask for" situations, because those settlements are now going to impose new deadlines upon the Aamodt and Taos adjudications to get things done to be able to get those decrees entered. That may require some reallocation of resources to achieve those new deadlines.

Lessons Learned

Finally, let me present some lessons we have learned from our experience prosecuting adjudications. This is adapted from a talk I gave to the adjudication judges at our Rule 71.3 working session earlier this year. It is an attempt to boil down our experience to a set of principles that describe the best way to make lasting, incremental progress in adjudications, regardless of the amount of resources we have available. Given the nature of adjudications in New Mexico and the resource limitations we face, I think these principles are going to be important for years to come. This presentation is structured as a light-hearted parody of "All I Really Need to Know I Learned in Kindergarten," but the principles it tries to present are serious.

1. The first and most important principle is that we need to finish what we started before moving on to something new. By that we mean that we must focus on achieving incremental progress by resolving discrete matters with finality before we move the resources involved on to other matters. For example, when we start subfile work in a section or subsection of an adjudication, we need to complete the adjudication of all rights in that section or subsection before we move those resources elsewhere. It has been a recurring problem over the decades that after starting work on one adjudication or section of an adjudication, another pressing matter forces us to pull those resources away. When we finally are able to allocate those resources back to the first adjudication, we have to do even more work to bring matters back to where they were when we left it. This principle also applies at the highest level. As I mentioned earlier, we can't afford to start a new adjudication now for the Middle Rio Grande until we have finished several of our pending adjudications.

2. Second, cookies are best warm out of the oven, by which we mean that we need to schedule both hydrographic survey and adjudication subfile work to minimize the chance that the data and information in the hydrographic survey will grow old and become stale. Judge Valentine made this point very well and I agree with him that this is something we need to do better. We need to work smarter and schedule our survey work so that

as soon as it is completed we are ready to begin working on the adjudication of subfiles.

The Judge's comments also touched on another point related to this one. We've learned that when we join individual defendants to the adjudication, we should not join defendants en masse, thousands at a time. Instead, we should be joining them only when we are ready to work on their individual subfile. Joining water right owners as defendants and then taking no other action in the adjudication on their subfiles for months or years only creates confusion, misunderstandings, and more problems down the road.

3. Third, don't bite off more than you can chew, by which we mean that we must focus our limited technical and legal resources and avoid over-committing those resources. This principle applies both across adjudications and within each adjudication. Across adjudications, we strive to focus our resources on a few adjudications rather than spreading our resources thinly across all pending adjudications. The annual Rule 71.3 working session with the judges is an important opportunity to communicate to the judges and adjudication defendants where we plan to focus our adjudication work in the coming year. Within adjudications, we divide the adjudication into sections and focus our resources on one or two sections at a time.

4. The last principle is to play fair, share, and not hit people. We have advocated this approach before the legislature several times in recent years; this is sometimes referred to as the "Chama adjudication model." The idea here is to promote the informal, out-of-court resolution of subfile disputes over the formal litigation of those disputes. We do that by minimizing the adversarial aspects of water rights adjudications. These are civil lawsuits, and so they are necessarily adversarial at some level. It's intimidating to the average person, for example, to receive a summons and be forced to answer the State's adjudication complaint. But we have learned we can make more progress in adjudications when we minimize the formal litigation of disputes and instead work to resolve disputes informally and promote an atmosphere where there is an open exchange of information between the state and individual defendants. We can do that by a variety of techniques, including public outreach and education, mandatory field offices where the State's legal and technical representatives meet with individual defendants, and follow up field checks by hydrographic survey staff when requested by defendants.

To conclude, I've outlined the fundamental principles we have identified that promote the achievement of incremental and lasting progress in adjudications. Today, at a time where resources are at a premium, it is more important than ever to work smart. These principles are scalable – they can be applied at different levels of resources and they will produce results in any budget climate – but they are even more important in our current difficult budget climate.

Attachment #6: NMED Water Quality Control Commission Regulations - Ground and Surface Water Protection

Excerpt from:

TITLE 20 ENVIRONMENTAL PROTECTION
CHAPTER 6 WATER QUALITY
PART 2 GROUND AND SURFACE WATER PROTECTION

20.6.2.1201 NOTICE OF INTENT TO DISCHARGE:

A. Any person intending to make a new water contaminant discharge or to alter the character or location of an existing water contaminant discharge, unless the discharge is being made or will be made into a community sewer system or subject to the Liquid Waste Disposal Regulations adopted by the New Mexico Environmental Improvement Board, shall file a notice with the Ground Water Quality Bureau of the department for discharges that may affect ground water, and/ or the Surface Water Quality Bureau of the department for discharges that may affect surface water. However, notice regarding discharges from facilities for the production, refinement, pipeline transmission of oil and gas or products thereof, the oil field service industry, oil field brine production wells, geothermal installations and carbon dioxide facilities shall be filed instead with the Oil Conservation Division.

B. Any person intending to inject fluids into a well, including a subsurface distribution system, unless the injection is being made subject to the Liquid Waste Disposal Regulations adopted by the New Mexico Environmental Improvement Board, shall file a notice with the Ground Water Quality Bureau of the department. However notice regarding injection to wells associated with oil and gas facilities as described in Subsection A of Section 20.6.2.1201 NMAC shall be filed instead with the Oil Conservation Division.

C. Notices shall state:

(1) the name of the person making the discharge;
(2) the address of the person making the discharge;
(3) the location of the discharge;
(4) an estimate of the concentration of water contaminants in the discharge; and
(5) the quantity of the discharge.

D. Based on information provided in the notice of intent, the department will notify the person proposing the discharge as to which of the following apply:

(1) a discharge permit is required;
(2) a discharge permit is not required;
(3) the proposed injection well will be added to the department's underground injection well inventory;
(4) the proposed injection activity or injection well is prohibited pursuant to 20.6.2.5004 NMAC.

[1-4-68, 9-5-69, 9-3-72, 2-17-74, 2-20-81, 12-1-95; 20.6.2.1201 NMAC - Rn, 20 NMAC 6.2.I.1201, 1-15-01; A, 12-1-01]

Attachment #7: Evaluation of Different Methods to Calculate Heavy-Truck VMT

Evaluation of Different Methods to Calculate Heavy-Truck VMT

Final Report—December 2004

Sponsored by

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16. Abstract

Reliable estimates of heavy-truck volumes are important in a number of transportation applications. Estimates of truck volumes are necessary for pavement design and pavement management. Truck volumes are important in traffic safety. The number of trucks on the road also influences roadway capacity and traffic operations. Additionally, heavy vehicles pollute at higher rates than passenger vehicles. Consequently, reliable estimates of heavy-truck vehicle miles traveled (VMT) are important in creating accurate inventories of on-road emissions.

This research evaluated three different methods to calculate heavy-truck annual average daily traffic (AADT) which can subsequently be used to estimate vehicle miles traveled (VMT). Traffic data from continuous count stations provided by the Iowa DOT were used to estimate AADT for two different truck groups (single-unit and multi-unit) using the three methods. The first method developed monthly and daily expansion factors for each truck group. The second and third methods created general expansion factors for all vehicles.

Accuracy of the three methods was compared using *n*-fold cross-validation. In *n*-fold cross-validation, data are split into *n* partitions, and data from the *n*th partition are used to validate the remaining data. A comparison of the accuracy of the three methods was made using the estimates of prediction error obtained from cross-validation. The prediction error was determined by averaging the squared error between the estimated AADT and the actual AADT.

Overall, the prediction error was the lowest for the method that developed expansion factors separately for the different truck groups for both single- and multi-unit trucks. This indicates that use of expansion factors specific to heavy trucks results in better estimates of AADT, and, subsequently, VMT, than using aggregate expansion factors and applying a percentage of trucks. Monthly, daily, and weekly traffic patterns were also evaluated. Significant variation exists in the temporal and seasonal patterns of heavy trucks as compared to passenger vehicles. This suggests that the use of aggregate expansion factors fails to adequately describe truck travel patterns.

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EVALUATION OF DIFFERENT METHODS TO CALCULATE HEAVY-TRUCK VMT

MTC Project 2002-02

Final Report
December 2004

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EXECUTIVE SUMMARY

Reliable estimates of heavy-truck volumes are important in a number of transportation applications. Estimates of truck volumes are necessary for pavement design and pavement management. They also affect bridge performance. Truck volumes are important in traffic safety. The number of trucks on the road also influences roadway capacity. Heavy trucks have more difficulty accelerating and maneuvering than passenger cars and have a lower deceleration in response to braking compared to passenger cars. They are particularly affected by grade. As a result, the number of heavy trucks present in the traffic stream influences traffic operations. Additionally, heavy vehicles pollute at higher rates than passenger vehicles. Consequently, reliable estimates of heavy-truck vehicle miles traveled (VMT) are important in creating accurate inventories of on-road emissions.

Most states use a traffic-count-based method for estimating truck VMT. One method used to estimate truck VMT involves developing separate expansion factors for specific classes of heavy vehicles. Annual average daily traffic (AADT) from shorter term classification counts for a class of heavy vehicles is factored up using the expansion factors. Truck VMT for a highway segment is obtained by multiplying truck AADT by the length (centerline mileage) of a roadway section. This method however is resource-intensive, and, therefore, most DOTs use a more aggregate method to derive truck VMT. In this aggregate method, generic expansion factors are developed that apply to all vehicle classes. A limited number of vehicle classification counts are used to calculate truck percentages. For short-term counts, the expansion factors are applied and AADT for all vehicle types is estimated. VMT is calculated by multiplying AADT by the section length. Truck VMT is calculated by multiplying total VMT by the average truck percentages (by truck types) obtained from limited classification counts. Truck percentage may also be determined from short-term counts.

Several studies have indicated problems with the use of generic expansion factors for estimating truck VMT or volumes. Although truck volumes, like passenger car volumes, vary over time and space, the pattern of temporal variability in truck volumes differs significantly from passenger vehicles. Trucks experience more variability between weekdays and weekends than passenger vehicles, and expansion factors derived from aggregate count data may fail to adequately explain temporal variations in truck traffic.

This research evaluated three different methods to calculate heavy-truck AADT which can subsequently be used to estimate VMT. Traffic data from continuous count stations provided by the Iowa DOT were used to estimate AADT for two different truck groups (single-unit and multi-unit) using the three methods. The first method developed monthly and daily expansion factors for each truck group. Truck AADT was calculated by applying truck expansion factors to short-term counts. The second and third methods created general expansion factors for all vehicles. Truck AADT was calculated by multiplying short-term counts by generic expansion factors and truck percentages. Truck percentages for the second method were based on the annual percentage of trucks for each group from continuous count stations. The third method used daily truck percentages from short-term counts.

Accuracy of the three methods was compared using *n*-fold cross-validation. In *n*-fold cross-validation, data are split into *n* partitions, and data from the *n*th partition are used to validate the

remaining data. Accordingly, data from continuous count stations were divided into four groups, and each group was reserved for one partition as the validation dataset. Short-term counts were extracted from the validation dataset and then AADT was estimated using each of the three methods. Actual AADT by truck group for each count station was compared to the estimated AADT by truck group for each method.

Data were analyzed for rural primary and interstate roadways. Data from continuous count stations for the 2001 counting year were used. Although 2002 data were available, the DOT felt that there had been significant problems with the data and suggested use of the 2001 data. Data were analyzed for two truck categories: single-unit (SU) trucks and multi-unit (MU) trucks. The single-unit truck category included FHWA vehicle classes 4 to 7, and the multi-unit truck category included FHWA vehicle classes 8 to 13.

A comparison of the accuracy of the three methods was made using the estimates of prediction error obtained from cross-validation. The prediction error was determined by averaging the squared error between the estimated AADT and the actual AADT. Overall, the prediction error was the lowest for the method that developed expansion factors separately for the different truck groups for both single- and multi-unit trucks. This indicates that use of expansion factors specific to heavy trucks results in better estimates of AADT, and, subsequently, VMT, than using aggregate expansion factors and applying a percentage of trucks.

Monthly, daily, and weekly traffic patterns were also evaluated. Significant variation exists in the temporal and seasonal patterns of heavy trucks as compared to passenger vehicles. This suggests that the use of aggregate expansion factors fails to adequately describe truck travel patterns.

1. BACKGROUND

1.1 Heavy-Truck VMT

Information about truck volumes is necessary to meet federal reporting requirements and to assist state and local agencies in assessing system performance and needs. Estimates of vehicle miles traveled (VMT) are used for a variety of transportation-related planning and policy analysis purposes. VMT is a measure of the amount of travel along a roadway section for a specified time period. VMT is a function of the number of trips made as well as the lengths of those trips.

VMT estimates are used extensively in transportation planning to estimate vehicle emissions, compute energy consumption, assess traffic impact, allocate highway funds, and estimate pavement performance (Kumapley et al. 1996). Estimates of VMT by vehicle class are required to derive accident rates by vehicle class, compare accident rates across classes, and to allocate highway costs across vehicle classes (Weinblatt 1996). For VMT-related revenue, estimates of VMT by vehicle class are required for producing estimates of revenue forecasts for proposed new taxes, tax payments by vehicle class (for equity analyses), and revenue that should be collected. The U.S. economy thrives significantly on freight transportation, which takes place mostly by truck (Mohamedshah et al. 1993). Estimates of truck VMT are therefore necessary to understand the importance of trucks to the nation's economy and to evaluate the costs and benefits of potential changes in truck regulation (Weinblatt 1996). Estimates of truck volumes are also an essential input in geometric and structural design of roadways and bridges.

Trucks have characteristics that differ from passenger vehicles. Typically, trucks are larger in size and much heavier than passenger vehicles, thus influencing roadway capacity and pavement performance. Trucks are also characterized by less effective acceleration and maneuvering capabilities and have a lower deceleration in response to braking than passenger cars (Mohamedshah et al. 1993). These characteristics need to be accommodated in geometric and pavement design of roadways to facilitate smooth traffic operations. Estimates of truck VMT therefore serve as vital input in geometric and pavement design of roadways. Truck VMT is also a key factor in traffic safety. VMT estimates by vehicle class are required to derive accident rates by vehicle class and compare accident rates across vehicle classes. According to the 2003 Traffic Safety Facts published by the National Highway Traffic Safety Administration (NHTSA), 12% of all the traffic fatalities reported in 2003 resulted from collisions involving large trucks (gross vehicle weight rating greater than 10,000 pounds), yet trucks accounted for only 8% of the total VMT. A better understanding of where trucks are located on the highway system may assist in evaluating the causes of truck-related crashes and consequently minimize fatalities and injuries resulting from such crashes. These important applications of heavy-truck VMT warrant its accurate estimation. Previous research has, however, revealed that current methods used in the estimation of heavy-truck VMT are often less accurate than those used for passenger vehicles. There is, therefore, the need to improve current heavy-truck VMT estimation methods by reducing or possibly eliminating inherent biases.

Each state maintains a traffic count program to collect volume data continuously at permanent count stations sites. Classification counts may also be collected at a limited number of permanent count stations. Daily and monthly expansion factors are calculated from permanent counts. Factors are typically generated for each day of the week by month for separate road types. Portable or short-term counts are collected at other locations to estimate site specific volumes. Short-term counts are usually collected for periods up to 48 hours. Since short-term counts do not represent an average annual daily count, the short-term count data is multiplied by expansion factors to estimate annual average daily traffic (AADT) and VMT. To account for temporal variations in short-duration traffic counts, data from sites that are counted continuously are used to develop expansion factors for factoring short-duration counts to estimates of AADT. Vehicle classification data are used to estimate AADT and VMT by vehicle class. VMT is the product of volume and section length and is usually reported as the total amount of travel in a day (daily vehicle miles traveled) or in a year (annual vehicle miles traveled).

About 70% of state DOTs, including the Iowa DOT, use a traffic-count-based method for estimating truck VMT (Benekohal and Girianna 2002). One method to estimate truck VMT is to develop separate expansion factors for specific classes of heavy vehicles. AADT from short-term classification counts for a class of heavy vehicles is factored up using the expansion factors. Truck VMT for a highway segment is obtained by multiplying truck AADT by the length (centerline mileage) of a roadway section. This method however is resource-intensive, and most DOTs use a more aggregate method to derive truck VMT. In this method, generic expansion factors are developed that apply to all vehicle classes. A limited number of vehicle classification counts are used to calculate truck percentages. For short-term counts, the expansion factors are applied and AADT for all vehicle types is estimated. VMT is calculated by multiplying AADT by the section length. Truck VMT is calculated by multiplying total VMT by the average truck percentages (by truck types) obtained from limited classification counts. Truck percentage may also be determined from short-term counts.

Several studies have indicated problems with the use of generic expansion factors for estimating truck VMT or volumes. Although truck volumes, like passenger car volumes, vary over time and space, the pattern of temporal variability in truck volumes differs significantly from that in passenger vehicles. Trucks experience more variability between weekdays and weekends than passenger vehicles. As such, adjustment factors derived from aggregate count data (total volume) may fail to adequately explain temporal variations in truck traffic culminating in biased estimates of annual average daily truck traffic (AADTT). Hu et al. (1998) evaluated extrapolated data from permanent count stations and reported that more precise estimates resulted for passenger vehicles than for heavy trucks and that estimates were more precise when volumes were high. Stamatiadis and Allen (1997) reported that trucks experience more seasonal variability than passenger vehicles. They also observed more variability between weekdays and weekends for heavy trucks than for passenger vehicles. Both factors are difficult to capture with current extrapolation methods. Hallenbeck (1993) also observed that trucks do not exhibit the same seasonal patterns as passenger vehicles. As a result, seasonal estimates based on aggregate count data may fail to adequately explain seasonal variations in truck flow.

Weinblatt (1996) also indicated that, although extrapolated traffic counts can be quite accurate in estimating VMT for systems of roads, less sophisticated methods are often used to estimate VMT by vehicle class resulting in less satisfactory results. Researchers recommended using seasonal and day-of-week factors developed for several groups of vehicle classes to better reflect heavy-truck patterns and to reduce errors in heavy-truck AADT estimates. Additionally, extrapolation methods, such as the Highway Performance Monitoring System (HPMS) method, were designed for federal-aid roads but are not as applicable to local roads (Kumapley and Fricker 1996).

1.2 Problem Statement and Scope of Work

VMT and vehicle classification are vital inputs in the design and operation of an efficient transportation infrastructure system. In particular, heavy-truck VMT is important as the number of heavy vehicles on a road affects traffic operations, safety, and pavement performance. Research has revealed, however, that current methods used in the estimation of heavy-truck VMT are often less accurate than those used for passenger vehicles. Consequently, the goal of this research was to evaluate existing methods used by state DOTs, identify deficiencies, and make recommendations on reducing uncertainties in heavy-truck VMT estimates.

Current heavy-truck AADT estimation methods were evaluated and compared. Traffic data from permanent counting stations provided by the Iowa DOT were used to develop a statistical model to compare different traffic count–based methods. Although VMT is often the metric of interest, AADT was evaluated for this study since VMT is dependent on AADT estimates and can easily be derived once AADT is estimated. Recommendations on reducing uncertainties in heavy-truck AADT were made.

This research focuses on heavy-truck AADT and VMT. Heavy trucks are defined as the aggregation of all vehicles belonging to classes 4 to 13 of the FHWA 13-class vehicle classification scheme. The FHWA vehicle classification scheme with the definitions of the various classes of vehicles is presented in Appendix A. In this report, the term "truck" is used interchangeably with the term "heavy truck."

2. INTRODUCTION

2.1 Methods of Estimating VMT

AADT and VMT estimation methods can be classified into two broad divisions. The two methods are non–traffic count based and traffic count based. Each is discussed in the following sections.

2.1.1 Non-Traffic-Count-Based Method

The non-traffic-count-based method for estimating AADT and VMT uses non-traffic data such as socio-economic data, including fuel sales, trip-making behavior, household size, household income, population, number of licensed drivers, and employment.

Travel Demand Forecasting Models

Travel demand models project regional traffic and forecast link volumes through the four-step process. Base year estimates are typically calibrated against ground counts, and then volume projections are made for future scenarios. VMT estimates are obtained from the product of the forecasted link volumes and the respective centerline mileage of the link.

Output from travel demand forecasting models is also used to estimate heavy-truck and passenger-vehicle VMT. One of the main problems with travel demand forecasting models is that they often lack the data to model heavy trucks as well as they model passenger vehicles. The accuracy of the output volumes also depends on the trip generation and trip distribution components of the model and the representativeness of the network to the actual street system. Local roads, for instance, are usually not modeled in travel demand models. Several studies report different methods to improve heavy-truck VMT estimates using travel demand forecasting methods. Drishnan and Hancock (1998) used statewide freight flow data from the Commodity Flow Survey (CFS) with travel demand forecasting in a GIS to estimate truck flows. Ross et al. (1998) recorded trip diaries for heavy trucks to locate origins, destinations, and routes.

Fuel Sales

This method estimates VMT from fuel sales. Total fuel sales for retail gasoline and diesel are divided by the unit price per gallon of fuel to obtain the total amount of fuel purchased in an area. Estimates of fuel fleet efficiency are used to determine miles traveled per gallon of fuel purchased, and VMT is then calculated using the following equation:

$$VMT = (Ret_{sales} \times MPG)/PPG \qquad (2\text{-}1)$$

where

Ret_{sales} = total sales of fuel for study area in dollars
PPG = average unit price per gallon of fuel in dollars
MPG = fleet fuel efficiency in miles per gallon

Errors associated with this method result from the inaccurate estimates of retail fuel sales and prices. Additionally, wide variations exist in the fuel efficiency of individual vehicles. Consequently, estimates of fleet fuel efficiency are gross estimates at best. Additionally, it is difficult to distribute VMT between residents and non-residents (Kumapley and Fricker 1996).

2.1.2 Traffic-count-based methods

The traffic-count-based method uses actual counts of traffic volumes. VMT is calculated by multiplying AADT on a section of road by the length of the section. To annualize this value, it is multiplied by the number of days in a year. In estimating VMT using traffic counts, it is customary to assume that a vehicle counted on a section of road travels the entire length of the section. Under this method, some vehicles traveling only a portion of the section will be counted while others will not, depending on whether they cross the counting location (Roess et al. 1998). This method of estimating VMT is presently the most preferred by state DOTs as it utilizes actual data of vehicle movement on a road segment (Kumapley and Fricker 1996). About 70% of state DOTs, including the Iowa DOT, use a traffic-count-based method (Benekohal and Girianna 2002).

Highway Performance Monitoring System (HPMS) Method

The HPMS is a national level highway information system that includes data on the extent, condition, performance, use, and operating characteristics of the nation's road infrastructure. It was originally developed in 1978 by the Federal Highway Administration (FHWA) to monitor the nation's highway infrastructure and has been continuously modified over the years (most recently in 1998) to reflect changes in highway systems, legislation, and national priorities, as well as to streamline reporting requirements. The HPMS data are the source of a large portion of information published in the annual Highway Statistics Series and other FHWA publications. They also form the basis of the analyses that support the biennial Condition and Performance Reports to Congress. In addition, data from the HPMS are used to produce statewide estimates of total VMT used for the apportionment of Federal-Aid funds under TEA-21.

The HPMS method of estimating VMT involves the use of continuous count stations to develop expansion factors which reflect daily and monthly traffic patterns. Sample sections on other roadways are identified through a systematic stratified random sampling process. After the sections are identified, 24-hour traffic counts are taken. The short-term counts are extrapolated to reflect annual daily volumes using the expansion factors developed with continuous count data. The sample section VMT is estimated as the product of the centerline mileage and AADT of the section. Sample section VMT is used to approximate area wide VMT. The HPMS method usually covers only roadway sections under state jurisdiction. Local and county roads, which usually form a major percentage of the road network in a state, are not considered in the HPMS submittal (FHWA 2001).

2.2 Calculation of Annual Average Daily Traffic

VMT usually is the product of the roadway section length in miles (centerline mileage) and AADT. In order to obtain reliable VMT estimates, accurate estimates of AADT must be developed from traffic monitoring programs. The Federal Highway Administration's (FHWA) Traffic Monitoring Guide (FHWA 2001) provides guidance for improved traffic counting, vehicle classification, and truck weighing. Statistical procedures are provided that allow State Highway Agencies (SHAs) to determine the amount of monitoring required to achieve a desired precision level for their traffic counting needs. The Traffic Monitoring Guide (TMG) recommends two types of counts to be conducted in order to estimate AADT:

- Long-term or permanent continuous counts (year-round)
- Portable short-term counts

Additional Counts are performed as a supplement to the coverage program to address "special needs" and may include the following:

- Pavement design counts performed to provide data for pavement design
- Maintenance, repair, rehabilitation, and reconstruction
- Traffic operations counts performed to provide inputs to traffic control studies (e.g., the creation of new signal timing plans)
- Traffic counts for other special purpose studies (FHWA 2001)

2.2.1 Permanent Continuous Counts

Continuous counts are performed using permanent counters, frequently called Automatic Traffic Recorders (ATRs), which collect traffic data continuously for 24 hours a day, 365 days a year. The primary goal of the continuous count program is to assist agencies in understanding the time-of-day, day-of-week, and seasonal travel patterns and to facilitate the development of seasonal expansion factors required to convert short-term counts to accurate estimates of AADT. Continuous ATR count data is also reported on a monthly basis to the FHWA for the preparation of the Traffic Volume Trends Report.

Since the ATRs monitor traffic every day of the year, an Annual Average Daily Traffic (AADT) is obtained by adding all volumes collected by an ATR for an entire year and dividing by the number of days in a year. Permanent counters record volume variation by day of the week and month of the year. Expansion factors are created by permanent count data to allow adjusting short-term count data to account for daily and monthly variation facility type (Roess 1998). The adjustment factor is then obtained from the ratio of the AADT to the Monthly Average Daily Traffic (MADT) of the same ATR group for each road type. Multiplying the short-term count by the appropriate factor expands the short-term counts.

2.2.2 Short-Term Counts

The installation, operation, and maintenance of permanent counters are expensive. Consequently, short-term coverage counts are conducted on roadways throughout a state to provide the geographic coverage needed to understand the traffic characteristics of the state roadway system.

The TMG recommends a short-term count program comprised of periodic comprehensive coverage of all roads on all systems over a 6-year cycle and counting on HPMS sample and universe sections on a 3-year maximum cycle to meet the national HPMS requirements. Short-term count data used for AADT computation must be adjusted to remove temporal bias from the data. Seasonal adjustment factors derived from the permanent continuous counts are used to adjust the short-term counts to arrive at AADT estimates (FHWA 2000).

2.3 Truck VMT Estimation

About 70% of state DOTs, including the Iowa DOT, use a traffic-count-based method for estimating truck VMT (Benekohal & Girianna 2003). Currently, two different traffic-count-based methods are used to calculate truck VMT. In the first method, truck VMT is estimated on a highway segment basis by multiplying truck AADT by the length (centerline mileage) of a roadway section. The second method is the HPMS method described above. It estimates truck VMT by multiplying total VMT by an average truck percentage.

The best possible VMT estimates would be those obtained using the traffic-count-based method if all road sections of interest are monitored continuously throughout the year to produce AADT (Kumapley and Fricker 1996). Resource constraints, however, make it impractical for the collection of traffic count data on all sections of interest. Hence, data are collected continuously at a limited number of count locations, while other locations are counted only at infrequent intervals, such as once every 3 years, for relatively short durations—usually 24 or 48 hours (Weinblatt 1996). To account for the temporal variations in short-duration traffic counts, data from sites that are counted continuously are used to develop expansion factors for factoring short-duration counts to estimates of annual average daily traffic (AADT). Although truck volumes, like passenger car volumes, vary over time and space, the pattern of temporal variability in truck volumes differs significantly from that in passenger vehicles (Roess et al. 1998). Trucks experience more variability between weekdays and weekends than passenger vehicles. As such, adjustment factors derived from aggregate count data (total volume) may fail to adequately explain temporal variations in truck traffic, culminating in biased estimates of annual average daily truck traffic (AADTT). In order to obtain accurate estimates of annual average truck volumes and, consequently, truck VMT, truck adjustment factors must be developed specifically to convert short-duration truck volume counts into estimates of AADTT.

3. VMT ESTIMATION METHODOLOGIES USED BY STATE DOTS

The DOTs for ten states were contacted to determine the methodology used in their Traffic Monitoring Program to estimate truck AADT and VMT. When possible, information was obtained from DOTs websites. DOTs were contacted for additional information and clarification when necessary. Responses received from the DOTs are provided in Appendix B.

All the state DOTs contacted use the traffic-count-based method to estimate VMT. The traffic-monitoring programs adopted by the state DOTs contacted were similar and all conform to the recommended procedures outlined in the FHWA's Traffic Monitoring Guide (FHWA 2001). A summary of the methodologies used by the different DOTs to estimate VMT, as well as methods to estimate truck VMT, are provided in the following sections. A summary of the truck VMT estimation methods by the states contacted is presented in Table 3.1 below. In general, two methods are used by these DOTs to estimate truck VMT. In the first method (method 1), truck VMT is estimated on a highway segment basis by multiplying the segment truck AADT by the length of the segment. The second method (method 2), also referred to as the HPMS method, involves multiplying total aggregate traffic VMT (by functional class) by average truck percentages (by truck types).

Of the ten state DOTs contacted, six (California, Illinois, Iowa, Minnesota, Nebraska, and Florida) use method 1 for the estimation of truck VMT. Kansas, Missouri, South Dakota, and Wisconsin DOTs use method 2. A more in-depth explanation of the different methods used by the various states to estimate truck VMT is provided in the following sections.

Table 3.1. Methodologies to estimate truck VMT by state surveyed

State	Methodology	Truck Adjustment Factor
California	Method 1	Yes
Illinois	Method 1	Yes
Iowa	Method 1	No
Kansas	Method 2	No
Minnesota	Method 1	No
Missouri	Method 2	No
Nebraska	Method 1	Yes
South Dakota	Method 2	No
Wisconsin	Method 2	No
Florida	Method 1	No
**Method 1 (highway segment basis): truck AADT by length of a roadway section. **Method 2(HPMS): total VMT by average truck percentages		

3.1 Wisconsin

3.1.1 Data Collection

On the state trunk network, sites are selected to be representative of traffic on a segment bounded by roadways functionally classified as collector or above. Permanent sites were semi-randomly selected to provide a statistically valid sample for each factor group. A total of 27,000 counting sites (permanent and short duration) are located throughout the state of Wisconsin.

Peek 241 and ADR counters are used to collect volume, class, and speed, while Peek ADR and PAT DAW200 are used for Weigh-in-Motion (WIM). The equipment is tested annually to verify their operational integrity. Equipment is bench tested and observed in the field to determine if it is working when installed/inspected.

Wisconsin Department of Transportation (WisDOT) collects both volume counts with loops and axle counts. Axle counts are adjusted using an axle adjustment factor. At the short-term count locations, counting is conducted at 15- to 60-minute intervals for 48 hours every three years. The interval is determined by the population density in the area of the count.

3.1.2 Truck VMT Estimation

WisDOT at this time does not develop separate truck adjustment factors but is moving in that direction. VMT estimates for all vehicles are made. The average percentage of vehicles for each vehicle type by highway functional classification is calculated. VMT for a particular category of heavy trucks for a particular functional class is determined by multiplying VMT for that specific functional class by the percentage of heavy trucks. These are then summed to a statewide total VMT for heavy trucks. Consequently, heavy truck VMT is not disaggregated below the statewide highway functional level (Stein 2003).

3.2 Nebraska

3.2.1 Data Collection

Most of the permanent count sites used by the Nebraska Department of Roads (NDOR) were established years ago. While the exact reasoning behind the selection was not recorded, it is believed that they were selected to give information that was representative of long segments of the natural traffic corridors in the state. In addition, some stations were established to give information on a greater saturation of the most important corridor (I80), while others were established to give information on typical urban routes or county roads. NDOR collects and processes continuous traffic data at 65 locations. Short-duration counts are located to give information that is representative of much shorter sections of road, short enough to be used to update NDOR's computerized traffic log with site-specific information.

"Diamond" brand traffic counters are used for both permanent and short-duration counts. Vehicle classification information is collected at most of the permanent-count stations. At the short-duration stations, volume only is generally collected; although, occasionally, classification information is collected. Nearly all short-duration counts are performed using a pneumatic hose as a detection device. The notable exception to this is the urban interstate and other high-volume urban roads where radar detectors are used.
NDOR has not made an attempt to quantify the level of accuracy it achieves in its counting program. When posting counts, however, a comparison of the final results with historical results is made to give an indication of the reliability of the results of the count.

When factoring short-duration portable counts, a monthly adjustment factor, a day-of-week adjustment factor, and an axle correction factor (if a hose type counter) are used. The adjustment for short-term manual classification counts is based upon the road group category, month, day-of-week, hours-of-count, and the individual vehicle type.

3.2.2 Truck VMT Estimation

Truck VMT is calculated on a biennial basis by NDOR during the years when traffic counts are performed on its state highway system. Expansion factors are developed separately for trucks from the data collected at ATR locations where detailed vehicle classification information is collected. On the highway system, truck VMT is calculated by a simple accrual of what is on the Nebraska DOT's traffic log files. Off the highway system, sample manual counting data is used to estimate truck VMT. NDOR has documentation of its Traffic Monitoring Program that specifies much more detailed information, instructions, and techniques, available for in-house use only (Ernstmeyer 2003).

3.3 Missouri

The Missouri DOT currently does not develop separate expansion factors for trucks. Instead, it determines the average percentage of trucks for each of the ten functional classes, using approximately 60 continuous Automatic Vehicle Classifiers (AVC) statewide. Truck VMT is then estimated by applying this percentage to the total VMT for each functional class of roadway. However, the Missouri DOT is in the process of refining their process and has approximately 550 AVCs to update all Traffic Monitoring Sites (TMS) segments with a similar process as is currently used to update uncounted AADT segments. This process will provide a method for calculating actual Truck VMTs (Grither 2003).

3.4 Illinois

3.4.1 Data Collection

Illinois DOT's (IDOT) permanent count sites were selected in the early 80's using functional class and average daily traffic (ADT) volumes to gain a good representation of roads within Illinois. Additional sites were added in the late 90's using the same criteria along with a geographical distribution. The short-term counts that are done each year are at locations between significant traffic generators. Counts are done in cycles with the marked routes every two years. The rest of the county counts on a five-year cycle. IDOT maintains 88 permanent sites throughout the state of Illinois. 20,000 short-term counts are taken each year. During a five-year period, approximately 85,000 different locations are counted.

The permanent sites use single loops or dual loops with a piezo classifier. A variety of recorders (Peek 241, Peek ADR3000, and ITC TRS recorders) are used. For short-term counts on marked routes, the NuMetric Hi-Star magnetic lane counter is used. This counter is used because it gives volume, vehicle length, and speed (vehicles are counted, not axles). For lower class roads in the counties, road tubes with Mitron counters (axle counts are collected) are used.

When searching for new equipment and new traffic technologies, in-house testing is performed. IDOT will look at manual counts vs. the new equipment, compare different types of equipment, and conduct studies to determine consistency and reliability of the equipment. To evaluate the accuracy of counting devices at the permanent locations, IDOT has someone on staff who downloads the data daily and reviews the data for consistency, looking for loops not reporting or not providing reasonable data. Using this long-term experience with the permanent locations gives a good indication of the reliability of the permanent equipment.

Most short-term counts are 24-hour counts (counted on a Monday, Tuesday, Wednesday, or Thursday). HPMS counts required for FHWA are 48-hour counts.

3.4.2 Truck VMT Estimation

The data (over a four-year period) from the permanent locations is used to derive monthly factors. These monthly factors convert 24-hour short-term counts into annual average daily traffic (AADT). Along with the factoring, the AADT numbers are rounded to the nearest 100, 50, or 25, depending on the volume range. IDOT uses separate adjustment factors for trucks in the estimation of annual average daily truck traffic. The truck factors currently used were developed from an extensive manual count program maintained by IDOT in the past. This extensive manual count program was, however, eliminated many years ago. IDOT is in the process of updating its truck factors based on the permanent locations. Truck expansion factors from the manual count program are used to convert 24-hour short-term truck counts into the truck annual average daily traffic. After factoring, truck AADT is rounded to the nearest 100, 50, 25, or 10, depending on the volume range. The truck ADT for a segment of road is multiplied by the length of that

segment to calculate the truck VMT for the individual segment. The total truck VMT is obtained by adding all segments together. For roads where truck counts are not required (lower functional class roads), default values for the trucks are used in the truck VMT calculation.

IDOT has made significant changes in its Traffic Monitoring program during the last few years. It has changed equipment to the NuMetric Hi-Stars for its Marked Routes. Also, the cycles of counts have been revised to better distribute the work between the years. IDOT has an Illinois Traffic Monitoring Guide (ITMG); however, it represents the old way in which IDOT executed the program. It is envisaged that a completely revised version of the ITMG would be available soon (Robinson 2003).

3.5 Minnesota

3.5.1 Data Collection

For AADT segments on Minnesota trunk highways, every traffic segment is counted every two years. A traffic segment is defined by a section of road where traffic is expected to vary longitudinally (up and down the segment) within specified limits. The limits are defined by a curvilinear relationship between permitted percentage difference and the AADT of the segment. Higher AADT segments have a smaller percentage deviation allowance than lower AADT segments. When traffic changes along a segment, special counts can be made to confirm the change of traffic segment definition before a formal change to the segment is made. Changes to segments include simple lengthening and shortening, as well as adding new segments and deleting segments based upon actual traffic measurements and the sliding scale described above.

The sliding scale represents a minimum coverage strategy for Minnesota DOT (MnDOT) traffic monitoring program. Additional locations are sampled routinely, even if they are within the allowable limits, to increase sensitivity to traffic volume differences between segments in some areas and along certain roadways. The same segmenting procedure is used for county and municipal highways when determining AADT. Local highways are counted on a two or four-year cycle, depending upon how many changes the local jurisdictions believe will happen in the near future. Quickly growing jurisdictions typically desire a two-year count cycle, while relatively slow growing jurisdictions are content with a four-year cycle.

Short-duration vehicle classification count studies are usually conducted on segments between the intersection of one trunk highway and the intersection of another trunk highway. Some trunk highway to trunk highway segments have more than one vehicle classification count site since the shorter segments were found to be serving different commercial traffic.

Permanent sites were initially selected decades ago to represent traffic in many different areas of the state and on different highways where a variety of traffic patterns and volumes exist. The initial selection process had more to do with differences in traffic patterns and volumes than with which functional class systems the highways belong to.

MnDOT reduced the number of ATRs from 144 to 78 in an effort to remove relatively redundant sites. The active ATRs were retained because of their importance to the department in the following areas:

- Location of the monitors provides the traffic pattern data that, when clustered statistically, provide the basis for determining adjustment factors (day of the week and month of the year). These factors are used to expand short counts (48-hour ADT counts) to annual average daily traffic.
- Values from a number of stations closely follow the measured statewide VMT growth rate during the past ten years. The data from these ATRs are used to constrain the annual statewide VMT every year as counted and uncounted road system AADTs are determined through counts and through annual growth factoring.
- Traffic volumes and traffic patterns (Design Hour Volume among other things) on interstate highways in the Minneapolis/Saint Paul metropolitan area are necessary for a number of applications.
- Traffic volumes and traffic patterns (Design Hour Volume among other things) on interstate highways in the rest of the state are necessary.
- Traffic volumes and traffic patterns for state identified "interregional corridor" highways were desired.
- Speed monitoring capability is present.
- Continuous vehicle classification using traffic volumes and patterns is becoming a stronger emphasis in MnDOT's traffic monitoring program.

Approximately 32,000 locations are counted for AADT. About 4700 of those 32,000 locations are on the trunk highway system, and many of these counts are taken directionally. MnDOT has 78 ATRs (for continuous volume counting), 14 of which are classification capable. Data from the department's traffic management center loop detectors are used in place of tube counts or intermittently sampled loop sites for the freeway system in the Minneapolis/Saint Paul area. There are approximately 1000 routinely sampled short-duration classification count locations in the state that are sampled on a two- or six-year cycle. Additional classification counts are conducted to satisfy special requests and additional research needs.

ATRs are equipped with either piezo-loop-piezo detectors, dual-loop detectors, or single-loop detectors with PEEK ADR controllers. Short-duration ADT tube counts are taken with equipment from TimeMark and Golden River. Short-duration vehicle classification tube counts are taken with TimeMark equipment by people assisted by a personal computer touch-screen based application. For short-count equipment, the tubes are checked for holes and the counters' switches are checked for accuracy each year. Inevitably, some data are suspect, and recounts are usually taken at the same location to verify an unexpected value or determine whether there was a faulty count taken the first time. Accuracies within 5% for classification and 2% for axle hits and for vehicle detection at the ATRs are normally expected.

At the permanent sites data are checked within one month following the date of collection to determine if there are failing electronics or detectors. It is believed that such failures can be detected when the daily and hourly directional data are compared to historically typical data at the same sites. If a consistent bias seems to be "creeping" into the data, a field test is requested, and the results allow salvaging the data for the time period in question if it is warranted. This type of data screening and editing only happens for ADT data and not for vehicle classification data. A system is currently being developed to screen the continuous classification data.

For short-duration ADT counts, raw data are screened using a system that compares the factored raw counts to previously determined past AADT and to previously adjusted raw counts from the same count cycle and from the past count cycle. Direction distribution is compared where possible and a report is run for machine numbers where the machines have been involved in a high proportion of "suspect data" instances. Those machines are identified and pulled from the active stock during the counting program to be bench tested. For locations with counts that are deemed "suspect" according to a permitted percentage change function, recounts are requested during the same year or count cycle. Short-duration classification counts are compared to previous counts at the same location. Axle correction factors are determined at each of the routine and special count classification sites (approximately 1400 statewide). Segments adjoining and beyond the classification sites also have axle correction factors. The factors, however, are determined using an algorithm based on "change in AADT" vs. "change in vehicle mix" relationship relative to the vehicle classification sample site and the roadway segments associated with the vehicle classification site.

Usually sample 48-hour counts are taken at all of the short count sites where counting equipment is used. Past federally sponsored "best practices" research indicated that 48 hours is better than 24 hours but only marginally worse than 72 or more hours. Also, more tube anchorage failures have been experienced in counts longer than 48 hours. For each manually counted vehicle classification site, two periods of 8 hours at a time are monitored between 8 AM and 10 PM. MnDOT does not count over the weekend and tries to conduct counts between noon on Monday and noon on Friday during weeks that do not include holidays or local festivals or events. In towns and cities, counting is done during the school year.

3.5.2 Truck VMT Estimation

MnDOT currently does not develop separate adjustment factors for trucks but is now investigating how it might in the near future. Since MnDOT has a census-based estimating system for the trunk highway system, Heavy Commercial Annual Daily Traffic (HCADT) by segment is used to estimate Truck VMT on a highway segment basis. The segment Truck VMT is then summed to produce a statewide total for trunk highways. For county, municipal (and other types of roadways) default values are used to estimate truck VMT to complete truck VMT statewide calculations (Flinner 2003).

3.6 California

3.6.1 Data Collection

The following is taken into account when selecting sites for permanent and short-term counts:

- Beginning of Route
- End of Route
- Break in Route
- Significant change in traffic (approximately 10% change)

A breakdown of the count sites (permanent and short-term) located throughout the state of California is given as follows:

- 650 permanent count sites where data is collected 365 days a year
- 1800 quarterly sites which are counted for a one-week period 4 times a year every 3 years
- Over 5000 profile sites which are sites on conventional highways counted between one and seven days every 3rd year
- Over 14,000 Freeway on and off ramps counted between one and seven days every 3rd year

The California Department of Transportation (CalTrans) uses the same equipment for both permanent and short-term counts. The number of lanes and type of detector used will determine how many detectors the counter will have. The equipment must meet the following accuracy standards:

- ***Accuracy of Traffic Volume counts***: The unit must have an accuracy of plus or minus 5% with a 95% confidence level when using pneumatic tubes and plus or minus 3% when using inductive loops.
- ***Accuracy of Vehicle Classification***: Vehicle classifiers must classify to accuracy standards as follows:
  - ***Permanent Classifiers:*** The accuracy of permanent classifiers using inductive loops and piezoelectric axle sensors must be such that, if good lane discipline is maintained, the recorded axle spacing must consistently be within plus or minus four inches of the actual measured spacing.
  - ***Portable Classifiers:*** The accuracy of portable classifiers using dual pneumatic tubes must be such that, if good lane discipline is maintained, the recorded axle spacing must consistently be within plus or minus six inches of the actual measured spacing. Of the 650 continuous and 1800 quarterly count sites, total volume is collected at all of them. At 200 of them, vehicle class is collected. Only total volume is collected at all other count sites. If resources are available, truck counts are collected at a limited number of sites.

3.6.2 Truck VMT Estimation

From continuous and quarterly count sites, daily and seasonal factors are developed to extrapolate one-day counts. CalTrans develops separate adjustment factors for trucks from continuous truck count sites. If resources are available, short-term truck counts are collected at a limited number of sites. The short-term counts are converted to Annual Average Daily Truck Traffic (AADTT) using the truck factors obtained from the continuous truck sites.

3.7 Kansas

3.7.1 Data Collection

Permanent count sites were selected for coverage of the major highways. Portable count sites were selected for coverage of HPMS sections, for spatial coverage between permanent sites, and for special needs studies. Portable classification sites were selected for stratified coverage as specified in the TMG and for special needs studies. Permanent classification/weight sites were chosen for proximity to long-term pavement performance (LTPP) test sections. The permanent count sites maintained by the Kansas DOT (KSDOT) are made up of 103 volume-count sites, 3 vehicle classification sites, and 12 weigh sites. The short-term count sites are made up of over 30,000 volume-count sites, over 1,000 vehicle classification sites, and 73 portable weigh sites.

3.7.2 Truck VMT Estimation

The Kansas DOT at this time does not develop adjustment factors separately for trucks. Average truck percentages are determined from continuous vehicle classification sites for each functional class of roadway. Truck VMT is then estimated by applying this truck percentage to the total VMT for each functional class (Spicer 2003).

3.8 South Dakota

3.8.1 Data Collection

There are 51 ATR locations around the state of South Dakota. The breakdown by functional classification is given as follows:

Classification	Urban	Rural
Interstate	3	9
Principal Arterial	4	17
Minor Arterial	3	6
Collector	4	5

ATRs collect traffic data continuously 24 hours a day, 365 days a year. The data collected are used for the development of seasonal factors to expand the short-term counts to AADT. ATRs also provide peak hour, 30th highest hour, or design hour and are used to track volume trends on the state highway system. The PEEK Inc. ADR traffic counters are used for the collection of data at all the 51 ATR stations.

Short-term traffic volume counts provide the majority of the geographic diversity needed to provide traffic volume information on the state roadway system. There are approximately 6,660 short-term count locations throughout the state. These are located on all functional classifications of highways—from the interstate system to the local roads system. Short-term interstate counts are taken 2 times a year for 48 hours each time. All other short-term counts are taken once a year for 24hours. A sampling plan is developed each year for short-term counting and is based on the following monitoring cycle:

- All trunk locations—every other year
- Non-state trunk locations with ADT<75—every eight years
- Non-state trunk locations with ADT>75—every four years
- Urbanized areas—every four years
- Small cities and towns—every six years
- HPMS sample segments (non-interstate)—every year
- HPMS sample segments (interstate)—every three years
- Special site-specific counts as requested
- Sites are chosen each year for specific data needs for future construction projects and for requirements of HPMS

3.8.2 Truck VMT Estimation

Short-term volume count results are posted in the station description file spreadsheet, where the appropriate seasonal and axle correction factors are applied to calculate the AADT for that location. Comparison of the AADT with the historical count record at that location is made, and any count that does not compare reasonably to the historical pattern is flagged and marked to be reset and counted again during the current count season. Counts that pass this check are used in the year-end reporting process.

At the end of the year, all counts in the station description file are entered into the roadway environment subsystem (RES) spreadsheet at their proper locations along a highway based on mileage reference marker (MRM). The counts are averaged with the previous year's counts and the result is reviewed to ensure realistic flow in comparison with surrounding sites. All counts passing this check are then entered into the RES traffic file located on the mainframe computer. The program calculates growth factors and applies them to locations where counts were not taken for the current year. Current year traffic is calculated from the previous year's traffic on these sections using the calculated growth factors. Twenty-year projected traffic counts are also calculated for each section of highway. A final count edit check program is run comparing the new count information with the previous years. A percentage of increase or decrease from the previous years is calculated. Any percentage outside the range set for the volume group the count falls in is flagged and manually analyzed. The South Dakota DOT uses only the HPMS method for Truck VMT estimation. Expansion factors are not developed separately for trucks.

3.9 Florida

3.9.1 Data Collection

The Florida Department of Transportation (FDOT) maintains more than 300 Telemetered Traffic Monitoring Sites (TTMSs) across the state of Florida. All these sites count traffic volumes, 49 of them record speed as well, 194 record vehicle classification, as well as volume and speed, and 37 measure vehicle weights in motion. Data are collected continuously at the TTMSs and are downloaded over phone lines each night. The seasonal variations in data at the TTMSs are used to apply seasonal corrections to the spot counts at the Portable Traffic Monitoring Sites (PTMSs) to make them representative of year-round averages.

There are over 6,100 PTMSs across the state of Florida. Data are collected over a 24- or 48-hour period each year. Vehicle classification data are collected at nearly 2,000 sites, and weigh-in-motion data are collected by portable equipment at 24 sites for FDOT's Strategic Highway Research Program.

3.9.2 Truck VMT Estimation

Truck VMT is calculated by multiplying segment AADT by percentage of trucks and segment length and then summing all the segments on the highway system. Counts are taken each year on all of the state highways for which FDOT is responsible to obtain the AADT of each segment of its highway network. Florida state highway system consists of about 1,100 sections, each of which can be broken into smaller segments. Traffic data is collected on about 7,000 of those smaller segments. Of those segments, all are counted, and about 2,500 are classified. FDOT's procedures call for a minimum of one class survey on each of the 1,100 sections of road. For the segments not classified, percentage of trucks is assigned based upon the axle factor categories assigned to all stations. The great majority of FDOT's count stations have highway-specific axle factor categories assigned to them. For the segments of road without either actual class stations or axle factor categories, percentage of trucks is assigned by either region or statewide functional class defaults.

4. IOWA DOT METHODOLOGY

The Iowa Department of Transportation uses the traffic-count-based method to estimate VMT. To achieve the desired precision required for national reporting requirements for AADT estimates, the Iowa DOT bases their methodology on the procedures outlined in the Federal Highway Administration's (FHWA) Traffic Monitoring Guide (TMG) for its Traffic Monitoring Program.

In compliance with TMG procedures, Iowa DOT's Traffic Monitoring Program consists of a short-term count program and a permanent continuous count program. The short-term counts are usually conducted for a 24- or 48-hour period to ensure that adequate geographic coverage exists for all roads under the jurisdiction of Iowa DOT. The permanent continuous counts conducted continuously throughout the year facilitate the computation of seasonal adjustment factors utilized in the conversion of the short-term counts to AADT.

4.1 Permanent Continuous Count Program

A total of 139 permanent continuous count stations are located throughout the state of Iowa. Data collected at the permanent count sites include volume, classification (3-class and 13-class), speed, and axle weight. A breakdown of the type of data collected at these stations is presented in Table 4.1. A number of sites have been in place since 1950, when the Iowa DOT began its Traffic Monitoring Program. Additional new sites are selected on the basis of regionality, population, and functional class.

Table 4.1. Data collected at permanent stations

Data Type	Number of the Count Stations Capable of the Indicated Function
Volume	139
Speed	93
3-Class	67
13-Class	38
Automatic Traffic Recorder	128
Weigh in Motion	22
LTPP/SHRP	15

*ATR-Automatic Traffic Recorder, WIM-Weigh-in-Motion, LTPP-Long Term Pavement Performance, SHRP-Strategic Highway Research Program.

The Iowa DOT uses PEEK ADR 2000 and the Trafficomp (TC) 3 control units, which are attached to piezo-electric sensors (Brass Linguini (BL) Axle Sensors) or induction loops, which are permanently embedded in the road surface for continuous data collection. The use of piezo-electric sensors enables the collection of the same information as that obtained using a portable counter unit but with a slightly higher level of accuracy and precision. The use of induction loops facilitates vehicle classification by overall length instead of axle spacing but results in less precision. On the other hand, the accuracy of volume data obtained using induction loops is increased since the true presence of vehicles is detected.

4.2 Short-Term Count Program

For the purpose of short-duration counts, the state was divided into four quarters, as shown in Figure 4.1. One quarter of the state is counted each year; thus, the entire state is covered in a four-year cycle. During the four-year cycle, the complete road network in some counties within a quadrant is covered, whereas only major routes are covered in the remaining counties. Counties scheduled for complete counting in the current schedule are shown hatched in Figure 4.1. The reverse is true in the alternate cycle. This ensures that the entire road network within a quadrant is covered in an eight-year cycle and enables Iowa DOT to concentrate its effort in providing more detailed information while utilizing its resources efficiently.

Mechanical and manual counts are conducted at the short-term count sites to collect volume and classification data. Approximately 11,000 to 12,000 mechanical counts and 800 to 1,000 manual counts are performed in each counting year. The ADR or TraffiComp3 portable automatic counters connected to pneumatic road tubes are used for mechanical counts and the Titan count board (a portable microprocessor) is used for manual counts. Mechanical counts are usually conducted for a 24- or 48-hour period, whereas manual counts are usually done in two time periods of four hours each or three consecutive eight-hour blocks. Counts are conducted in at least 48-hour periods on interstates and primary roads and 24-hour periods on non-primary roads.

Volume data are obtained either by manual counts or by factoring axle strikes from mechanical counts using axle correction factors (obtained from continuous counts and based on the type of road system).

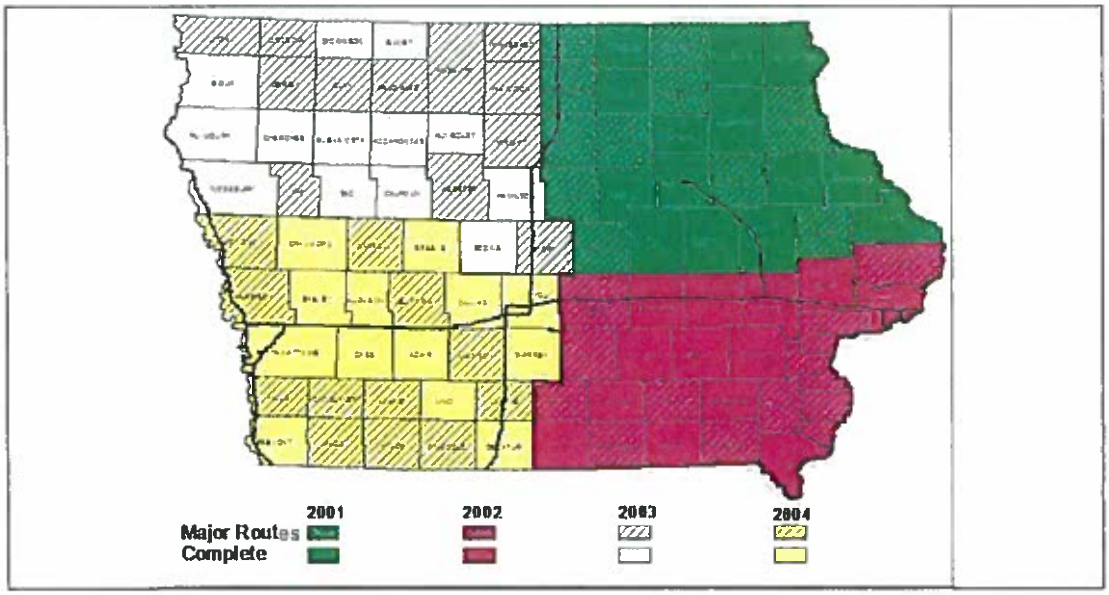

Figure 4.1. Iowa Traffic Count Program (2001-2004). Source: IDOT Traffic Monitoring Manual

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4.3 Factoring Process

The conversion of raw data from short-term counts to estimates of AADT requires the application of adjustment factors to account for temporal biases, as well as the type of traffic counting equipment used. The specific set of adjustment factors required is therefore a function of the equipment type and the duration of the count (FHWA 2001). For example, a 24-hour short-term count at a particular location in which axle strikes are collected will require the application of an axle-correction factor, day-of-week, and seasonal factors. In this case, the equation for the estimation of AADT will be the following:

$$AADT = VOL_{24} \times M \times D \times A \qquad (4\text{-}1)$$

where

AADT=the annual average daily traffic
VOL=the 24-hour axle volume
M=the applicable seasonal (monthly) factor
D=the applicable day-of-week factor
A=the applicable axle-correction factor

4.4 Axle-Correction Factors

Iowa DOT usually collects axle strikes on rural secondary roads and city streets using short-duration portable recorders with one pneumatic hose. Since most vehicles have two axles, axle strikes are divided by two to provide a total volume, assuming all vehicles are cars. The portable counters do this automatically. The volume obtained after dividing the total axle strikes by two is then multiplied by axle correction factors computed for the various road systems using thirteen-class manual count information.

4.5 Seasonal and Day-of-Week Factors

Two different methods are used to create adjustment factors, as described in the following paragraphs.

Specific road approach. With this approach, road specific adjustment factors are developed using data collected from continuous counts. Short-term classification count for a specific road is adjusted using factors from the nearest continuous classification counter on that road. This method, in addition to simplifying the computation and application of adjustment factors, also has an advantage of reducing errors associated with using average adjustment factors to estimate AADT. It is, however, more costly since state DOTs have to maintain a large number of continuous counters (Benekohal and Girianna 2002).

Group factor approach. With this approach, roadway sections with similar travel patterns and roadway functional classification are grouped together. Continuous classification count locations are selected from each grouping of roadway sections and

adjustment factors are developed for data collection sites within each group. Adjustment factors for each group are averaged and used to adjust short-term data that are collected at locations within the group.

lowa DOT utilizes the group factor approach for the development of combined seasonal and day-of-week adjustment factors. Six different factor groups clustered according to road system type and regionality are developed. Roadway types include rural interstate, rural primary, rural secondary, municipal interstate, municipal primary, and city streets. Factor analysis was used to determine if breakdown by road system type and regionality was appropriate. Factors are generated based on the volume data obtained from the permanent continuous count sites. AADT at the permanent count sites is a simple average of volume data for all days. Since traffic is monitored continuously throughout the year at these sites, adding all volumes collected by an ATR for an entire year and dividing by the number of days in a year produces an AADT:

$$AADT = \frac{\sum_{i=1}^{365} VOL_{24}}{365} \qquad (4\text{-}2)$$

The ratio of the AADT to the average total traffic of each day of week for a specific month of the same individual ATR produces factors for each day of the week, by month, for each road system type. An average of the factors for all ATRs within a factor group is determined. In the computation of the factors, data for the last three years at each ATR location are utilized. The days when holiday traffic may skew the results are excluded.

Raw data from the 24- or 48-hour mechanical and manual short-duration counts are multiplied by the adjustment factors based on the day-of-week, month, and road type to obtain the estimated AADT.

4.6 Missing Data

Some ATRs may suffer periods of down time due to problems with the equipment, communication, and power failures. This may result in hours or days of missing data that consequently introduces biases in the factor computation, particularly when blocks of data are lost (FHWA 2001). To account for missing data, the lowa DOT employs historical methods. This involves analyzing data from previous years for the same period in which data are missing in the current year and making projections to fill in the missing data. For instance, if data collected at an ATR station on a Monday in October 2002 are missing data from 1 pm to 3 pm, data for the same period in previous years, such as 1999, 2000, and 2001, are used to extrapolate the missing hours. In a case where an ATR station is missing data over a long period of time, the entire data from that station are excluded from the factor computation. This is sometimes the case when there is an ongoing construction activity along the section of road on which the ATR station is located.

4.7 Estimation of Heavy-Truck AADT

The Iowa DOT specifically conducts short-term truck counts from which truck AADT is obtained. On the primary roads system, truck volumes are obtained primarily from manual turning movement counts and a few portable automatic traffic classifiers. For the secondary road system, truck volumes are obtained from portable automatic traffic classifiers installed at eight locations per county—four on gravel roads and four on paved roads. The Iowa DOT is, however, in the process of revising its traffic count program to ensure an extensive coverage of the secondary road system by installing more traffic counters capable of collecting both volume and vehicle classification data. In the case of city streets where traffic volumes are usually high with relatively small gaps between vehicles, the use of ATRs has been found to produce inaccurate vehicle classification results. Truck volumes on city streets are therefore obtained from eight-hour manual turning movement counts only. These manual counts yield total volume for all vehicles and classification for three vehicle classes: passenger vehicles, single-unit trucks and combination trucks. To expand truck volumes obtained to truck annual average daily traffic, seasonal day-of-week adjustment factors for trucks are developed based on the permanent continuous count locations.

4.8 VMT Estimation

VMT is generally obtained by multiplying the roadway segment AADT (obtained as described above) by the length of that segment. In particular, truck VMT is estimated on roadway segment basis by multiplying the roadway segment truck AADT by the length of that segment. The total truck VMT by road system type is obtained by summing the truck VMT for individual segments belonging to that road system. Multiplying by the number of days in a year annualizes this value. Typically, VMT for municipal roads are adjusted based on the percentage increase or decrease in AADT obtained from the ATR stations (Meraz and Bunting 2003).

5. METHODOLOGY

The purpose of this research was to evaluate and compare several different methods to calculate heavy-truck AADT and, subsequently, VMT. Traffic data from continuous count stations provided by the Iowa DOT were used to estimate AADT for two different truck groups (single-unit and multi-unit) using three different methods. The first method developed monthly and daily expansion factors for each truck group. Truck AADT was calculated by applying truck expansion factors to short-term counts. The second and third methods created general expansion factors for all vehicles. Truck AADT was calculated by multiplying short-term counts by generic expansion factors and truck percentages. Truck percentages for the second method were based on the annual percentage of trucks for each group from continuous count stations. The third method used daily truck percentages from the short-term counts.

Accuracy of the three methods was compared using n-fold cross-validation. In n-fold cross-validation, data are split into *n* partitions and data from the *nth* partition are used to validate the remaining data. Accordingly, data from continuous count stations were divided into four groups, and each group was reserved for one partition as the validation dataset. Short-term counts were extracted from the validation dataset, and then AADT was estimated using each of the three methods. Actual AADT by truck group for each count station was compared to the estimated AADT by truck group for each method. A description of the data and methodology is provided in the following sections.

5.1 ATR Data

Automatic Traffic Recorder (ATR) data for rural primary roadways and rural interstates were obtained from the Office of Transportation Data of the Iowa DOT for the 2001 counting year (January 2001 to December 2001). The study started in 2003, and the 2002 ATR dataset was preferred. However, the DOT indicated that numerous errors were present in the 2002 data and suggested use of the 2001 data instead. Additionally, they felt that the rural interstate and primary road data were the most reliable. Consequently, analysis was made for these two road types.

The rural primary network is made up of all federal and state highways, excluding interstates, outside the limits of any incorporated city or town. Rural interstate network encompasses all interstates outside the limits of any incorporated city or town. Traffic data are collected year round at all ATR sites. Only ATR sites that collect vehicle classification data were considered for the study. At some of the sites, data were collected for 3 classes: passenger vehicle, single-unit (SU) truck, and multi-unit (MU) truck. At other sites, data were collected for all 13 classes of the FHWA vehicle classification scheme.

Some of these sites had a considerable amount of missing data as result of equipment malfunction, communication, and power failures. Data from such sites was discarded. A total of 36 ATR sites remained for the rural primary analysis after eliminating ATR sites which were missing substantial amounts of data. The locations of the 36 ATR sites on the

rural primary network are shown in Figure 5.1. A total of 14 rural interstate ATR stations remained for the rural interstate analysis.

5.2 Vehicle Classification Scheme

Ideally, each of the FWHA truck categories would be evaluated separately, and expansion factors would be created for each class. However, many of the FHWA truck classes contain low traffic volumes. Expansion factors based on low volumes can be unreliable since, with low traffic volumes, small changes result in high percentage of changes. In order to develop reliable seasonal and day-of-week truck adjustment factors, an aggregation of the 13 classes of the FHWA classification scheme into three or four vehicle categories is recommended by the traffic monitoring guide (FHWA 2001). Additionally, a number of ATR stations only recorded 3 classes of vehicles. Consequently data were aggregated into 3 vehicle classes. Stations that reported 13 classes were aggregated into the 3 vehicle classes reported by the remaining stations. The 3 vehicle categories consist of passenger vehicle, single-unit truck, and multi-unit truck. Aggregation of the 13 FHWA vehicle classes is shown Table 5.1.

Table 5.1. FHWA vehicle classes in each vehicle category

Vehicle Category	FHWA Class
Passenger Vehicle (PV)	Classes 1 to 3
Single Unit Truck (SU)	Classes 4 to 7
Multi-Unit Truck (MU)	Classes 8 to 13

Truck VMT is estimated by multiplying AADT by section length once AADT has been estimated. Consequently, AADT, not VMT, was the variable used to evaluate the different methods.

5.3 Creation of Expansion Factors

The Iowa DOT uses the group factor approach to develop expansion factors. The factor groups are made up of all the ATR stations in that functional class, as described in Section 4.5. The group factor approach was used to estimate expansion factors for this research as well. AADT was first determined for each station, and then expansion factors were created for each station.

5.3.1 AADT

ATR data were available in the form of a single 24-hour count for each day for each station. A sample is provided in Appendix C. Each file contains counts by hour of the day, and data are presented by vehicle class. Some stations report 3 vehicle classes, and other stations report all 13. Data were aggregated into 3 vehicle classes, as discussed in Section 5.2. All daily data had to be summarized for each station in order to calculate AADT and expansion factors, requiring a significant amount of effort.

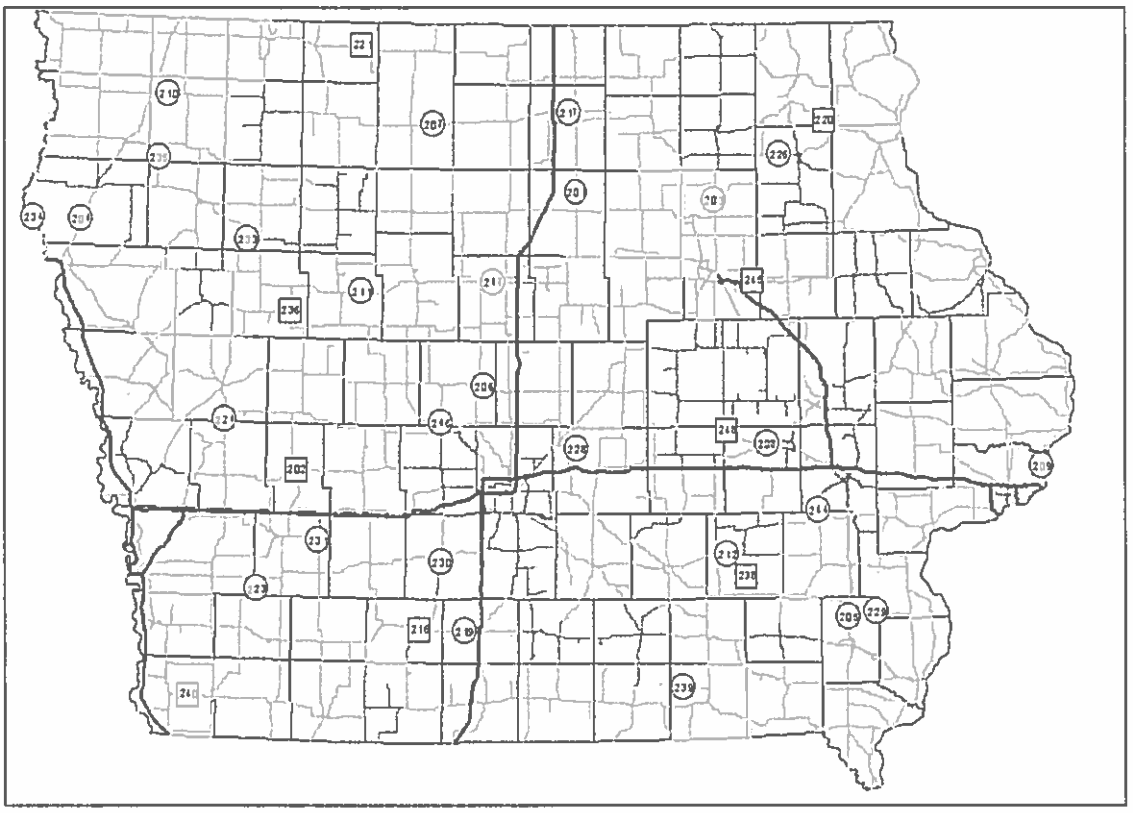

Figure 5.1. Location of rural primary ATR stations

AADT by vehicle category and for total traffic for each ATR station was computed using the American Association of State Highway and Transportation Officials (AASHTO) method—a three-step averaging process. This method was used instead of the simple average of days approach because it has the advantage of effectively removing most biases that result from missing days of data. This advantage is especially important when those missing days are unequally distributed across months or days of the week by weighting each day of the week and each month the same regardless of how many days are actually present within that category (FWHA 2001).

In the first step of this process, 7 averages corresponding to the 7 days of the week were obtained for each month of the year for each vehicle category and total traffic. These 84 (12 months by 7 days) monthly average days of the week traffic (MADWT) volumes are then averaged across all 12 months to yield 7 annual average days of the week (AADW). The 7 AADW values are averaged to produce AADT.

The AASHTO approach for computing AADT can be expressed as follows:

$$AADT_c = \frac{1}{7}\sum_{i=1}^{7}\left[\frac{1}{12}\sum_{j=1}^{12}\left(\frac{1}{n}\sum_{k=1}^{n} VOL_{ijk}\right)\right] \qquad (5\text{-}1)$$

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where

$AADT_c$ = Annual average daily traffic for vehicle category c
VOL = Daily traffic for day k, of day-of-week i, and month j
I = Day of the week
j = Month of the year
k = 1 when the day is the first occurrence of that day of the week in a month and 4 when it is the fourth day of the week
n = The number of days of that day of the week during that month (usually between 1 and 5, depending on the number of missing data)

5.3.2 Expansion Factors

For each ATR station, different expansion factors for each day of the week of a specific month were developed. The combined seasonal and day-of-week expansion factor is given by the ratio of the annual average daily traffic (AADT) to the monthly average day of the week traffic (MADWT), as shown in Equation 5-2:

$$f_{atrgi} = \frac{AADT_c}{MAWDT_c} \qquad (5\text{-}2)$$

where

f_{atrgi} = Combined seasonal and day-of-week factor for vehicle category c for station i
$ADDT_c$ = Annual average daily traffic for vehicle category c for station i
$MAWDT_c$ = Monthly average day-of-week traffic for vehicle category c for station i

Table 5.2 illustrates data used to calculate AADT for rural interstate Station 119. The dataset includes all vehicles. The daily average was calculated by summing AADT for a specific day of the week over the 12 months and then dividing by 12. Final AADT was calculated by summing the daily average over the 7 days and dividing by 7.

Table 5.2. Volumes by day-of-week AADT for Station 119

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Daily Avg
Mon	19336	21138	22389	24164	25994	27160	28123	28656	26476	24869	23713	19957	24331
Tue	21365	21131	22946	24126	25562	26473	27768	27851	25296	24278	24705	21274	24398
Wed	21927	21155	23950	24975	26292	27948	26620	29120	26255	25223	28055	24798	25527
Thu	22510	21875	24350	26798	27717	29582	30080	30388	28207	26735	24412	25453	26509
Fri	23588	22797	27354	30026	32258	33640	34560	35574	32339	31079	27407	28241	29905
Sat	19681	18727	22464	22780	25609	28266	29026	30396	26539	24706	24637	23581	24701
Sun	17373	18495	22394	23804	24567	27973	30120	30423	26317	26690	26765	19931	24571
AADT													25706

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