TAC Meeting – December 2, 2008
Announcements from the Chair

Welcome to the next to last meeting of the Los Osos Wastewater Project Technical Advisory Committee.

In the process of developing the draft Environmental Impact Report (dEIR), Michael Brandman Associates and their professional engineering staff delved deeply into the effects the various alternative components would have on our environment and, as a result, only those deemed to have the least effect were carried forward.

I would like to emphasize that these were not capricious decisions. They are based on a rigorous analysis of the data available and the cumulative impact that each alternative would have on the environment.

Tonight's meeting focuses around how the dEIR handled the issues pertaining to the collection system that were raised in the TAC's Pro/Con Analysis published in July of 2007,prior to the successful proabition zone 218 election.

It is no secret to those residents of Los Osos who have been closely following the project that the collection system (STEP or gravity) has become a topic of heated debate among some members of this community. Within the body of the dEIR, the environmental impacts of both of these alternatives have been evaluated in great depth. Although the two systems are considered to be co-equal there are vast differences in their effects on the environment. It is hoped that between the information presented in the document and our discussion this evening the general community will become better informed on this topic.

This will be an open TAC meeting so there will be no committee reports. Each TAC member may ask questions or make comments as they choose. Formal comments on the dEIR MUST be submitted in writing.

I would also like to remind everyone that environmental impact is NOT related to cost. That is a separate though extremely important aspect of the project that can only be truly measured when the bids from qualified contractors are received.

Shortly, everyone in the community will be receiving a brochure showing the four projects from the dEIR and a short description of each. For those of you who are computer savvy you may also go to the website ***lowwp-eir.net*** where you can find the complete dEIR and an interactive map to guide you through it. In addition the County will be holding meetings to answer questions and, if you know or are a neighbor of any of the TAC members, I'm sure they will also try to assist you.

Since our meeting this evening consists only of a discussion by the TAC of the Collection system we will have just a single public comment period at the end. Those of you who might wish to comment during that time should restrict your comments to either that topic or if you wish any other topic that is within the purview of the TAC. In order for us to get through our agenda and adjourn by 9:30, I ask you to stay on topic.

The next and last meeting of the TAC is scheduled for next Tuesday, December 9th, and the topic of discussion will be Effluent reuse.

Los Osos Wastewater Project

Technical Advisory Committee

December 2, 2008

Meeting Topics

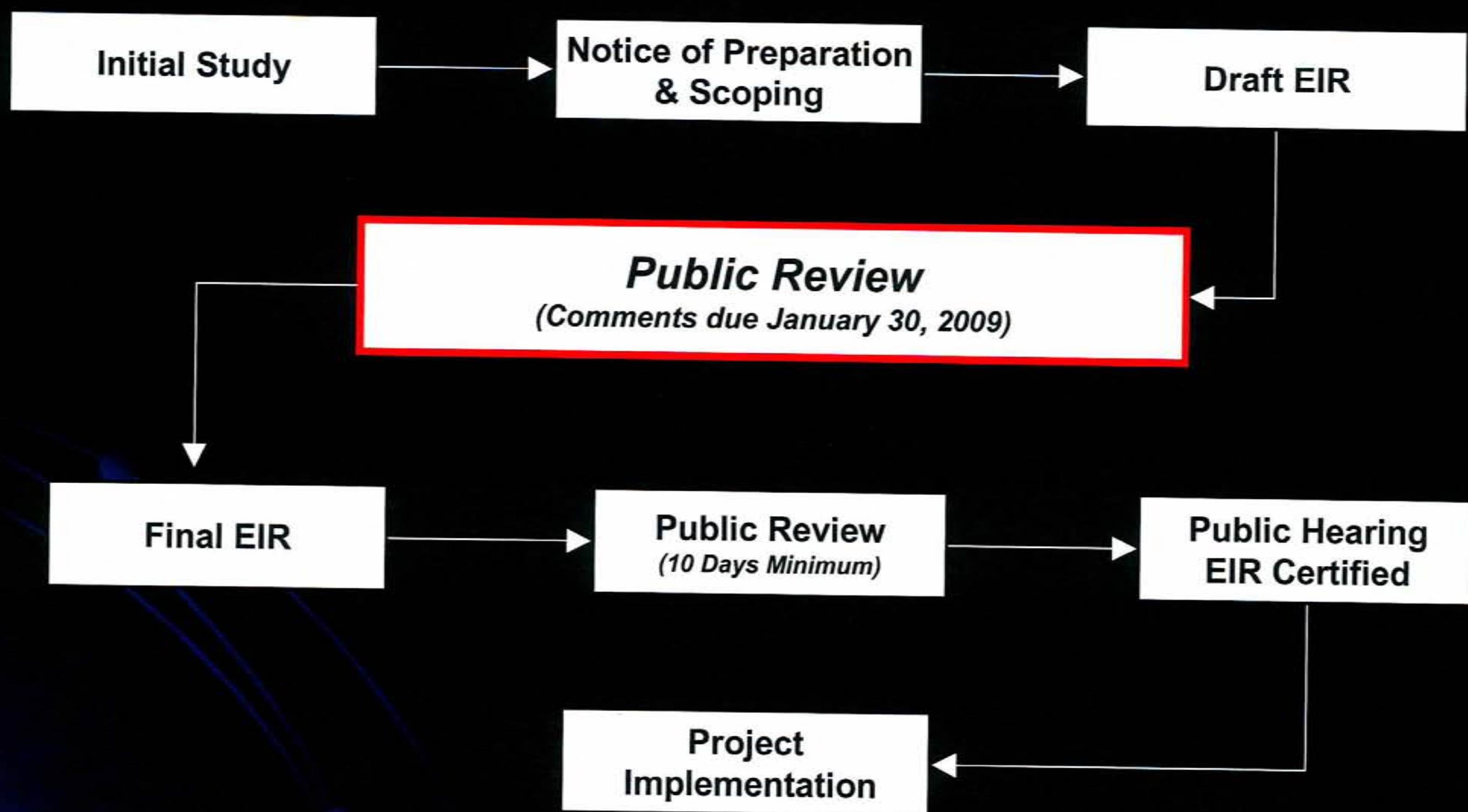
- Project Status Update
- Collection Systems
  - DEIR comparison to TAC Pro/Con Analysis

Project Major Milestones

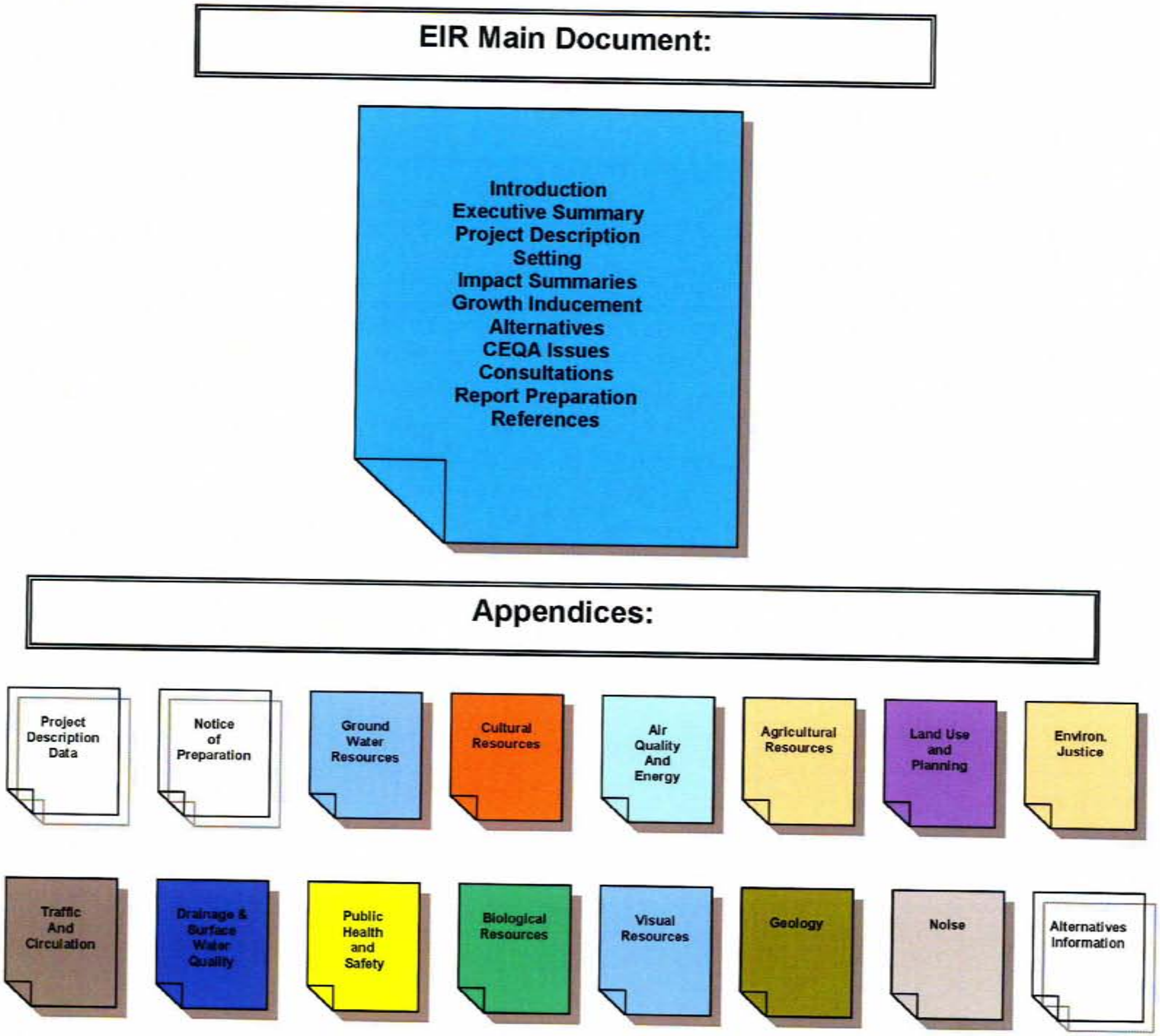
- ☑ Board Policies June 6, 2006
- ☑ AB2701, September 20, 2006
- ☑ Rough Screening Report
- ☑ Fine Screening Report
- ☑ TAC Pro/con Analysis
- ☑ Technical Memos

- ☑ Prop 218 vote
- ☑ EIR Scoping
- ☑ Draft EIR
- Design/Build Process
- Coastal Permit
- Design/Build Contract
- Construct Project

Environmental Impact Report Process



EIR Architecture



Level "A" Projects

	Treatment Site	Collection	Treatment System	Wet Weather Storage
1	Cemetery Giacomazzi Branin	Step	Ponds	Cemetery Giacomazzi Branin
2	Giacomazzi	Gravity	Ox Ditch or Biolac	Tonini
3	Giacomazzi Branin	Gravity	Ox Ditch or Biolac	Giacomazzi
4	Tonini	Gravity	Ponds	Tonini

EIR Review Copies:

- WWW.LOWWP-EIR.net
- CD**
- Libraries in Los Osos & San Luis Obispo
- Public Works offices in SLO
- Paper loan copies at the Public Works offices in SLO

** Those wishing their own paper copy should take a CD to their nearest copy center.

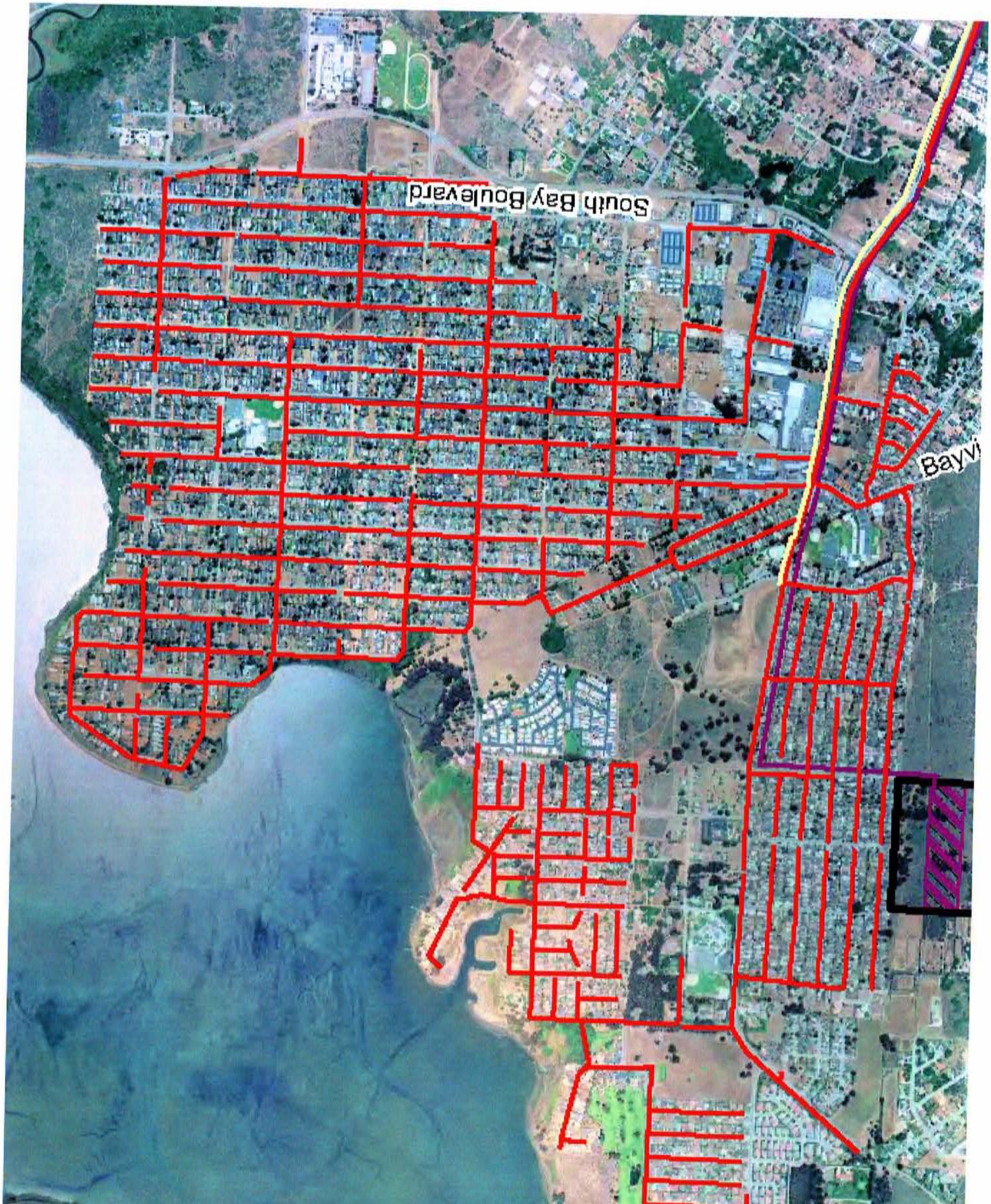
EIR Next Steps:

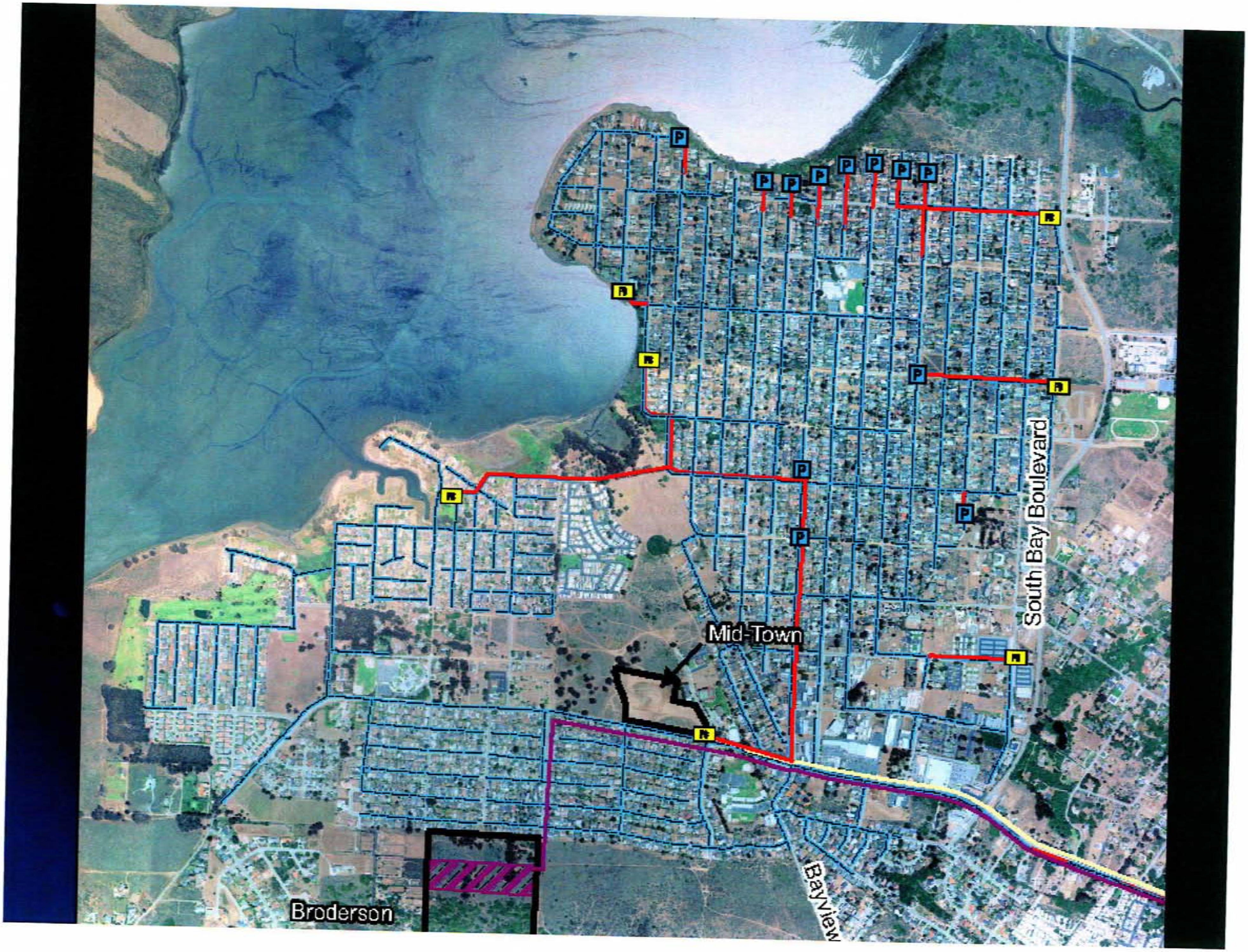
- Comments due by January 30, 2009
- Revisions to respond to comments and design/build proposals
- Final EIR coincides with design/build process
- EIR certification @ Planning Commission Spring/Summer 2009

EIR Comments

Comments must be in writing to:

Mark Hutchinson
Environmental Programs Manager
San Luis Obispo County Department of Public Works
County Government Center Room 207
San Luis Obispo CA 93408


South Bay Boulevard
Bayvi



South Bay Boulevard
Mid-Town
Bayview
Broderson

Pro/Con vs DEIR

Gravity

PROS

- Lower O&M
- Less on-lot disturbance
- No easement on private property
- No septage hauling in collection area

CONS

- Higher capital costs
- Longer construction time
- Higher treatment costs
- Higher solids costs
- Increased risk of I/I
- Deeper trenching (dewatering; traffic; etc.)
- Higher risk of archaeological impacts
- 20 pump stations (footprint & odor control)
- Greater road impacts with longer closures
- Gravity collection pipes require cleaning every 2 years

Pro/Con vs DEIR
STEP/STEG

PROS

- Lower capital costs
- Shorter time to construct
- Reduced solids treatment
- Shallow trenching/drilling = less archaeological impacts
- No lift stations
- Minimal risk of I/I

CONS

- Higher O&M costs
- Additional nitrification/denitrification
- Additional electrical for SRF
- Higher private property impacts
- Higher risk of archeological impacts
- Regular pumping of septic tanks
- Odor from vents
- Higher on-lot capital costs
- Active on-lot components

Summary of Collection Systems

The advantages of Gravity are that it has lower annual O&M costs and it has less impact on individual properties. The greatest concerns of Gravity are that it has higher capital costs and has greater impacts of construction, i.e. trenching up to 23 feet, dewatering, and longer street closures. There is also a greater potential for infiltration of groundwater and inflow of storm water (I/I). Gravity collection will have permanent impacts due to lift stations and manhole maintenance. Also, Gravity collection results in significantly higher bio-solids handling at the treatment facility.

The advantages of STEP/ STEG are that it has lower capital costs; it provides primary treatment in the septic tank, thereby reducing the costs associated with solids; has less road impacts due to smaller pipe and shallow trenching or directional drilling; and may reduce the risk of archeological impacts and resultant delays. The greatest concerns are with higher annual O&M costs, and impacts on individual properties, both during construction and ongoing, including pumping of septic tanks with attendant odor and traffic.

COLLECTION	PROS	CONS
Gravity	• Lower annual O&M costs for collection • Less on-lot disturbance. • No easement or access required on private property • No requirement to haul septage within the collection area	• Higher capital costs • Longer time to construct • Impact on treatment costs (higher capital costs, and annual O&M) • Increases cost of solids treatment and disposal • Increased risk of I/I over time; may require additional cost of monitoring/ repair program • Requires deeper trenching and dewatering, resulting in need to protect water quality from disposal of collected water, significant soil erosion, traffic nuisance • Higher risk of impacts on archeological resources may result in delays, additional cost • 20 Pump stations have permanent impact, requiring additional footprint and odor control • Greater road impacts resulting in longer closures and traffic nuisance • Gravity collection pipes require cleaning every 2 years ("pigging out") with attendant odors
STEP/STEG	• Lower capital costs • Shorter time to construct • Provides primary treatment in septic tank, thereby reducing down-line costs for treatment system and solids treatment/ disposal • Shallow trenching and Horizontal Directional Drilling (HDD) where feasible, results in less road impacts and traffic nuisance, less risk to archeological resources and associated delays • Requires no lift stations, reducing footprint requirements • Minimal risk of I/I and resulting impact on Flow	• Higher annual O&M costs for collection- • May require additional nitrification/denitrification treatment for disposal options • If SRF loan is used, may require separate electrical connection premium • Construction and permanent impact on individual property, including footprint • Increased risk of impact on archeological resources due to new septic tanks • Nuisance and cost of regular pumping of septic tanks • Potential odor issues of vents if not properly maintained (200-500 collection vents located throughout community) • Higher total on-lot capital costs; unknown amount is homeowner responsibility; may be affected by funding • Individual properties have many active on-lot components including pumps, sensors, alarms that require periodic maintenance and have a greater risk of failure.

COMMENTS

- Note that 63% of trenching in town is less than 10 feet deep; 34% from 10 to 14 feet deep; 2% from 14 to 18 feet deep; and 1% from 18 to 23 feet deep (which is .4 mile).
- Both systems result in abandonment of existing septic tanks.
- On-lot costs may not be covered if SRF funding is used for a STEP system
- Considering life cycle costs for construction and O&M, the two systems are comparable.
- It is recommended that the Project Team investigate the history of spills (based on miles and age) and characterize the inherent risks of both Gravity and STEP collection systems.

AD-HOC COMMITTEE'S CRITERIA FOR PRO/CON ANALYSIS

COLLECTION SYSTEM

Engineering & Water Resources

- Life cycle costs.
- Design life.
- Property impact for both private and public properties.
- Reliability of System.
- Environmental impact of system.
- Infiltration and inflow potential.
- Energy.

Environment

- Construction disturbance
- Impact on biological resources
- Community impact
- System failure risk
- Impact on archaeological resources

Financial

- Capital Costs:
  - Land acquisition
  - Construction costs
  - Road impacts
  - Cost for individual hook-up
  - Cost of future upgrades
  - Potential environmental mitigation costs
- Operations & Maintenance Costs
  - Energy requirements
  - Labor, materials, overhead
  - Cost of solids handling/ disposal
  - Projected schedule for repairs, replacements, and maintenance
- Financial Risk Factors
  - Construction risks associated with archeological and biological impacts
  - Costs relating to system failure risks
  - Cost of achieving groundwater balance
  - Cost of potential repairs resulting from natural disasters (earthquake, flood)
  - Risk of inflated costs and uncertainty of 3rd party handling and/or participation
- Funding Factors
  - Eligibility for best financing (rate, terms, engineering constraints, flexibility, timing)
  - Grant eligibility, attractiveness
  - Conducive to 3rd party financial participation
  - Potential for revenue generation

COLLECTION SYSTEM

CRITERIA	PROS	CONS
ENGINEERING & WATER RESOURCES		
STEP		
Life cycle costs **Const. costs** **O & M costs**	Lower construction costs	Higher operations and maintenance costs
Construction impacts	Smaller amounts of road restoration- 2ft wide vs several ft. Shorter periods of road disturbance/ traffic control- could be ½ the time as compared to a gravity system in some areas Shallower trenches-6' or less vs. a gravity system with an average trench depth of 8' and depths reaching 28' in some locations Possibility of limited directional boring being used	
Property impact for both private and public properties		Requires easements on private property Requires access on private property Higher on-site capital costs-approximately 3 times that of a gravity system Higher level of private property disturbance – new septic must be installed (digging area) Requires periodic (5 yr. max.) pumping of on-site septic tanks
Reliability of system	Very small chance for inflow and infiltration- mainly through septic tank risers and lids.	Many small pumps and support systems with possibility of failure
Environmental impact of system	Fewer impacts associated with small diameter pipe installation	Minor odor issues in conjunction with air release valves. However, this can be mitigated by installing carbon filtration treatment at the air release valves.
	Results in significant reduction of bio-solids volume Existing septic tanks will have to be abandoned or retrofitted for storm water disposal	Boring and trenching occurs in the cultural resource zone Higher level of private property disturbance (digging)
Infiltration and inflow potential	Very small chance for inflow and infiltration. When it does occur mainly at septic tank risers lids	
Energy		Many small sources (pumps and support electronics) of electrical use but comparable to gravity in total use
Gravity		
Life cycle costs **Construction costs** **O&M costs**	Lower O&M costs	Higher construction costs
Construction impacts		Greater amounts of road restoration Longer periods of road disturbance/ traffic control- twice the time as compared to a STEP/STEG system Deeper trenches, with an average trench depth of 8 feet and trench depths reaching up to 28 ft in some areas.
Property impact for both private and public properties	No easements on private property No access required on private property Lower on-site capital costs – approximately 1/3 that of step Lower level of private property disturbance (digging) No periodic pumping of septic tanks	
Reliability of system	Fewer pumps and support systems with possibility of failure	Greater chance for inflow and infiltration
Environmental impact of system	Lower level of private property disturbance (digging)	Greater impacts associated with large diameter pipe installation Significantly greater amount of bio-solids Minor odor issues in conjunction with manholes and pump stations but can be mitigated through installation of carbon filtration Trenching occurs in the cultural resources zone. Wider areas of disturbance. Wider and deeper trenches will require shoring and dewatering in some areas. Water will have to be treated and disposed of. Existing septic tanks will have to be abandoned or retrofitted for storm water disposal
Infiltration and inflow potential		Greater possibility for inflow and infiltration.- primarily through manhole installations.
Energy		Fewer, but larger sources (pumps and support electronics) of electrical use but comparable to step in total use

COLLECTION SYSTEM

CRITERIA	STEP/STEG	Gravity
ENVIRONMENTAL		
Construction disturbance	Excavation for new tank replacement est. @ 150 square feet	Excavation for installation
	Tank decommission est. @ 100 square feet	Tank decommission est. @ 100 square feet
	Higher on lot disturbances to residents	Street impact approximately 2 weeks for main installation
	Street impacts < significant; shallower & narrower trenches and increased potential for boring	Potential for 20+ feet excavation
Impact on biological resources	Dewatering less significant	Dewatering: the need to protect water quality with the disposal of collected water
Community impact	Permanent impacts Easements requires homeowner cooperation Manholes and controls in front yard of each home Ongoing pumping of tanks, approx. 5 per day; associated truck traffic and odor	Permanent impacts 20 Lift stations throughout the community Grinder pumps @ certain locations
	Pump on each tank	Truck traffic to plant
	Resident responsibility significant	Odor control @ lift stations
	Venting at high points of system< 200>500	
System failure risk	Homeowner responsibility significant	
	Effluent has less volume; with suspended solids in pressurized line	Effluent throughout system
Impact on archaeological resources	155 Square feet additional excavation	Increased volume of disturbance due to depth of pipe placement
	Assuming boring, less volume of disturbance	
Energy Kwh/year	500,000- energy required to convey 1.2 mg/d to an out-of –town treatment facility	500,000- energy required to convey 1.4 mg/d to an out-of – town treatment facility

The environmental committee felt that the PRO/CON format was too limiting in bringing out a comprehensive comparison

COLLECTION SYSTEM

FINANCIAL

CRITERIA	Collection System	PROS	CONS
Capital Costs ▪ **Land acquisition** ▪ **Construction costs** ▪ **Road impacts** ▪ **Cost for individual hook-up** ▪ **Cost of future expansion, upgrades**	GRAVITY	- Potential modest savings with combined gravity/ vacuum/ low pressure system.	- Higher construction cost range $69.4M to $77.7M. - Construction costs do not include additional road restoration for out-of-town treatment sites - Higher homeowner costs (approx. $6M higher than STEP) - Unknown additional costs for land and easement to convey pipe to out-of-town site
	STEP/STEG	- Lower STEP construction cost range of $59.4M to $75.3M (vs. Gravity $69.4M to $77.7M) due primarily to open trenching; elimination of manholes pump stations, standby power; and minimal shallow access points. (Assumes that separate electrical connections are not required.) - On-lot costs include new septic tanks and all work on private property up to house inlet. (Additional homeowner costs are detailed in following table.)	- Costs for new electrical connection for pump, etc. range from $1,900 to $3,000 per connection; could be much high for separate electrical connection.
Operations, Maintenance & Repair ▪ **Maintenance, repair, & replacement costs**	GRAVITY	- Lower annual O&M at $450,000/ year	
	STEP/STEG		- Higher O&M at $750,000/ year
Financial Risk Factors ▪ **Financial risk relating to system failures and natural disasters**	GRAVITY		- Additional cost of bell & spigot maintenance program to address risk of future leakage
	STEP/STEG		
Funding Factors ▪ **Eligibility for best financing** ▪ **Grant attractiveness** ▪ **Potential for revenue generation**	GRAVITY		
	STEP/STEG		- SRF loan may require separate electrical connection, adding significant cost to system ($13.4M to $25.3M) STEP/STEG

Construction Costs	**Gravity**		**STEP/ STEG**	
	Low	**High**	**Low**	**High**
Mobilization	$3.7M	$4.2M	$2.4M	$3.1M
Common facilities	$57.6M	$64.2M	$11.8M	$15.5M
On-lot facilities	-0-	-0-	$33.3M	$40.9M
Road restoration (1)	$5.2M	$5.2M	$1.3M	$2.6M
Conveyance to out-of-town site	$2.9M	$4.1M	Included	Included
Overhead, profit & taxes	Included	Included	$10.6M	$13.2M
Total Construction Costs	**$69.4M**	**$77.7M**	**$59.4M**	**$75.3M**
Premium electrical costs (2)	-0-	-0-	$13.4M	$25.3M
Total Costs with electrical premium (not incl. homeowner costs	**$69.4M**	**$77.7M**	**$72.8M**	**$100.6M**
Homeowner on-lot costs (3)	$10.9M	$12.0M	$5.4M	$5.9M
Total Construction and Homeowner Costs (not including electrical premium) (3)	**$80.3M**	**$89.7M**	**$64.8M**	**$81.2M**
Operations & Maintenance Costs	**Gravity**		**STEP/ STEG**	
Labor	$140,000		$175,000	
Energy requirements	$ 60,000		$ 60,000	
Maintenance, Replacement	$250,000		$360,000	
Septic hauling	$ -0-		$150,000	
Total O&M Costs	$450,000		$745,000	

(1) Road restoration for additional conveyance of gravity pipeline out of town not included.
(2) Separate electrical required if project is financed with SRF loan
(3) Homeowners' on-lot costs are not part of gravity collection project costs, but presented for comparison purposes only.

FROM: DON BEARDEN

December 2, 2008

Comments on the Los Osos Wastewater Project Draft Environmental Impact Report, November 14, 2008, by Don Bearden.

I searched high and low in the Fine Screening Report (**Att. 1**) and the Draft EIR (**Att. 2**) and can not find anywhere a 100% vacuum collection system has been analyzed for the Los Osos Wastewater Project. In fact, the DEIR Table 7-5, "Screening of Collection System Alternatives" (**Att. 2**), rules out a Vacuum System due to:

- Highest energy demand.
- Highest maintenance cost.
- Vacuum system pumps and 4,769 vacuum interface valves to maintain.

One supplier of Vacuum Systems, Tom LaHue of AIRVAC, at a town hall meeting in Los Osos on November 21, 2008, said that they can collect all of the Prohibition Zone with three Vacuum Stations and 1,590 Valve Pit packages for 4,769 connections (an average of 3 homes per Valve Pit package). Each Vacuum Station would have two vacuum pumps, two sewage pumps, and a standby power facility. The following table compares a gravity collection system to a vacuum collection system.

Gravity System (**Att. 2**)	Vacuum System
• 4,769 connections from property line to gravity main in street • 907 manholes	• 4,769 connections from property line to 1,590 valve pits in the county right-of-way then to the vacuum main in the county right-of way
• 8-18 inch pipeline, most at depths of less than 8 feet	• 4-10 inch pipeline at depths less than 6 feet
• 5 duplex pump stations • 2 triplex pump stations • 12 pocket pump stations	• 3 vacuum stations
• 7 standby power facilities for 7 of the pump stations	• 3 standby power facilities

As can be seen above, the Vacuum System has far fewer pumps and backup power facilities; also, the pipes are smaller and can be installed in shallower trenches. AIRVAC estimates the construction costs for a Los Osos Vacuum System to be approx. 32 million dollars compared to the 83-90 million dollars for a Gravity Collection System as shown in Table 7.4 of the Fine Screening Analysis (**Att. 1**). If you add contractor overhead, profit, and 30% design contingency, there is still a potential for saving tens of millions of dollars in construction costs.

As far as high Operation and Maintenance costs are concerned, the EPA Manual on Alternate Wastewater Collection Systems, October 1991, page 20 (**Att. 3**) says: "MYTH: Vacuum sewers are operation and maintenance intensive. REALITY: In general, vacuum sewers may be less costly to construct than conventional sewers, but may be more expensive to operate and maintain. However, the magnitude of the O&M effort has been greatly overstated."

PDHengineer.com, course No. C-4029, "Vacuum Sewers – Operation and Maintenance and Management Guidelines" (**Att. 4)** documents a 2003 survey of O&M data from 22 selected projects with a total of 49 operating vacuum systems. Page 22 says: "A review of operating records of systems discussed in this chapter suggests that previously published O&M figures may no longer apply. Reasons for this are twofold. First, the previous figures were based on a very limited data on a few early systems. Second, component improvements have resulted in significantly fewer service calls and lower O&M costs."

There are many communities that have researched gravity vs. vacuum sewers. Here are three large communities that opted to install vacuum sewers:

1. Sarasota County, Florida – "Considering the relatively dense urban development in the project area, Sarasota County selected central sewer collection systems as the design alternative for all 16 communities within the Phillipi Creek Study Area, with vacuum collection chosen for approximately 80% of the areas." From an article titled "Septic vs. Sewer: A Cost Comparison for Communities in Sarasota County, Florida", by Burden, Daniel G., et al, WEFTEC 2003, pp 319-343 (**Att. 5**).

2. Albuquerque, New Mexico – "Extensive use of vacuum sewers allowed the City of Albuquerque to develop a sanitary sewer collection system that would work effectively and cost efficiently in the unincorporated portions of Bernalillo County. Over the past 12 years, the City has implemented a program that ultimately has a construction cost of $140 million. The program will ultimately serve over 8,000 residences as septic systems will all be demolished and the groundwater will be provided protection from human pollution." From an article titled "Vacuum Sewers – Engineered Solution for a Multitude of Problems" by Paulette, Robert J., WEFTEC 2006, pp3609-3620 (**Att. 6**).

3. York County, Virginia – "The vacuum sewers comprise about 25 percent of our sewer infrastructure. We have 36 people who are in operations, but only two or three are required for vacuum sewer maintenance." From an article titled "Vacuum Sewer Saves York", www.govengr.com, Government Engineering magazine, September – October 2004 (**Att. 7**).

In summary, I think the Vacuum System alternative in the DEIR Table 7-5, Screening of Collection System Alternatives, needs a more extensive evaluation. I would fill in the vacuum system column as follows:

Baseline Criteria	Vacuum System
Level Designation	Level A
Groundwater Quality & RWQCB Waste Discharge Requirements	• Meets RWQCB requirements for elimination of pollution to groundwater. • No exfiltration due to vacuum always in the header. • Septic tank effluent that currently recharges aquifer is removed.
Water Resources	• In a vacuum sewer system, the only potential source of inflow and infiltration is the homeowner's building sewer. Old piping from house foundation to the valve pit stub out should be replaced to prevent I/I. • Septic tank effluent that currently recharges aquifer is removed.
Energy/Air Quality	• ???,??? kWhr/year • Odors – minimal due to sealed system and short retention time. • Low GHG emissions due to sealed system.
Costs	• 3 vacuum system stations to maintain. • 1,590 interface valves to maintain. • Low maintenance costs due to less equipment to maintain and fewer operators needed. • Low construction costs due to smaller piping and shallower depths.
Permitability	• Noise – Comparable to gravity during construction. Moderate operation noise from vacuum pumps, can be muffled by enclosures. • Cultural Resources - Lowest potential impact due to shallow trenching , small valve pits and fewest pump stations. • Aesthetics: Least impact. Valve pits below ground like manholes. Only 3 vacuum station buildings that can be designed like other buildings in the neighborhood.

The vacuum collection system appears to be the environmentally superior alternative.

List of Attachments

Attachment 1 - LOWWP Viable Project Alternatives Fine Screening Analysis, August 2007, pages 1-4, 3-1, 7-8.

Attachment 2 - LOWWP Draft Environmental Impact Report, November 14, 2008, pages 3-50, 3-51, 7-23, 7-24, 7-25.

Attachment 3 - EPA Manual on Alternate Wastewater Collection Systems, October 1991, pages 17, 18, 19, 20, 93.

Attachment 4 - PDHengineer.com, course No. C-4029, "Vacuum Sewers – Operation and Maintenance and Management Guidelines", pages 1-36

Attachment 5 - "Septic vs. Sewer: A Cost Comparison for Communities in Sarasota County, Florida", by Burden, Daniel G., et al, WEFTEC 2003: Session 51 through 60, pp 319-343
and Phillippi Creek Septic Replacement Program, Quarterly Executive Summary, March 2008.

Attachment 6 - "Vacuum Sewers – Engineered Solution for a Multitude of Problems" by Paulette, Robert J., WEFTEC 2006, pp3609-3620.

Attachment 7 - "Vacuum Sewer Saves York", www.govengr.com, Government Engineering magazine, September – October 2004.

Att. C

San Luis Obispo County
Los Osos Wastewater Project Development

VIABLE PROJECT ALTERNATIVES FINE SCREENING ANALYSIS

August 2007

FINAL

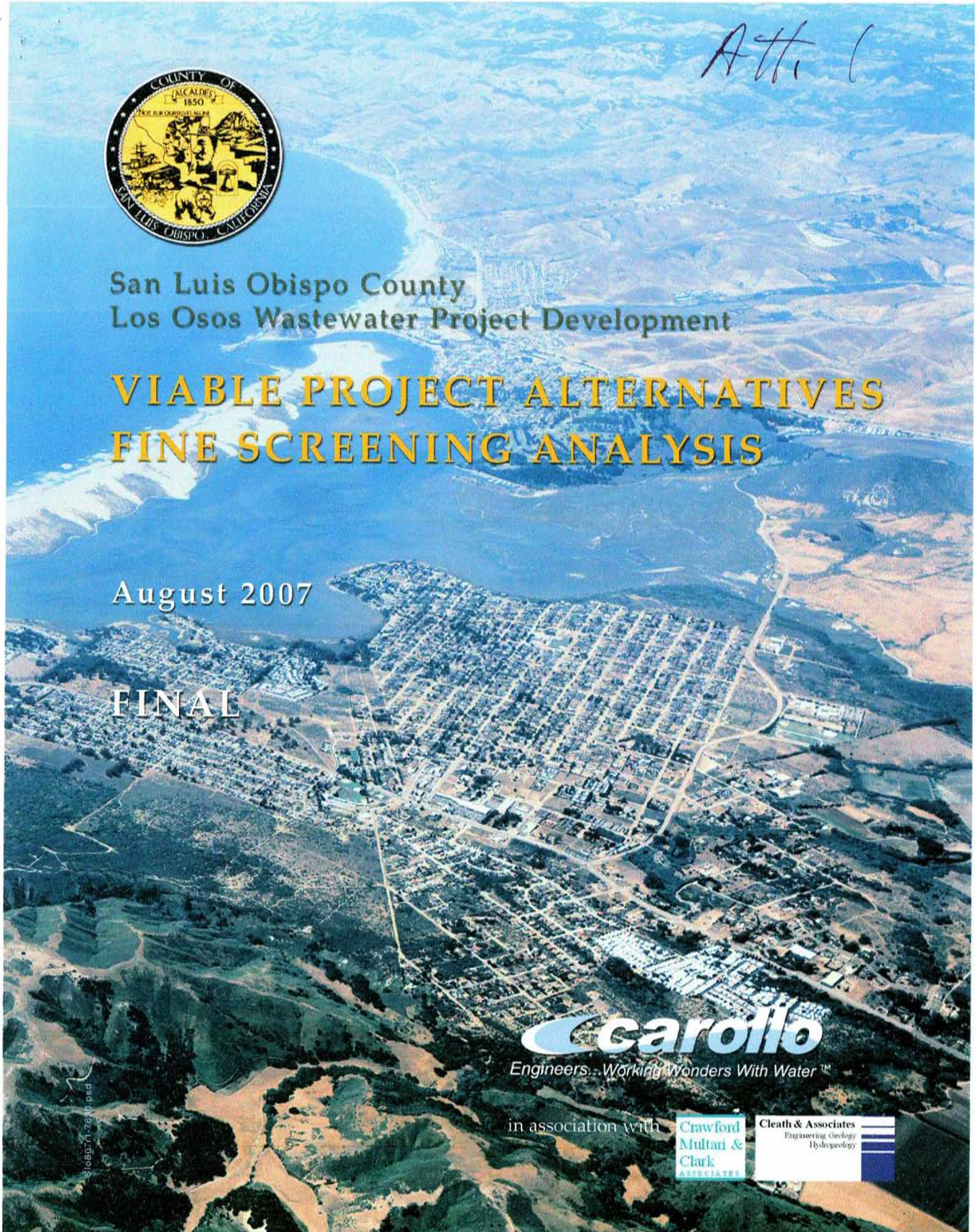


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Table 1.1 Potentially Viable Project Components that Passed Rough Screening
Los Osos Wastewater Project Development
San Luis Obispo County

Potential Treatment Process	Potential Reuse/Disposal Alternatives	Potential Siting Alternatives	Potential Solids Disposal Alternatives	Potential Collection System Alternatives
• Membrane Bio-Reactor (MBR) • Extended Aeration • Sequencing Batch Reactor (SBR) • Oxidation Ditch • Biolac® Extended Aeration • Trickling Filter Solids Contact • Partially Mixed Facultative Ponds	• Leach Fields • Percolation • Spray Fields • Agricultural Reuse • Urban Reuse • Constructed Wetlands	• Tri-W • Cemetery • Giacomazzi • Andre 2 • Morosin/FEA • Branin • Gorby (LOVE Farm) • Robbins 1 • Robbins 2	• Recycling of Digested/ Composted Class A Biosolids • Recycling of Composted Class A Biosolids • Hauling of Digested Class B Biosolids • Hauling of Composted Class B Biosolids • Hauling of Sub-Class B Dewatered Biosolids	• STEP/STEG • Gravity/ Vacuum/ Low Pressure Combination

COLLECTION SYSTEM ALTERNATIVES

3.1 COLLECTION SYSTEM OVERVIEW

3.1.1 Rough Screening Alternatives

The Potential Viable Project Alternatives Rough Screening Analysis (Carollo, March 2007) recommended three alternatives for further evaluation. The alternatives include gravity similar to the system designed and permitted as part of the previous Tri-W Project, septic tank effluent pumping/septic tank effluent gravity (STEP/STEG) collection, and a combined gravity/vacuum/low pressure system.

3.1.1.1 Combined Gravity/Vacuum/Low Pressure Collection System

The gravity collection system is a mostly passive central sewer system that uses gravity to move wastewater. Based on topography, it is necessary to employ lift stations at various locations throughout the collection system to move wastewater to the treatment facility.

The combined system consists of gravity, vacuum, and/or low-pressure collection systems depending on the localized topography throughout the system. The combined system allows for optimization of construction and operation and maintenance (O&M) costs as compared to a dedicated gravity system. The previously designed gravity system included elements of a low pressure system (grinder pumps) and would serve as the starting point for this option. Additional vacuum and low pressure elements would be incorporated in locations where topography, groundwater, or other site-specific conditions dictate.

Modifications to the previously designed gravity/low pressure system will not be examined in detail in this fine screening analysis. Modifications are viewed as a value-engineering alternative where additional vacuum and low-pressure equipment will be employed in the gravity collection system, if appropriate, to reduce costs. Assessment of site-specific options requires detailed design analysis and is beyond the scope of this report. Cost savings for the combined system are expected to be modest. The previously designed gravity/low pressure system is assumed to provide a conservative estimate of the capital and O&M costs.

3.1.1.2 STEP/STEG Collection System

A STEP/STEG collection system utilizes septic tanks to settle solids and provide a primary level of treatment. The effluent from the tanks is conveyed to an in-street collection system and the treatment facility via pumping (STEP system) or gravity (STEG system) through small diameter, pressurized pipes.

- Competitive bidding and public contracting efforts are optimized for the project, including options on funding, for example, through private markets.
- The Draft Environmental Impact Report (EIR) will be completed by mid-2008 at which point a preferred treatment facility site will be identified.

7.4 COSTS FOR VIABLE PROJECT ALTERNATIVES

Using the lowest and highest treatment costs identified for each disposal alternative in Table 7.3, the total construction cost and total project cost ranges are developed in Table 7.4 for all elements of the projects including the collection system reuse/disposal, and siting.

Table 7.4 Viable Project Alternatives Range of Costs, Millions(1)
Los Osos Wastewater Project Development
San Luis Obispo County

Project Element		Seawater Intrusion Mitigation Level 1		Seawater Intrusion Mitigation Level 2		Seawater Intrusion Mitigation Level 3		Tri-W Project
		90 AFY	140 AFY	190 AFY	240 AFY	550 AFY	600 AFY	~285 AFY
Collection System	STEP	$65 - 81	$65 - 81	$65 - 81	$65 - 81	$65 - 81	$65 - 81	$N/A
	Gravity(7)	$83 - 90	$83 - 90	$83 - 90	$83 - 90	$83 - 90	$83 - 90	$81 - 82
Treatment (Liquid and Solids) (2)	STEP	$14 - 18	$23 - 25	$20 - 22	$23 - 25	$23 - 25	$23 - 25	N/A(8)
	Gravity	$15 - 22	$23 - 26	$20 - 22	$23 - 26	$23 - 26	$23 - 26	$55
Disposal/Reuse		$13 - 16	$13 - 14	$15 - 17	$13 - 14	$26 - 30	$26 - 27	$20 - 23
Treatment Facility Site(3)		$1 - 3	$1 - 3	$1 - 3	$1 - 3	$1 - 3	$1 - 3	$1 - 3
Permitting/Mitigation(4)		$1 - 2	$1 - 2	$1 - 2	$1 - 2	$1 - 2	$1- 2	$1 - 2
Total Construction Costs	STEP	$94-120	$103 -126	$102-125	$103-126	$116-142	$116-139	N/A
	Gravity	$113-132	$121-135	$120-134	$122-135	$135-151	$134-148	$158 - 165
Total Construction Costs Escalated to Mid-Point of Construction(5)	STEP	$117-150	$128-157	$126-156	$129-157	$144-176	$144-173	N/A
	Gravity	$141-164	$151-168	$149-167	$152-168	$168-188	$167-184	$197 - 205
Project Costs(6)	STEP	$18-24	$18-24	$18-24	$18-24	$21-26	$21-26	N/A
	Gravity	$16-21	$16-21	$16-21	$16-21	$19-23	$19-23	$12 - 17
Total Project Costs(5)	STEP	$135-174	$146-181	$144-180	$147-181	$166-202	$165-199	N/A
	Gravity	$157-185	$167-189	$165-188	$168-189	$187-211	$186-207	$209 - 222

N/A - Not Available.

Notes:

(1) Estimated Construction Costs in April 2007 dollars including contractor overhead and profit and 30% design contingency (feasibility-level estimate).
(2) From Table 7.3 - shows combined costs of liquid treatment and solids treatment/disposal.
(3) Assumes approximately 40 acres acquired, except for Tri-W Project. Actual acreage may vary depending on the final site and plant configuration.
(4) Costs do not include land restoration costs at $20,000 to $50,000 per acre.
(5) Assumes mid-point of construction is June 2011. Escalation at 24.5% of construction cost sub-total per the Basis of Cost Evaluation (Carollo Engineers, May 2007).
(6) Project costs include design, construction management, administration and legal costs, as detailed in the Basis of Cost Memorandum in Appendix C.
(7) Cost do not include $13 to 25 million for electrical connection premium for separate electrical service that may be incurred if permitting and/or funding requirements stipulate this requirement and the funding is pursued.
(8) Tri-W costs based on gravity collection system. Treatment Costs for the Tri-W Project with STEP collection are not available from bid tab information. Based on other treatment process costs, MBR costs associated with STEP collection could be approximately 10 to 15% less than when associated with a gravity collection system.

Att. 2

Table 3-7 (Cont.) Summary of Proposed Projects Los Osos Wastewater Project (LOWWP)
Page 4 of 5[3]

Proposed Project	Treatment Plant Site	Collection System [1]	Conveyance Systems: Raw Wastewater	Conveyance Systems: Treated Effluent	Treatment Process and Wastewater Flows	Storage Location	Effluent Disposal	Biosolids Disposal
4	Tonini	**Gravity:** • Abandon 4,679 existing septic tanks (75% in front yards and 25% in backyards). • Install 4679 connecting 4-inch sewer laterals from property line to street collection system (about 140,000 lf). • 230,000 lf of gravity sewer and force mains [1]8-18 inch pipeline, most at depths of less than 8 feet[2]) • 907 manholes. • 5 duplex pump stations. • 2 triplex pump stations. • 12 pocket pump stations. • Standby power facilities (For stationery duplex, triplex and Mid-town pump stations.). Maintenance includes inspections of the collection system every 2 years (half of system each year). • Telemetry will signal false and real alarms for pump station malfunctions. • Energy consumption of about 500,000 kWhr/year.	1. Mid-rown Pump Station to Tonini. • Install 28,500 lf of 14-inch force main at 4- foot depth. • Install Mid-town Pump Station with 3 75-hp pumps with average pumping capacity of 875 gpm at 170 TDH. • Pump Station site is 0.1 acre. • Construct 500 foot Los Osos Creek Crossing. 2. Tanker trucks will pump and transport septage from 150 septic tanks each year and discharge to the treatment plant headworks.	1. Install conveyance system to transmit treated effluent from Tonini site to Broderson Leachfield. • Install 26,800 lf of 12-inch pipeline. • Install pump station at Tonini to pump maximum of 65 AF monthly (448 AF annually) of treated effluent to Broderson Leachfield. (75 hp pump with capacity of 1000 gpm.) • Install possible second pump station at Broderson to achieve equal distribution throughout disposal field. (20 hp pump with capacity of 500 gpm at 40 psi). • Construct 500 foot Los Osos Creek Crossing. 2. Install conveyance system to transmit treated effluent from Tonini site to Tonini Sprayfields. • Install 6,500 lf of 12-inch pipeline. • During non-wet periods, pump maximum of 80 AF monthly (842 AFY) of treated effluent to Tonini sprayfields. Install possible site booster pump to increase pressure.	1. Assumes Water Conservation Measures are implemented: • Reduce water consumption and wastewater generation by 160 AFY (10% by buildout in 2020). • Mandate that bathrooms be retrofitted with all low-flow fixtures prior to hookup to the sewer. • Conduct Public Education campaign • Promote High-Efficiency appliance programs. 2. At buildout, the wastewater generation rate from the gravity collection system is forecast to be: ADDWF = 1.2 MGD ADWWF = 1.4 MGD PHWWF = 2.5 MGD[3] • Average Day Influent Characteristics: BOD5 = 340 mg/l Suspended Solids = 390 mg/l Total Nitrogen = 56 mg/l • Septic tank septage Typical Wastewater Characteristics: Average Daily Pumping = 720 gpd BOD5 increase = 30 lbs/day Suspended Solids increase = 90 lbs/day 3. Construct Partially-Mixed Facultative Pond Wastewater Treatment System to provide Secondary Treatment meeting RWQCB WDR. Plant includes: • Headworks to screen out inorganics and measure flow. • About 20-acre wastewater treatment facility site, assuming Advanced Integrated Pond System (AIPS). • Septage receiving station required to screen and process septage from 749 septic tanks remaining outside Prohibition Zone. • Energy consumption will be about 1.24 million kWhr/year. • Aeration and other features to prevent algae accumulation on pond surfaces. • Nitrogen Removal System with limited carbon addition. • Open air odor control system for ponds and enclosed odor control for headworks and biosolids handling processes. • Site will be fenced. • Requires 2.0 FTE crew for O&M.	Construct 46 AF seasonal storage pond for treated effluent onsite at Tonini site. • Potential surface area varies from 5 to 8 acres depending on the pond depth. • Allows for 4-foot freeboard. • Site will be fenced. • Pond will be lined to prevent leakage and protected with riprap.	Effluent Disposal will have two components: 1. Broderson Leachfield, • Construct 8-acre leachfield to discharge up to 448 AFY of treated wastewater effluent. • Can operate during dry and wet weather. • Mitigates 187 AFY of seawater intrusion. • Site will be fenced. • Excavate leachfield, disk or rip underlying ground and reconstruct leachfield every 5-10 years when it clogs. 2. Tonini Sprayfields. • Spray up to 842 AFY of treated wastewater effluent on approximately 175 acres of dedicated fields at Tonini site. • Disposal occurs through evapotranspiration and percolation. • Spraying will occur during daytime and dry weather only. • Any tailwater runoff will be collected and reapplied to the sprayfields. • Nitrates will be controlled by harvesting the grass several times a year and disposing of the grass at Cold Canyon or Chicago Grade landfills. • Site will be fenced.	1. Every 15-20 years, biosolids from ponds will be removed, dewatered by belt filter or screw presses and hauled to the Cold Canyon or Chicago Grade landfills for disposal. 2. Odors and noise will be controlled by enclosing the dewatering facility and providing odor scrubbing equipment.

4.

Table 3-7 (Cont.): Summary of Proposed Projects Los Osos Wastewater Project (LOWWP) Page 4 of 5[2]

Proposed Project	Treatment Plant Site	Collection System [1]	Conveyance Systems		Treatment Process and Wastewater Flows	Storage Location	Effluent Disposal	Biosolids Disposal
			Raw Wastewater	Treated Effluent				

Notes:

1. Cost of abandoning existing septic tanks and replacing onsite landscaping and other onsite improvements disturbed by sewer lateral and septic tank abandonment or installation is paid by property owner for all Proposed Projects. Property owner for STEP/STEG collection system pays cost of sewer lateral from house or building to new STEP/STEG tank. Property owner for gravity collection system pays cost of sewer laterals from property line to house or building.
2. 94 percent of gravity collection system will be 8-inch PVC, 3 percent will be 10- to 12-inch PVC, and 3 percent will be 15- to 18-inch PVC. 72.6 percent will be buried 8 feet or less, 24.6 percent from 9 to 12 feet, and less than 3 percent from 13 to 18 feet. See Appendix B, Project Description Data, for more detail.
3. ADDWF = Average Day Dry Weather Flow, ADWWF = Average Day Wet Weather Flow, AF = Acrefeet, AFY = acre-feet per year, gpm = gallons per minute, gpd = gallons per day; FTE=full-time equivalent employees, kWhr = kilowatterhours; lbs = pounds; lf = linear feet, MGD = million gallons per day, O&M = operations and Maintenance, PHWWF = Peak Hour Wet Weather Flow, RWQCB = Regional Water Quality Control Board, STEP/STEG = Septic Tank Effluent Pumps/Septic Tank Effluent Gravity.

Source: Appendix B, Project Description Data; LOWWP Environmental Impact Report Draft Proposed Projects Descriptions, Draft August 1, Final October.

Table 7-5: Screening of Collection System Alternatives

Baseline Criteria	Gravity[1]	Combined Septic Tank Effluent Pumping (STEP)/ Septic Tank Effluent Gravity (STEG) System	Low Pressure Collection System (LPCS)[1]	Vacuum System
Level Designation	**Level A**	**Level A**	**Level C**	**Level C**
Groundwater Quality & RWQCB Waste Discharge Requirements	• Meets RWQCB requirements for elimination of pollution to groundwater • Least ex-filtration • Septic tank effluent that currently recharges aquifer is removed	• Meets RWQCB requirements for elimination of pollution to groundwater • Some exfiltration with pressurized pipelines. • Septic tank effluent that currently recharges aquifer is removed	• Meets RWQCB requirements for elimination of pollution to groundwater • Less exfiltration than STEP; more than gravity system. • Septic tank effluent that currently recharges aquifer is removed	• Meets RWQCB requirements for elimination of pollution to groundwater
Water Resources	• Inflow - As gravity system ages, Inflow can occur at lateral connections, manholes, and mainline joints. Regular maintenance can reduce • Infiltration - Potential where mainlines and manholes are below water table. • Septic tank effluent that currently recharges aquifer is removed.	• Inflow - As STEP/STEG system ages, Inflow can occur at house lateral connections and STEP/STEG tank joints. • Infiltration - Unlikely. • Septic tank effluent that currently recharges aquifer is removed	• Inflow - As LPCS system ages, Inflow can occur at house lateral connections and grinder pump station connections. • Infiltration - Unlikely. • Septic tank effluent that currently recharges aquifer is removed	Not evaluated.
Energy/Air Quality	• 500,000 kwhr/year • Odors - Minimal to Moderate Potential • Lower GHG emissions due to absence of septic tank venting and less chemical production.	• 425,000 kwhr/year • Odors - Moderate to severe potential • Higher GHG emissions due to septic tank venting, chemical production and septage hauling. • Sludge reduction in treatment plant is partially offset by septage addition. • Requires carbon addition for nitrogen removal. • Tanks replaced or moved to front yard	• 425,000 kwhr/year • Grinder pumps less efficient that STEP pumps. • Odors - Moderate potential	• Highest energy demand

Table 7-5 (Cont.): Screening of Collection System Alternatives

Baseline Criteria	Gravity[1]	Combined Septic Tank Effluent Pumping (STEP)/ Septic Tank Effluent Gravity (STEG) System	Low Pressure Collection System (LPCS)[1]	Vacuum System
Level Designation	**Level A**	**Level A**	**Level C**	**Level C**
Costs	• 7 pump stations and 12 pocket pumps to maintain. • Deeper Sewers require greater disruption during construction. • Higher construction cost but lower O & M cost due to lower staffing and maintenance requirements.	• 4,769 pumps and STEP tanks to maintain. • Septage haulers pump STEP tanks at least every 5 years. • Shallower Depth for pipeline so trenchless technology can be used for portions of collection system. • Greater private yard disruption during STEP/STEG tank installation. • Lower construction cost but higher maintenance and septage hauling costs. • Permanent public easement required for STEP/STEG tank maintenance.	• 4,769 grinder pumps to maintain. • Shallower Depth for pipeline so trenchless technology can be used for portions of collection system. • Greater private yard disruption during grinder pump installation. • Can be used with gravity system in areas with shallow groundwater • Permanent public easement required for grinder pump maintenance.	• Highest maintenance cost. • Vacuum system pumps and 4,769 vacuum interface valves to maintain. • Shallower Depth
Permitability	• Noise - Comparable to STEP/STEG during construction. Quieter during operations. • Cultural Resources - Lower potential impacts. • Aesthetics: Less impact since most community facilities are underground. Traffic - Construction of a gravity system would lead to temporary impacts, but would be located further away from homes, etc.	• Noise - Comparable to gravity during construction. Higher operations noise from false and real STEP/STEG tank alarms and septage pumping. • Cultural Resources - Higher potential impacts from STEP/STEG tank excavation in private yards. • Aesthetics: More impact during operations due to 2 24-inch grade lids, alarms and lights.	• Noise - Comparable to STEP/STEG during construction. Higher operations noise from false and real grinder pump alarms. Grinder pumps noisier than STEP pumps. • Cultural Resources: - Higher potential impacts from grinder pump excavation in private yards. • Aesthetics: More impact during operations due to access hatch, alarms and lights.	Not evaluated

Table 7-5 (Cont.): Screening of Collection System Alternatives

Baseline Criteria	Gravity[1]	Combined Septic Tank Effluent Pumping (STEP)/ Septic Tank Effluent Gravity (STEG) System	Low Pressure Collection System (LPCS)[1]	Vacuum System
Level Designation	Level A	Level A	Level C	Level C
		• Traffic - STEP/STEG traffic impacts would occur during installation and would occur in close proximity to sensitive land uses.	• Traffic – Comparable to STEP/STEG traffic impacts during installation in close proximity to sensitive land uses.	

NOTES:
[1] The proposed gravity collection system is a hybrid that may install a LPCS for small subareas with high groundwater and difficult excavation conditions.
Sources: Appendix P-2: Kennedy/Jenks Consultants, Systems Component Evaluation, October 2008, Carollo Engineers 2008i, Carollo Engineers 2007b.

Att. 3

EPA/625/1-91/024
October 1991

Manual

Alternative Wastewater Collection Systems

U.S. Environmental Protection Agency

Office of Research and Development
Center for Environmental Research Information
Risk Reduction Engineering Laboratory
Cincinnati, Ohio

Office Of Water
Office of Wastewater Enforcement and Compliance
Washington, DC

Printed on Recycled Paper

1.3.2.3 Operation

Vacuum or negative-pressure sewer systems use vacuum pumps at central collection stations to evacuate air from the lines, thus creating a pressure differential.[11] In negative pressure systems, a pneumatically operated valve serves as the interface between the gravity system from the individual user and the vacuum pipelines. Pressure sensors in a wastewater holding tank open and close the interface valve to control the flow of wastewater and air into the vacuum system.

The normal sequence of operation is as follows:

- Wastewater from the individual service flows by gravity to a holding tank.
- As the level in the holding tank continues to rise, air is compressed in a small diameter sensor tube. This air pressure is transmitted through a tube to the controller/sensor unit mounted on top of the valve. The air pressure actuates the unit and its integral 3-way valve which allows vacuum from the sewer main to be applied to the valve operator. This opens the interface valve and activates a field adjustable timer in the controller/sensor. After a set time period has expired, the interface valve closes.[11] This happens as a result of the vacuum being shut off, allowing the piston to close by spring pressure.
- The wastewater within the vacuum sewer approximates the form of a spiral rotating hollow cylinder traveling at 38-45 cm/s (15-18 fps). Eventually, the cylinder disintegrates from pipe friction, and the liquid flows to low points (bottom of lifts) in the pipeline.
- The next liquid cylinder and the air behind it will carry the liquid from the previously disintegrated cylinders up over the sawtooth lifts designed into the system. In this manner, the wastewater is transported over a series of lifts to the vacuum station.

The principles of operation of a vacuum sewer system are not completely understood. An early concept was that of liquid plug flow. In this concept, it was assumed that a wastewater plug completely sealed the pipe bore during static conditions. The movement of the plug through the pipe bore was attributed to the pressure differential behind and in front of the plug. Pipe friction would cause the plug to disintegrate, thus breaking the vacuum. With this being the situation, reformer pockets were located in the vacuum sewer to allow the plug to reform and thus restore the pressure differential (Figure 1-12). In this concept, the re-establishment of the pressure differential for each disintegrated plug was a major design consideration.

In the current design concept, the reformer pockets are eliminated so that the wastewater does not completely fill or "seal" the pipe bore. Air flows above the liquid, thus maintaining a high vacuum condition throughout the length of the pipeline (Figure 1-13). In this concept, the liquid is assumed to take the form of a spiral, rotating, hollow cylinder. The momentum of the wastewater and the air carries the previously disintegrated cylinders over the downstream sawtooth lifts. The momentum of each subsequent air/liquid slug and its contribution to the progressive movement of the liquid component of the previous slugs are the major design considerations.

Both of the above design concepts are approximations and oversimplifications of a complex, two-phase flow system. The character of the flow within the vacuum sewer varies considerably. The plug flow concept is probably a reasonable approximation of the flow as it enters the system, whereas the progressive movement concept is probably a better approximation of the flow throughout the vacuum main.

The significance of the air as a driving force cannot be overemphasized. The atmospheric air expands within the vacuum sewer, thus driving the liquid forward. The air affects not only the liquid in the associated air/liquid slug, but also the liquid downstream.

1.3.3 Potential Applications

Below are the general conditions that are conducive to the selection of vacuum sewers.

- Unstable soils
- Flat terrain
- Rolling terrain with small elevation changes
- High water table
- Restricted construction conditions
- Rock
- Urban development in rural areas

Experience has shown that for vacuum systems to be cost effective, a minimum of 75-100 customers is needed per custom vacuum station. Package vacuum stations have proven to be cost-effective for service areas of 25-150 customers. The average number of customers per station in systems presently in operation is about 200-300. There are a few systems with fewer than 50 and some with as many as 2,000/station. There are communities which have multiple vacuum stations, each serving hundreds of customers.

Hydraulically speaking, vacuum systems are limited somewhat by topography. The vacuum produced by a vacuum station is capable of lifting wastewater 4.5-6 m (15-20 ft), depending on the operating level of the system.

Figure 1-12. Early design concept- reformer pockets.

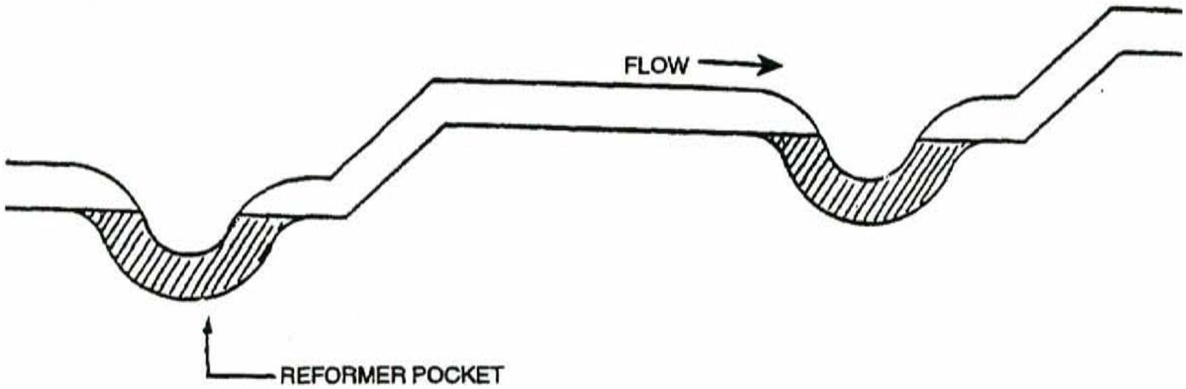
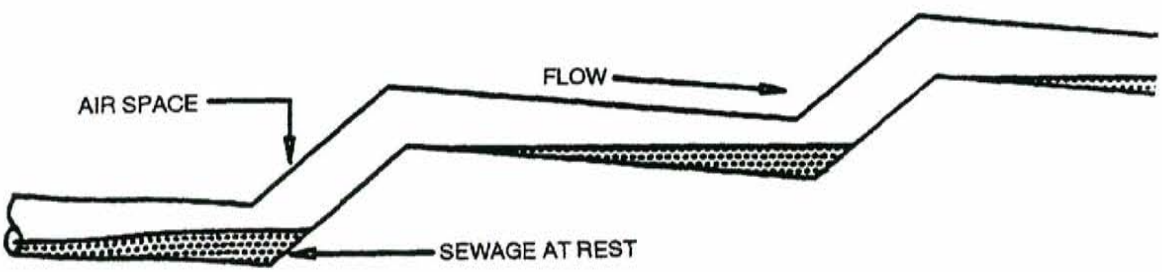


Figure 1-13. Current design concept - pipe bore not sealed.



This amount of lift many times is sufficient to allow the designer to avoid the lift station(s) that would be required in a conventional gravity system.

1.3.4 Extent of Use in the United States

Table 1-4 shows the operating residential vacuum sewer systems in the United States as of January 1990. There are another dozen or so presently in the construction phase, with more being planned and designed.

In addition to the above residential systems, several industrial facilities use vacuum systems to collect wastewater.[3] These companies include the Scott Paper Company pulp and paper mill in Mobile, Alabama, with 25 AIRVAC valves; Stauffer Chemical Company in Baton Rouge, Louisiana, with 7 AIRVAC valves; and Keystone Steel and Wire Company in Peoria, Illinois, with 29 AIRVAC valves. ENVIROVAC type systems using vacuum toilets are used in remote construction camps and park restroom facilities, and along with another vacuum system manufacturer, Jered Industries, in many shipboard installations. These types of installations are beyond the scope of this report and will not be addressed.

1.3.5 Myths vs. Reality

Many myths exist concerning vacuum sewer systems. In reality, a vacuum system is not unlike a conventional gravity system. Wastewater flows from the individual homes and utilizes gravity to reach the point of connection to the sewer main. The equipment used in the vacuum station is similar in mechanical complexity to that used in a conventional lift station. The most common myths concerning vacuum sewer technology are discussed below.

MYTH: Vacuum sewers are only to be considered where flat terrain exists.

REALITY: Vacuum sewers should be considered in level, downhill, and uphill terrain. The practical limit of uphill transport historically has been 4.5-6 m (15-20 ft) of vertical lift, although experimental systems are being tested which may increase the feasible vertical lift limit.

MYTH: Vacuum sewers should not be considered when the potential for gravity flow exists.

REALITY: Many times a broad view of an area's terrain automatically rules out vacuum sewers as an alternative to be considered. However, a closer look may reveal many small advantages, that, when considered collectively, add up to a significant savings.

Table 1-4. Operating Vacuum Systems in the United States

Project Name	Project Location	System Type
Martingham	St. Michaels, MD	AIRVAC
Foxcliff Estates	Martinsville, IN	AIRVAC
Country Squire Lakes	North Vernon, IN	AIRVAC
Mathews Courthouse	Mathews, VA	AIRVAC
Plainville	Plainville, IN	AIRVAC
Eastpoint	Eastpoint, FL	AIRVAC
Westmoreland	Westmoreland, TN	AIRVAC
Fallen Leaf Lake	South Lake Tahoe, CA	AIRVAC
Fairmont	Somerset County, MD	AIRVAC
Queen Anne's County	Queen Anne's Co., MD	AIRVAC
LaFargeville	LaFargeville, NY	AIRVAC
Charlotte	Charlotte, TN	AIRVAC
Ohio Co. - Cedar Rocks	Wheeling, WV	AIRVAC
Ohio Co. - Peters Run	Wheeling, WV	AIRVAC
Ohio Co. - Short Creek	Wheeling, WV	AIRVAC
Friendly PSD	Friendly, WV	AIRVAC
Central Boaz PSD	Parkersburg, WV	AIRVAC
Red Jacket PSD	Red Jacket, WV	AIRVAC
Washington Lands PSD	Washington Lands, WV	AIRVAC
Cedar Grove	Lexington Park, MD	AIRVAC
Lake Chautauqua	Celeron, NY	AIRVAC
Lag Marina	Norfolk, VA	AIRVAC
Emmonak	Emmonak, AK	AIRVAC
Swan Point	Swan Point, MD	AIRVAC
Alton	Alton, KY	AIRVAC
White House	White House, TN	AIRVAC
Morristown	Morristown, NY	AIRVAC
Lake Manitou	Rochester, IN	AIRVAC
Theresa	Theresa, NY	AIRVAC
Sanford	Sanford, FL	AIRVAC
Claywood Park	Parkersburg, WV	AIRVAC
New Cumberland	New Cumberland, WV	AIRVAC
Big Sandy	Charleston, WV	AIRVAC
Lanark Village	Lanark Village, FL	AIRVAC
Pattersontown	Pattersontown, FL	AIRVAC
Beallsville	Beallsville, PA	AIRVAC
Salmon Beach	Puget Sound, WA	AIRVAC
Noorvik	Noorvik, AK	ENVIROVAC
Big Bear Lake	Big Bear Lake, CA	ENVIROVAC
Centertown	Centertown, KY	ENVIROVAC
Stafford Township	Manahawkin, NJ	ENVIROVAC
Ocean Pines	Berlin, MD	VAC-Q-TEC
Lake of the Woods	Locust Grove, VA	VAC-Q-TEC
Shipyard Plantations	Hilton Head Island, SC	VAC-Q-TEC
Palmetto Dunes	Hilton Head Island, SC	VAC-Q-TEC
Captain's Cove	Greenback, VA	VAC-Q-TEC

An example of this occurred in the Ohio County PSD-Peters Run project in Wheeling, West Virginia. In that project, it only seemed logical to the designer to use conventional gravity sewers. The area was rural with residential development following a creek. However, upon closer inspection, it was evident that the gravity main would be required to cross the creek in various places, since the development was on both sides. With the creek bank being 3-m (10-ft) deep and the creek crossing requiring 1 m (3 ft) of cover, the gravity sewer would have been 4-m (13-ft) deep for most of its length (Figure 1-14). At the terminus of the system, a lift station was needed to pump the wastewater to a plant, which was located above 100-yr flood elevation.

By utilizing vacuum, the designer used "lifts" to raise the main above the bedrock level to a depth of 1.2-1.5 m (4-5 ft) (Figure 1-15). The vacuum station that was required was nothing more than the lift station that was required in the gravity layout, with the exception of the addition of vacuum pumps. This additional expense was more than offset by the savings of the line installation. The "inexpensive" conventional gravity system would have required deep, difficult excavations with much rock. The vacuum alternative had much shallower excavations with little rock. In essence, the vacuum system was installed as a "vacuum assisted-gravity sewer" with significant cost savings.

MYTH: Since vacuum sewers are mechanized, they undoubtedly are unreliable.

REALITY: Early vacuum systems were not without their problems. However, component improvements, design advancements, and experience with the technology have resulted in systems that are very reliable.

MYTH: Vacuum sewers are operation and maintenance intensive.

REALITY: In general, vacuum sewers may be less costly to construct than conventional sewers, but may be more expensive to operate and maintain. However, the magnitude of the O&M effort has been greatly overstated. This is due largely to the little historical data that exist coupled with the conservative nature of most engineers.

MYTH: Replacement parts are expensive.

REALITY: The components of the vacuum station are not unlike those of a conventional pumping station. The small parts of the vacuum valve that are subjected to wear are very inexpensive. A vacuum valve and controller can be rebuilt for about $30. Rebuild frequency is 5-10 yr.

MYTH: The vacuum pumps must run 24 hr/d to keep vacuum on the system.

REALITY: The typical vacuum station is designed so that the vacuum pumps operate about 3-5 hr/d.

MYTH: It takes a tremendous amount of energy to keep constant vacuum on the systems.

REALITY: The average sized vacuum station contains 20-hp vacuum pumps. Considering a run-time of 5 hr/d and the cost of electricity at $0.08/kWh, the cost of power for the vacuum pumps is about $185/month. A system this size can and typically does serve 200-300 customers.

MYTH: The operation of a vacuum system requires a person with a college degree.

REALITY: Any person that is mechanically inclined can operate a vacuum system. Most of the systems in operation in the U.S. have operators with no more than a high school education.

MYTH: If the vacuum valve fails, wastewater will back up into my house.

REALITY: Vacuum valves can fail in either the open or closed position. One failing in the closed position will result in backups. This would be analogous to a blockage or surcharging of a gravity sewer. Fortunately, failure in this mode is rare. Almost all valve failures happen in the open position. This means that the vacuum continues to try to evacuate the contents of the pit. The vacuum pumps usually run continuously to keep up, as this failure simulates a line break. In these cases, a telephone dialer feature available in vacuum stations notifies the operator of this condition. Correction of the problem can generally be made in less than an hour after the operators arrive at the station.

In short, many of the major objections to the use of vacuum systems are not well founded. These systems have been acceptable in a variety of applications and locations. Any hypothetical or abstract difficulty that can be applied to the vacuum system can also be applied to the more conventional systems. In any event, the vacuum system offers the same convenience as any other type of

CHAPTER 3

Vacuum Sewer Systems

3.1 Introduction

The use and acceptance of alternative wastewater collection systems have expanded greatly in the last 20 years. One of these alternatives, vacuum sewers, has been used in Europe for over 100 years. However, it has been only in the last 25 years or so that vacuum transport has been utilized in the United States.

In this period of time, significant improvements have been made in system components. In addition, experience with operating systems has led to advancements in design, construction, and operational techniques. These factors have all contributed to vacuum sewer systems being a reliable, cost-effective alternative for wastewater conveyance.[1]

Vacuum sewerage is a mechanized system of wastewater transport. Unlike gravity flow, it uses differential air pressure to move the wastewater. It requires a central source of power to run vacuum pumps which maintain vacuum on the collection system (Figure 3-1). The system requires a normally closed vacuum/gravity interface valve at each entry point to seal the lines so that vacuum is maintained. These valves, located in a pit, open when a predetermined amount of wastewater accumulates in the collecting sump. The resulting differential pressure between atmosphere and vacuum becomes the driving force that propels the wastewater towards the vacuum station.

A vacuum system is very similar to a water distribution system, only the flow is in reverse (Figure 3-2).[2] This relationship would be complete if the vacuum valve was manually opened, like a water faucet. With proper design, construction, and operation a vacuum system can be made to approach a water system in terms of reliability.

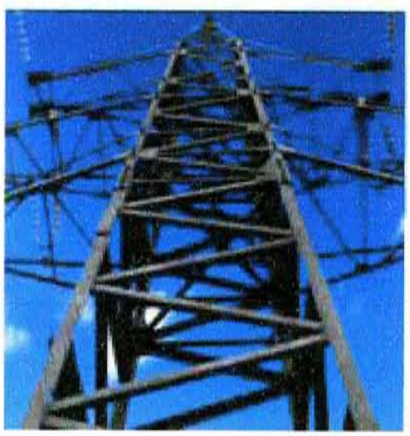
The choice of collection system type is usually made by the consulting engineer during the planning stages of a wastewater facilities project. This choice is the result of a cost-effectiveness analysis. Where the terrain is applicable to a gravity system, the vacuum system many times is not even considered. While gravity may be cost effective in these situations, many small factors considered collectively may result in a vacuum system being the proper choice. Vacuum sewers should be considered where one or more of the following conditions exist:

- Unstable soil
- Flat terrain
- Rolling land with many small elevation changes
- High water table
- Restricted construction conditions
- Rock
- Urban development in rural areas

The advantage of such systems may include substantial reductions in water use, material costs, excavation costs, and treatment expenses. In short, there is a potential for overall cost effectiveness. Specifically, the following advantages are evident:

- Small pipe sizes, usually 7.5-, 10-, 15-, and 20-cm (3, 4, 6, 8-in) are used.
- No manholes are necessary.
- Field changes can easily be made as unforeseen underground obstacles can be avoided by going over, under, or around them.
- Installation at shallow depths eliminates the need for wide, deep trenches reducing excavation costs and environmental impact.
- High scouring velocities are attained, reducing the risk of blockages and keeping wastewater aerated and mixed.
- Unique features of the system eliminate exposing maintenance personnel to the risk of H_2S gas.
- The system will not allow major leaks to go unnoticed, resulting in a very environmentally sound situation.
- Only one source of power, at the vacuum station, is required.
- The elimination of infiltration permits a reduction of size and cost of the treatment plant.

Att. 4



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Vacuum Sewers

O&M and System Management Considerations

PDHengineer Course No. C-4029

I. INTRODUCTION

From the time the very first public sewer system was constructed until the 1960's, a conventional gravity system was the only choice US engineers had when considering a public sewer collection system. This changed about 40 years ago when the USEPA challenged the industry to developed alternative collection by providing special funding for such endeavors. One of the alternative collection systems is vacuum sewers.

At one time, vacuum sewers were regarded as "new" and only to be used as a system of last resort. Improvements in the technology later led to acceptance as "alternative" sewers, but still only to be used when significant savings would result. Now, vacuum sewers have become an acceptable alternative in the proper application and are providing efficient and reliable sewer service to communities all around the world. In addition to proper design, proper operation and maintenance (O&M) is of utmost importance for these systems to perform efficiently.

This course is Part III of a three part series on vacuum sewers and will focus on operation & maintenance and system management considerations for vacuum sewer systems. Part I discusses the basics of vacuum sewer technology by providing a broad overview of the technology while Part II focuses on the design and installation aspects related to vacuum sewers.

II. EVALUATION OF OPERATING SYSTEMS

A. Operating history of vacuum sewers

Early vacuum systems were often plagued with consistent operational problems. Small diameter vacuum mains, improperly planned vacuum main profiles, too large liquid slug volumes, and insufficient air all resulted in transport problems[1]. Adding to the difficulties was the fact that they were installed without sufficient field experience, and with system components that were not yet fully reliable. In addition, operation and maintenance guidelines were not yet available. Frequent service calls and high power bills were common during this era.

Several breakthroughs occurred in the 1980's that led to significant improvements in the technology. These included the introduction of the saw-tooth profile, an improved valve controller, the use of gasketed pipe and the use of larger pipe and vacuum pumps. Many feel that more progress was made in the vacuum sewer industry during this decade than in other time. Service calls were less frequent, systems were more energy efficient, and overall the systems were becoming more reliable.

Improvements in the technology continued throughout the 1990's to the present day. A better understanding of vacuum sewer hydraulics, improved system components, and established operation and maintenance guidelines have combined to lead to significant operational improvements.

Today's vacuum systems are significantly different than the systems of the 1970's. Efficiency and reliability are the two areas where the most improvement has occurred. Continuing research and development is expected to further improve the technology.

B. O&M data: 2003 Operator Survey

In 2003, a survey form was sent to selected operators of vacuum systems. An attempt was made to survey systems that would give a good cross section of the technology. Age of the system, topography, geographical location and size were considered in the selection process. O&M data from 22 projects, with a total of 49 operating systems, was gathered (see Table 1). This represents about 20% of the operating systems in the U.S.

To be consistent with the O&M data previously reported in the 1991 EPA Manual, *Alternative Wastewater Collection Systems*[2], the survey requested information on labor, power and service call history.

For the labor component, operators were asked to breakout their maintenance effort into 3 categories: routine (day-to-day), preventive (planned/scheduled) and emergency (service calls). Adjustment to the raw data was required in some cases as several operators reported preventive maintenance as routine maintenance or vice-versa. The data was reduced to the ranges and averages shown in Tables 2 thru 5.

Table 1

2003 Operator Survey

Project	# connections	# vacuum stations	# vacuum valves	House to Pit ratio	Yr operational
Plainville, IN	270	1	163	1.66	1975
Westmoreland, TN	1000	4	550	1.82	1979
Fairmount, MD	238	1	159	1.50	1981
Queen Anne's Co, MD	6250	14	2299	2.72	1981
White House, TN	1177	2	575	2.05	1987
Alton, KY	430	4	210	2.05	1987
Theresa, NY	237	1	141	1.68	1989
Beallsville, PA	235	1	127	1.85	1991
Silver Lake, IN	492	2	192	2.56	1992
Waverly, WV	140	1	114	1.22	1992
Montpelier, OH	300	1	120	2.30	1993
Crystal Lake, OH	975	2	438	2.23	1994
Pine Grove, WV	380	1	184	2.07	1994
York County, VA	2238	5	1049	2.13	1995
Glen Park, NY	166	1	110	1.51	1995
Wolcottville, IN	725	2	390	1.86	1996
Crisfield, MD	258	1	162	1.59	1997
Kotlik, AK	102	1	75	1.36	1998
Jimmersontown, NY	200	1	98	2.04	1999
Iron Mountain Lake, MO	368	1	241	1.53	2000
Stanfield, NC	190	1	129	1.47	2001
Forest, OH	146	1	65	2.25	2002

Labor

The Operator Survey showed that labor associated with the vacuum station was relatively minor and predictable. Most viewed the labor effort for a vacuum station as similar to that required for a lift station in a conventional system (see Table 2).

Table 2

Labor: Vacuum Station
(from 2003 Operator Survey)

	Range reported (hrs/yr/station)		Average (hrs/yr/station)
Category	Low	High	Average
Routine	100	600	250
Preventive	0	90	50
Emergency	0	85	30

Labor associated with the vacuum mains varied widely, as this was generally was a function of whether any major line problems occurred in the past year. While the upper values shown on Table 3 did occur, the vast majority of operators reported few, if any problems with the vacuum mains. The average values are a more realistic view of a normally operating system.

Table 3

Labor: Vacuum Mains
(from 2003 Operator Survey)

	Range reported (hrs/yr/system)		Average (hrs/yr/system)
Category	Low	High	Average
Routine	0	100	30
Preventive	0	100	20
Emergency	0	110	10

For the labor associated with the vacuum valves, some operators reported preventive maintenance as routine and vice-versa. Others reported no preventive maintenance at all. The raw data was reduced and the resulting ranges and averages shown in Table 4.

Table 4

Labor: Vacuum Valves
(from 2003 Operator Survey)

	Range reported (hrs/yr/valve)		Average (hrs/yr/valve)
Category	Low	High	Average
Routine	0.20	0.90	0.50
Preventive	0.00	1.00	0.40
Emergency	0.10	1.35	0.60

Power

In most cases, the operators reported their power consumption in dollars (year 2003). Very few reported the unit charge for electricity ($/KwHr). An average cost of $0.07/KwHr was assumed, and the power costs were converted to the power consumption figures shown in Table 5. Because of the large disparity in power consumption between older and more recent systems, the data was broken into 2 eras.

Table 5

Power Consumption
(from 2003 Operator Survey)

	Range reported (KwHr/yr/conn)		Average (KwHr/yr/conn)
Category	Low	High	Average
Pre- 1990 systems	430	570	500
Post-1990 systems	200	400	300

C. Mean Time Between Service Calls (MTBSC)

MTBSC is calculated by dividing the number of valves by the number of service calls over a 1-year period. For example, a system with 500 valves that required 50 service calls in a year would have a MTBSC of 10 years.

An EPA *Technology Transfer Seminar Publication*, prepared in 1977, detailed the failure rate (MTBSC) of some of the early vacuum systems. In general, the MTBSC of the early systems ranged from less than 1 year to more than 8 years; all but one of the systems had a MTBSC of less than 4 years (EPA, 1977). In the 1991 EPA Manual, *Alternative Wastewater Collection Systems*, the MTBSC of the 6 systems visited ranged from 1 year to 22.5 years (EPA, 1991), with an average MTBSC of 2.2 years.

The 2003 Operator Survey showed a range of MTBSC of 2 to 27 years, with the average being 5.1 years. This survey included many of the early systems that have lower MTBSC values. Even with these included, the overall MTBSC figure has increased over the years.

Table 6

Mean Time Between Service Calls (MTBSC) Trend

Era	Source	MTBSC
6 systems (1970-1989)	1991 EPA Manual	2.2 yrs
49 systems (1970 - 2003)	2003 Operator Survey	5.1 yrs

D. Historical problems

Each of the systems visited as part of the 1991 EPA Manual effort experienced some type of problem that predominated as a demand on O&M staff time. However, most were short lived. The results of the 2003 operator survey indicate that many of these early problems have vanished (see Table 7).

Table 7

Summary of Historical Problems

	Pre - 1990 systems As reported in the 1991 EPA Manual	Post -1990 systems Per the 2003 Operator Survey
Component defect		
Broken controller spring	Isolated cases	No longer a problem
Unreliable controller	Until the mid 80's	No longer a problem
Shaft/seal	Until the mid 80's	No longer a problem
Plug valve	Isolated cases	No longer a problem
Design shortcomings		
Pump cavitations	Isolated cases	Not as frequent, but still a concern
Leaking check valves	Until mid 80's	No longer a problem
Oversized vacuum pumps	Mid 80's	No longer a problem
Operator Error		
WW into vacuum pumps	Fairly common	More safeguards now, but still a concern
Construction related		
Line breaks	Common w/solvent weld	Rarely w/gasketed pipe
Broken fittings	Common w/solvent weld	Rarely
Construction debris	Common after startup	Not as common due to operator training
Heat in station	Isolated cases	Still a concern when VFD's are used
Broken cleanout	Fairly common	Less frequent w/fewer cleanouts
Equipment malfunction		
Faulty level control	Isolated cases	Rarely; improved technology
Faulty telephone dialer	Isolated cases	Rarely; Improved technology
Extraneous water		
System waterlogging	More likely before saw-tooth	Less likely now, but still a concern
Water in controller	# 1 component problem	Less frequent, but still a concern
I&I	Root cause of most problems	Still the root cause of most problems

As is the case with other system types, extraneous water (I/I) is the root cause of most problems, whether it is heat build-up in the station due to excessive pump run-times or problems with the valve controller due to excessive cycles. In a vacuum sewer system, the only potential source of I/I is the homeowner's building sewer, where even a small amount of I/I can have a detrimental effect. Accepting flow from an existing gravity system, where I/I is common, further exaggerates the problems. (see box below).

The number one component-related problem remains "water in the controller", however, the incidence rate of this happening has drastically fallen over time, as is evidenced by the increasing MTBSC values of the recent systems. Water in the controller is a by-product of system problems that occur as a direct result of extraneous water (I/I) that is allowed to enter the system.

SITUATION TO AVOID!
ACCEPTING FLOW FROM AN EXISTING GRAVITY SYSTEM

Of all of the potentially bad situations that can occur, perhaps none is more damaging to a vacuum system than excessive flow that enters a vacuum system via an existing gravity system. Problems ranging from sluggish, inefficient flow transport to temporary system failure have resulted. With new construction, one can fairly accurately predict average and peak flow and design the vacuum mains and vacuum station accordingly. By accepting flows from an existing system, another element is introduced into the equation: infiltration & inflow (I/I).

Should it be possible to accurately predict I&I, this situation can be considered, but still with caution. An analysis of the existing gravity system must be done. This would include having flow records that identify the magnitude of flow that can be expected during normal periods as well as rain events (minimum 1 year of flow data). Even then, should there be a large difference between normal daily flow and flow during a rain event, it is recommended that the existing gravity flow be handled by other means.

(AIRVAC, 2005)

III. OPERATION & MAINTENANCE CONSIDERATIONS

A. Staffing Requirements

Because they are mechanized, vacuum systems have a reputation as being O&M intensive. This may have been true of the early vacuum systems; however, information from system operators suggests that the effort to operate and maintain a modern vacuum system is typically overstated.

One key to a successfully operating system is the attitude, training and skill of the system operator. An even more important consideration may be how the maintenance staff is structured and organized. Maintenance staffs that divide operating responsibility by system components, e.g., one division responsible for the vacuum station, another responsible for the vacuum mains and a third responsible for the valves are rarely successful. Successful operations are those that have at least one operator who is responsible for the entire system *(see box below)*.

KEY TO SUCCESSFUL OPERATION
THE SYSTEM APPROACH

The major components of a vacuum system...the interface valves, the piping network, and the vacuum station... are interrelated and must be designed to work as a ***system***. Even more importantly, they must be operated as a system, not as individual components.

Making a change at the vacuum station affects not only the station components, but also the hydraulics of the vacuum mains and the operation of the valves. Cause and effect can only be learned by understanding how the entire system works and not by concentrating solely on one particular component.

For this reason, the most successful systems are those that are operated by a group with a single thought process. There is nothing wrong with several operators working together as long as they all know how the ***system*** responds to their actions.

B Operator Training

It is desirable for the management entity to hire the system operator before or during the period when the system is under construction. This allows the operator to become familiar with the system, including the locations of all lines, valve pits, division valves, and other key components. Also, the operator may assist the construction inspector as a means of becoming more familiar with the system.

Further training may be offered by manufacturers at their facilities and management should take advantage of it. By viewing a small-scale vacuum system that includes clear PVC pipe with various lift arrangements, trainees can watch the flow inside a clear pipe during a wide variety of vacuum and lift conditions. Faults can be simulated so that the trainee can gain troubleshooting experience. Manufacturers also provide schooling where he operator is taught valve operation and overhaul and vacuum station maintenance.

The best training is actual operating experience. As sometime happens, the best knowledge is often gained from operating mistakes. This is especially true at startup time. During this time, the engineer, who provided day-to-day inspection services during construction, is gradually spending less time on the system. The operator is busy setting vacuum valves and inspecting customer hookups. Complicating the situation is the fact that the operating characteristics of the system continually change until all of the customers are connected and all of the valves are fine-tuned. However, with the operator(s) being preoccupied with other tasks, this fine-tuning sometimes is not done and problems develop. The biggest concern during this period is that community confidence in the vacuum system not be lost.

This training gap is present at the startup of virtually every vacuum system. One solution is for the engineer to budget a 3 to 6 month on-site training service during the start-up period to aid the system operator in the fine tuning and troubleshooting any early problems. The operator will benefit from the engineer's systematic approach to problem solving. This most likely will instill a certain degree of confidence in the operator(s) concerning the system. Operator attitude is vital to the efficient operation of a vacuum, or any mechanically based, system.

C. *Maintenance*

There are two major classifications of maintenance: normal and preventive maintenance and emergency repairs or maintenance. A well-conceived asset management program emphasizes the former and minimizes the latter.

Normal & Preventive Maintenance

Vacuum systems operate and must be maintained 365 days a year. Variations in operation and maintenance workloads occur, making it imperative that preventive maintenance be planned and scheduled. This will ensure that there is no idle time during non- peak workload periods. Inspection and maintenance planning and scheduling involves time, personnel, equipment, costs, work orders, and priorities.

A preventive maintenance schedule for all major equipment should be developed. To initiate the preventive maintenance tasks, a work order system should be established. This system identifies the required work, priority of task, and any special information, such as the tools or parts required for the job.

Vacuum Station

A properly designed vacuum station will be equipped with a fault monitoring system, such as a telephone dialer or a telemetry system. These systems monitor the operation of both the vacuum station and the collection system, and automatically notify the operator of low vacuum, high levels of sewage in the collection tank, and power outages.

Normal operation includes visiting each vacuum station daily. Some daily maintenance procedures include the recording of pump running hours and oil and block temperature checks. Once an operator is familiar with the operating characteristics of the system, a simple visual check of the gauges and the charts in the station will provide an adequate alert of any problems. This visual check along with recording operating data generally takes about 30 minutes.

Daily, weekly, monthly and semi-annual tasks associated with the vacuum station are shown on Table 8.

Preventive maintenance for the major equipment at the vacuum station should be done in accordance with manufacturers' recommendations. In addition to the items in Table 8, yearly (annual) maintenance might include removal from service and comprehensive inspection of check valves, plug valves, vacuum pumps, sewage pumps, generator, and the telephone dialer.

Collection system piping
On a normal day, the operator will not be required to visit the collection system. Normal station gage and chart readings are an indication that the collection system is fine.

Scheduled maintenance on the collection piping should be minimal. Areas where difficult or unusual conditions were encountered during construction should be visited periodically.

At least once a year, the division valves should be checked. This is done by moving the valve through the entire opening and closing cycle at least once. This procedure is known as "exercising" and will keep valves in good operating condition. In addition, it will familiarize any new operating personnel with the location of all these valves.

Vacuum Valve
Depending on a system's history of emergency valve breakdown maintenance, some periodic inspection may be required. As with pressure sewer systems, certain on-lot units are prone to more problems than the rest of the system.

Access to valves for maintenance reasons is gained by removing the manhole cover on the valve pit. Routine maintenance is easily performed inside the standard valve pit from the ground surface. The only tools required are a manhole cover pick and a sensor pipe puller to drain any ground water that may have accumulated in the valve pit.

All vacuum valves should be inspected at least once each year[3]. They should be manually cycled to see that they are operating properly. The controller timing cycle should be recorded and compared to the original setting. If necessary, the timing should be reset and recorded. The operator should check for dirt or water in the controller, valve or tubing. If used, the above ground vent screens should be checked to see that that are clear of debris, spider webs, etc.

Table 8 summarizes the normal daily, weekly and monthly tasks for the system.

Table 8

Normal Vacuum System O&M Tasks
And Frequencies

Frequency	Task
Daily	Visually check gauges/charts Record all pump run times Check oil level in vacuum pump sight glass Test cycle the AIRVAC sump valve in station
Weekly	Test cycle the AIRVAC sump valve in station Change chart on chart recorder Exercise generator
Monthly	Change oil and oil filters on vacuum pumps Remove and clean inlet filters on vacuum pumps Test all alarm systems Check all motor couplings and adjust if needed Clean all sight glasses Exercise all shut off valves (vacuum station)
Semi-annually	Exercise isolations valves (vacuum mains) Conduct external leak test on all vacuum valves Check valve timing and adjust if needed

Every 5 years, each controller should be removed and re-built[3]. For valves that cycle more frequently, the controller should be rebuilt every three (3) years or 500,000 cycles. These would typically be valves installed in buffer tanks or other high-use locations. The controller should be replaced with a spare and the removed unit returned to the owner's workshop. Rebuilding typically involves replacing the shaft seals, greasing the shaft, and cleaning all components.

Every 10 years, each vacuum valve should be removed, a spare put in its place, and the old valve returned to the workshop[3]. The valve should be taken apart and inspected for wear. If worn, the valve seat should be replaced and a new shaft seal and bearing should be fitted during reassembly.

Table 9 summarizes the preventive maintenance tasks and their frequencies.

Table 9 Other Preventive Maintenance Tasks And Frequencies	
Frequency	Task
Every Year	Exercise Division valves (station & vacuum mains) Inspect Vacuum and sewage pumps for wear Visual inspection of all valve pits and valves Check valve timing and adjust if needed
Every 3 years	Rebuild Controller (buffer tank valves only)
Every 5 years	Rebuild Controller (most valves)
Every 10 years	Rebuild valve

Normally the operator will remove a valve or controller and replace it with a spare. The removal and replacement procedure takes about 5 to 10 minutes. The valve or controller is then taken to the maintenance show where rebuilding takes place. The time required to rebuild controllers and valves is shown on Table 10.

Table 10

Time Requirements for Rebuild Tasks

Item	Maintenance Interval	Personnel Required	Labor (hours)
Physical Inspection	Every year	1 man	0.50 hrs
Controller Rebuild	Every 5 yrs	1 man	
Sanitize			0.25 hrs
Rebuild			0.50 hrs
QC tests			0.25 hrs
			1.00 hrs
Valve Rebuild	Every 10 yrs	1 man	
Sanitize			0.25 hrs
Inspect			0.25 hrs
Rebuild			1.00 hrs
QC tests			0.25 hrs
			1.75 hrs

Emergency Maintenance

Although very little effort is required on a day-to-day basis, there will be times that emergency maintenance is necessary. This effort usually requires more than one person, particularly when it involves searching for a malfunctioning valve. Many times problems develop after normal working hours, requiring personnel to be called out on an overtime basis. Emergency or breakdown maintenance can occur in the piping system, at the vacuum station, or at the vacuum valve.

Vacuum Station

Malfunctions at the vacuum station are generally caused by pump, motor, or electrical control breakdowns. Redundancy of most components allows for the continued operation of the system when this occurs.

Collection System Piping

Assuming proper design and construction, there is very little physically that can go wrong in the piping system. Occasionally, a line break will occur, due to excavation for other utilities or landslides, causing a loss of system vacuum. By closing and opening division valves in a logical sequence in key areas along the piping route, the operator can easily isolate the defective section.

Other potential problems include system waterlogging or even a complete loss of vacuum that renders the entire collection system inoperable. Fortunately, these instances are very rare and usually short-lived. The AIRVAC *Installation, Operation and Maintenance Manual*[3] provides detailed procedures for correcting these system anomalies.

Vacuum Valves

Most emergency maintenance is related to malfunctioning vacuum valves caused by either low system vacuum or extraneous water. While failure of the valve is possible in either the open or closed position, virtually all (99%) occur in the open position.

When open-position failure happens, a loss of system vacuum occurs, as the system is temporarily open to atmosphere. The fault monitoring system will recognize this low vacuum condition and alert the operator of the problem. A common cause of failure in this position is the entrance of extraneous water into the controller.

Valve failures, if not located and corrected quickly, may cause failures in other parts of the system. A valve that is hung open or that continuously cycles will cause system vacuum to drop. If the vacuum pumps cannot keep up with this vacuum loss, the result is insufficient vacuum to open other valves. This may lead to backups. When vacuum is finally restored, a large amount of sewage, in relation to the amount of air, will be introduced into the system, possibly resulting in waterlogging.

A valve failing in the closed position will give the same symptoms as a blocked gravity line, that is, the customer will experience problems with toilet flushing or backup of sewage on the property. A phone call from the affected party makes identification of this problem easy.

Some systems in Europe have used individual, hard-wired alarms at each valve pit. This practice is not done in the U.S., as the costs of such systems generally outweigh the benefits, especially considering the increased reliability of the modern vacuum valve. Future vacuum systems may include a wireless alarm system, as there has been some recent progress in the development of such systems.

D. Spare Parts Inventory

Valves and Valve Pits

For optimum operating efficiency, it is necessary that a sufficient inventory of spare parts be kept. Some of the spare parts, such as fittings and pipe, can be purchased through local builder's supply companies. However, there are parts that are unique to vacuum systems that cannot be purchased locally. For convenience, these spare parts many times are included as part of the construction contract.

Table 11 is a recommended list of spare parts. As previously described, faulty valves and controllers are not repaired in place, but rather are removed and replaced with a spare. The rebuilding procedure is then done at the maintenance facility. The 3% spare valves and controllers and rebuild kits shown in Table 11 are for this purpose (i.e. – for emergency maintenance).

The spare parts in Table 11 are not intended for use in the wholesale rebuilding of valves and controllers that is associated with the preventive maintenance program. For that, inexpensive rebuild kits are typically purchased by the operating entity prior to this scheduled maintenance.

Table 11

Spare Parts List Per Every 100 System Valves

Quantity	Part
3 ea	3" Vacuum Valve
3 ea	Sump breather unit assembly
3 ea	Sump breather installation parts bag
3 ea	Controller
3 ea	Controller rebuild kit
6 ea	3" No-hub couplings
1 ea	3/8" clear vacuum tubing (6 ft long)
1 ea	5/8" clear vacuum tubing (12 ft long)
3 ea	3" grommets
3 ea	6" grommets
6 ea	Vacuum valve rebuild kits
12 ea	Controller mounting O-Ring
2 ea	Tube controller grease
4 ea	Tube vacuum valve grease
3 ea	Surge suppressor
12 ea	Tubing clamps
3 ea	Controller mounting key
3 ea	Cycle counters

Vacuum Station

The vacuum station also requires spare parts. These range from spare pump seals to fuses. Specialty items that should be considered are given in Table 12.

Table 12

Vacuum Station Spare Parts

Quantity	Item
15 gal	Oil
1 ea	Overhaul kit (vacuum pump)
1 ea	Filter Kit (vacuum pump)
1 ea	Motor-pump coupling set (vacuum pump)
1 ea	Seal kit for sewage pump
2 ea	Motor coupling (sewage pump)
1 ea	Gasket set (sewage pump)

Special Tools

In addition to spare parts, certain specialty maintenance tools and equipment are needed and are listed in Table 13.

Table 13

Specialty Tools and Equipment
(1 set per Project)

Quantity	Item
1 ea	Portable vacuum chart recorders
100 ea	Vacuum charts
3 ea	Chart pens
2 ea	0-20 in W.G. Magnehelic gauges
1 ea	0-50 in W.G. Magnehelic gauges
1 ea	Sensor pipe puller
1 ea	Valve repair stand
1 ea	No-hub torque wrenches
1 ea	Vacuum gauges
1 ea	Controller test box

E. Record Keeping

Good records are important for the efficient, orderly operation of the system. Pertinent and complete records provide a necessary aid to control procedures as they are used as a basis of the system operation. The first step of any troubleshooting procedure is an analysis of the records. A wealth of information is contained in the basic records.

Records should be kept on all normal, preventive and emergency maintenance as well as on operating costs. These should be preserved and filed where they are readily available to operating personnel. All records should be neat and accurate and made at the time the data are obtained. It is good practice to summarize this data in a brief monthly report and a more complete annual report. Ideally, the information can be entered into a computer program that can be accessed prior to the O&M staff initiating a call.

Normal Maintenance Records

The following information should be recorded on a daily basis:

- Date & weather conditions
- Personnel on duty
- Routine duties performed
- Operating range of vacuum pumps
- Run-times of vacuum pumps, sewage discharge pumps & generator
- Flow data
- Complaints received and the remedies
- Facilities visitors
- Accidents or injuries
- Unusual conditions
- Alterations to the system

Preventive Maintenance Records

Adequate records provide information that tells operational personnel when service was last performed on each system component and indicates approaching service or preventive maintenance requirements. Efficient scheduling of these maintenance tasks can be made which avoid interference with other important aspects of system operation.

Results of periodic inspections should be kept. This would include a list of all potential problems, the likely cause of these problems, the repairs necessary to solve the problem, and recommendations for future improvements to minimize recurrence.

Emergency Maintenance Records

Records should be kept concerning all emergency maintenance, including:

- Date and time of occurrence
- Person(s) responding to problem
- Description of problem
- Remedy of problem including total time to correct problem
- Parts and equipment used
- Recommendations for future improvements

Operating Cost Records

To insure budget adequacy, it is very important to keep accurate information concerning the costs of all operation and maintenance items. Costs include:

- Wages and fringe benefits
- Power and fuel consumption
- Utility charges
- Equipment purchases
- Repair and replacement expenses
- Miscellaneous costs

F. Operation and Maintenance Manual

To properly operate a vacuum sewer system requires proper training. Operation and Maintenance (O&M) Manuals are a vital part of this training process. Problems arose in some of the early vacuum systems due to the lack of such aids. Manufacturers and engineers are now recognizing this fact and are reacting accordingly with improved technical assistance and O&M Manuals.

While an O&M Manual is a valuable tool, it should not be viewed as the ultimate solution to every problem. The efficiency of the system depends on the initiative, ingenuity, and sense of responsibility of the system's operation/maintenance staff. Also, the manual should be constantly updated to reflect new operational experience, updated equipment data, and previous problems and implemented solutions. Typical information that should be contained in the O&M Manual includes:

- Design data
- Equipment manuals
- Shop drawings
- Permits & Standards
- Operation & Control information
- Personnel information
- Records
- Preventive maintenance schedules
- Emergency operating & response program
- Safety information
- Utility listings

IV. SYSTEM O&M COSTS

A. *Basis of O&M estimating charts*

Fifteen years ago, very little historical O&M cost data existed on vacuum sewers. This lack of data led many to the conclusion that vacuum sewers must be O&M intensive. A review of operating records of systems discussed in this chapter suggests that previously published O&M figures may no longer apply. Reasons for this are twofold. First, the previous figures were based on very limited data on a few early systems. Second, component improvements have resulted in significantly fewer service calls and lower O&M costs.

The U.S. EPA did a study on alternative collection systems, including vacuum sewers, in 1989 and 1990. Part of this effort included visits to operating systems in order to obtain information on operation and maintenance costs. The report containing this information, called the *Alternative Wastewater Collection Systems Manual* (EPA/625/1-91/024) was published in 1991.

It is important to note that a wide variety of projects were visited by EPA, including some of the earliest systems built, as well as systems that utilize design concepts and system components other than those used by modern systems. As one would expect, the earliest systems had the highest O&M costs (see Section II for discussion).

Design advancements coupled with component improvements have led to modern vacuum systems that are operated at much higher levels of reliability than their predecessors.

Information from the 1991 EPA Report, as well as information from recent (post-1990) systems gathered from the 2003 Operator Survey was used in the formation of the estimating tables that follow. For each particular O&M item, a cost range is given. With proper design, installation, and maintenance, the O&M costs at lower end of the cost range can be achieved.

B. *Operation and Maintenance Cost Estimating*

A discussion of the typical O&M cost components that must be considered follows.

Labor

To estimate labor costs, the number of person-hours required is multiplied by the hourly rate. Fringe benefits are then added. The annual person-hour requirements are made up of normal, preventive, and emergency maintenance. Judgment must be exercised in interpreting other projects for use in labor estimates *(see box below)*.

For most systems normal maintenance does not require an operator 24 hours a day. Monitoring of the system is provided by the telephone dialer/telemetry system. However, someone must at least be on call around the clock in case the telephone dialer calls with a problem. In this respect, vacuum systems are unique. Very few problems in a vacuum system can go uncorrected for any length of time without causing a cumulative effect. Therefore, rapid response time is a key requirement.

Typically, the normal workforce does preventive maintenance during off-peak working hours. As such, preventive maintenance is usually reported as normal maintenance.

EFFORT TO OPERATE A SYSTEM
ACTUAL VS. BILLABLE TIME

The operating Utility's overall responsibilities should be considered when estimating labor costs. For example, the Utility is likely to be responsible for other sewage treatment/disposal facilities, and possibly even water facilities. In these cases, operating personnel are usually shared. At the end of the year, the time charged to the operation of the vacuum system will relate exactly to the effort required (e.g., one (1) hour per day for each vacuum station plus some hours charged to other preventive and emergency maintenance). If the overall facilities are large enough to warrant more than one shift, emergency work most likely will be done without overtime being required.

An entirely different situation exists for the Utility operating nothing but a vacuum system. Typically, a full-time operator is hired. This person charges 8 hours a day to the maintenance of the system although most days he will spend much less than this. Should a problem develop after normal working hours, he most likely will be paid overtime. Even though the primary operator and part-time operator assistants will spend the same amount of actual vacuum sewer maintenance time as the staff with broader responsibilities above, the amount of billed time will appear be entirely different.

The engineer should carefully analyze the client's overall management responsibilities, taking into consideration the possibility of shared duties, prior to making an estimate of the labor costs.

Emergency maintenance many times requires personnel after normal working hours. The result is overtime pay. Emergency maintenance typically requires two operators or one plus an assistant.

Table 14 provides a range of labor hours required per year. These factors were based on an analysis of the O&M data from the 2003 Operator Survey described in Section II, which included systems of all ages, including some of the earliest systems. The mid-range values shown in Table 14 represent the average of all of these systems, while the high and low values shown have been slightly modified to correct for unusually low or high figures that could skew the analysis. The values shown should be considered as realistic estimate for new systems with proper design, construction, and management.

Table 14

Labor Estimating Factors
(Based on 2003 Operator Survey)

	Vacuum Station (hrs/yr/station)		Vacuum Mains (hrs/yr/system)		Vacuum Valves (hrs/yr/valve)	
	Range	Mid-range	Range	Mid-range	Range	Mid-range
Normal	100 - 400	250	20 - 40	30	0.20 - 0.80	0.50
Preventive	20 - 80	50	10 - 30	20	0.20 - 0.60	0.40
Emergency	20 - 40	30	5 - 15	10	0.20 - 1.00	0.60
TOTAL	140 - 520	330	35 - 85	60	0.60 - 2.40	1.50

When a full-time operator is to be hired, regardless of anticipated workload, the values in Table 14 should not be used. In this case, the estimated annual person-hour requirements should include the full-time hours of employment plus an estimate of the overtime (emergency maintenance) hours, taking into consideration overtime work generally requires two people. No allowance is needed for normal or preventive maintenance since these tasks can be performed during normal working hours.

Power

Power is required for the vacuum pumps, the sewage pumps, and the heating, lighting and ventilation of the vacuum station. For planning purposes, values shown in Table 15 can be used to estimate the annual power consumption for the vacuum station.

Similar to the economy of scale in capital cost, there is an economy of scale pertaining to power costs. The smaller vacuum stations typically have the highest power consumption per connection and the larger vacuum stations have the lowest power consumption per connection.

Table 15

Vacuum Station Power Consumption Estimating Factors

	Range (KwHr/yr/conn)	Monthly Cost @ $0.08/KwHr	Monthly Cost @ $0.10/KwHr
Low	200	$1.33/mo/conn	$1.66/mo/conn
High	400	$2.66/mo/conn	$3.34/mo/conn
Ave	300	$2.00/mo/conn	$2.50/mo/conn

Utilities

Utilities at the vacuum station generally include water, telephone, and fuel. Water may be required for sinks and hose bibs. A telephone is required for the fault monitoring system. Fuel may be required for the standby generator. The cost of these utilities generally is less than $85 per month ($4^{th}$ qtr 2006).

Clerical

This item includes wages for the clerical staff as well as billing costs such as envelopes and stamps. Like labor costs, the value of this item most likely will depend on whether the operating Utility has an existing, ongoing operation which requires office staff. If so, the total costs need to be allocated between the administrative responsibilities.

Transportation

Vehicle expenses to maintain the system will be incurred. For estimating purposes, a mileage rate multiplied by the estimated annual miles will suffice. This rate should include vehicle amortization, depreciation, taxes, and similar expenses.

Supplies/Maintenance

As with a conventional system, certain supplies will be required. Restocking of spare parts and inventory is included in this item, as are oil, fuses, charts, and chart pens. Initial purchase of items on quantity discount should be maximized to take advantage of the lower unit costs when compared to subsequent prices for replacement.

Service contracts for emergency generators, as well as fuel for the generators, may also be included in this item.

Miscellaneous Expenses

Miscellaneous expenses include insurance and maintenance on the system structures as well as professional services (engineering, accounting, legal) that may be required during the year.

Equipment Reconditioning and Replacement

A set-aside account should be established to generate sufficient funds on an annual basis for major equipment reconditioning and replacement. The annual cost of these needs is initially estimated by dividing the replacement cost by the useful life. This amount is generally set-aside in an interest bearing account until needed. Present dollars can be used in the estimate since the interest earnings most likely will offset inflation. Alternative methods dictated by regulatory agencies also can be employed. This annual cost estimate should be reviewed regularly to assure that sufficient funds are available to keep the systems running optimally. Table 16 lists the major equipment items and their useful life.

Table 16

Typical Reconditioning & Replacement Costs
For Major Equipment (4th qtr 2006)

	Cost range *	Expected Life (yrs)	Annual R&R ($/yr/sta)
Vac Pumps (2)	$10,000-$34,500	15-20 yrs	$ 500-$2,300
Discharge Pumps(2)	$ 6,000-$19,200	15-20 yrs	$ 300-$1,280
Collection Tank	$ 5,000-$11,000	25-50 yrs	$ 100-$ 440
Control Panel	$ 5,000-$21,200	20-25 yrs	$ 200-$1,060
Misc equip	$ 2,000-$ 3,300	15-20 yrs	$ 100-$ 220
		TYPICAL RANGE	$1,200-$5,300

* function of equipment size

Valves and controller can be rebuilt very inexpensively (see Preventive maintenance section). For this reason, R&R funds are not required for total replacement, but rather just for the rebuild costs. Table 17 shows these operating costs.

Table 17

Typical Rebuilding Costs
For Valves & Controllers (4th qtr 2006)

	Cost range	Rebuild frequency (yrs)	Annual R&R ($/yr/valve)
Vacuum valves	$27.00-$38.00	8 -12 yrs	$2.25 - $ 4.75
Controller	$27.00-$38.00	4 - 6 yrs	$4.50 - $ 9.50
		TYPICAL RANGE	$6.75 - $14.25

V. SYSTEM MANAGEMENT CONSIDERATIONS

A. *Sewer Authority Responsibilities*

Customer connection to system

Table 18 shows the normal sequence of events, from construction of the system to home-hook-up. Note that the contractor does not install the vacuum valve during the construction phase (see discussion later in this section). When all contractual obligations are fulfilled, the system is accepted by the Utility and the homeowners are notified that the system is ready.

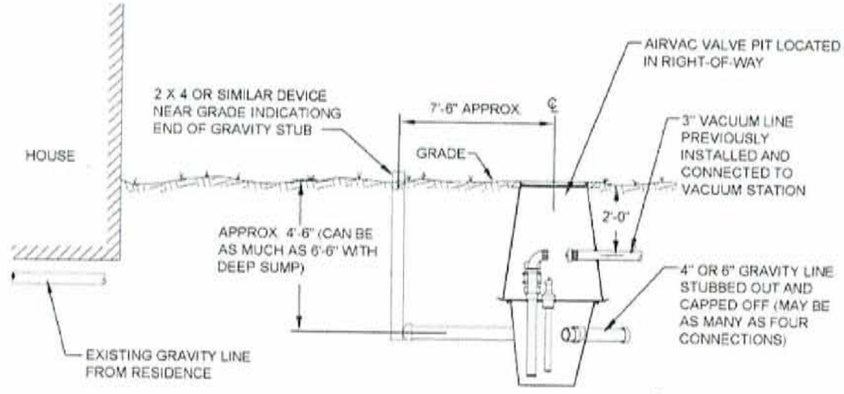
Table 18

Normal sequence for connection

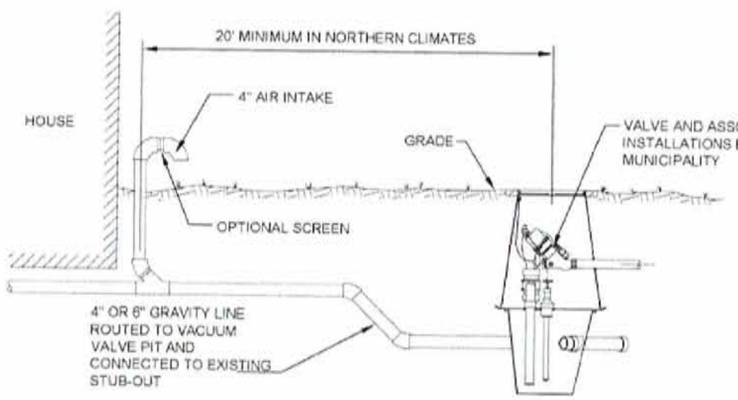
Tasks	Responsible party
Lines, pits & vacuum station installed	Installation Contractor
Final 4 hr vacuum test & line flushing	Installation Contractor
System acceptance & notification to homeowners that system is ready	Utility
Building sewer & air intake installed	Homeowner's plumber
Vacuum valve installed	Utility

Recommended: Utility installs the vacuum valve after construction phase

The vacuum valve is not installed until the customer is ready to connect to the valve pit setting (see Figure 1). It is common for the contractor to install the valve pit/sump, including all of the necessary piping, during collection system construction. The valve is supplied to the Utility for their installation at a later date. In this manner, the Utility can systematically install the valves as each customer requests connection.



VALVE PIT INSTALLATION PRIOR TO HOME CONNECTION



VALVE PIT INSTALLATION WITH HOME CONNECTED

Figure 1
Valve Pit Installation
(Courtesy AIRVAC)

Not recommended: Installing the vacuum valve during construction phase
In an effort to relieve the Utility from installing the vacuum valve, some engineers set up their bid documents to require the Contractor to install the vacuum valve during construction. This is not recommended for the reasons shown in Table 19.

Table 19

Potential Problems
If valve is installed during construction phase

Potential Problem	Reason
Pit collapse or implosion	Cycling the vacuum valve without the homeowner's building sewer and 4-inch air intake installed can result in the bottom sump collapsing. This would require the pit to be re-excavated and replaced.
Difficulty assigning blame if 4 hr vacuum test fails	The intent of the final 4-hour vacuum test is to test the contractor's workmanship in installing the vacuum lines. Testing with the valve in place introduces one more variable: the valve may leak. Failure due to a leaking valve is not the contractor's responsibility.
Homeowner may illegally hook-up early	With a complete system available, the homeowner may connect to the valve pit without the Utility's knowledge. This action would preclude the Utility from doing the normal inspection of the homeowner's gravity lateral, air intake, etc. This could lead to some serious problems such as sump collapsing, I&I problems, water in the controller, etc.

A further complication may occur if a failed vacuum test is due to a combination of a valve leaking as well as a line leak(s). This could cause some real difficulties in troubleshooting to determine where the problem really is and in subsequently assessing liability. Contractor liability versus manufacturer liability is clear-cut when the testing is done without the valve in place.

Operating personnel

Once all customers are connected, the Utility's only focus should be providing reliable, efficient service to their customers. To achieve this, the operating personnel must be capable, dependable, and knowledgeable. Of utmost importance is attitude. An operator that does not believe in the system will ultimately cause the system to operate below its potential, in terms of reliability and costs. Conversely, one with a good attitude uses creativity to get more out of the system than was originally planned.

Sewer Use Ordinance

To operate any system at a high level of efficiency requires a Sewer Use Ordinance. This document sets consistent rules for all users to follow. Included are material specifications, minimum slope requirements and air-intake locations for the building sewer. Of extreme importance to the Utility is a limitation of use of the vacuum sewer to convey sanitary wastes only, as extraneous water (illegal discharges or I/I) will cause operational problems.

An active program for the identification of extraneous water sources should be developed. This may include smoke testing and dye testing, but the simplest approach to quantify sources of extraneous water in a vacuum system is to use cycle counters. This device, when connected to an interface valve, will record the number of times the valve opens in a given period. Knowing that each cycle is approximately 10 gallons, the Utility can estimate, based on water consumption records, the number of cycles expected over that period. A count significantly in excess of the expected number of cycles usually implies that extraneous water is entering the system.

The Utility's other major concern during this full-operational phase is its responsibility for future extensions of the system. This includes proper planning, design, and construction of such extensions. Utility, in accordance with the provisions of the Sewer Use Ordinance, is also responsible for implementing future connections to the existing system.

Private vs Public ownership of equipment serving house

There are two issues to consider: 1) actual ***ownership*** of the valve/valve pit and 2) ***maintenance*** the valve/valve pit. In the case of vacuum systems, the valve and valve pit are both owned and maintained by the public operating Utility as discussed in the following paragraph.

Because of the "system" nature of vacuum sewers, the maintenance of a vacuum system, including the valve pit and the valve, must be done by the Utility. Improper maintenance at a single valve pit could affect the entire system, including the line hydraulics and the operation of the station. Obviously this would jeopardize the system and affect other customers. So, it is not prudent to put this in the hands of the homeowner. The only way to guarantee maintenance of the valve and valve pit is by the Utility actually owning it.

B. Homeowner Responsibilities

The homeowner's responsibility usually begins at the end of the valve pit stub-out and includes the building sewer, the air intake and any in-house needs.

Most Utilities require the homeowner to replace the building sewer from the house foundation to the stub-out connection, since vacuum sewers are not designed to handle extraneous water. By accepting old, possibly defective building sewers, the Utility would be taking a serious risk on increased operation and maintenance problems.

The homeowner is also responsible for the installation of the 4-inch air-intake. The air-intake is necessary for the proper operation of the valve. It is desirable for this to be located against a permanent structure, such as the house itself, a fence, or a wall.

All of the work required by the homeowner must be inspected by the Utility prior to final connection. This ensures the proper and efficient operation of the system. Compliance with the Sewer Use Ordinance is the only remaining user responsibility. Typical requirements include that the homeowner should not drive or build over the valve pit, and should protect the facilities from damage. Discharge of flammables, acids, and excessive amounts of grease, sanitary napkins, or other non-sewage items is forbidden. This requirement differs little from user ordinance requirements for conventional sewers. Proper use of the system results in lower user charges and improved reliability.

C. *Other Entities*

During the planning, design, and construction of wastewater management systems, there are many different entities involved. Two vitally important ones are the regulators and the engineer. It is during these times that critical decisions are made and details finalized.

Engineer

Historically, engineers have often viewed the startup of a wastewater system as their final involvement. While this attitude is economically understandable, it is not acceptable where local management programs are minimal. Continuing involvement should be provided to help the Utility develop an experience base with newer systems that permits intelligent applications in the future.

The engineer should spend a significant amount of time assisting the Utility during the startup of the system. Tests should be run and problems simulated to see if the system is operating as designed. On a regular basis (often annually), the operating records should be analyzed for budget sufficiency purposes. Institution of EMS practices can assure that any problems and their solutions will be identified and addressed by the Utility. In short, the engineer should be prepared to assist the Utility in using the operating experience of the system to help develop improvements in future designs.

Regulatory agencies

Likewise, regulatory agencies must, as part of their oversight responsibilities, be aware of the potential impacts of the operation of a new collection system on environmental compliance of the entire wastewater management program. Information on problems, including causes and the remedies, should be gathered by the Utility for review by the regulatory agency. Cost and other data should be obtained and used accordingly by the regulators in counseling future potential users of this type of collection system.

It is this present lack of useful capital and operational costs and other pertinent information that causes many engineers and regulatory agencies to shy away from new technologies. Continued use of conventional solutions that are well known and codified is far easier for regulators and engineers than seeking lower-cost, new solutions to solve wastewater pollution problems. Therefore, implementing new solutions, no matter how cost-effective, will continue to be difficult.

D. *Education Process*

Prior to 1990, very little written documentation existed on vacuum sewers. Much of the recent growth in the vacuum sewer industry can be attributed to the ever-increasing amount of information regarding the technology. Sources of this information can be found in technical presentations, papers that have been presented at conferences, articles that have appeared in trade journals, and factory & project tours.

Papers and trade journals

Since 1990, there have been several papers on vacuum sewers presented at the Water Environment Federation's (WEF) annual conference as shown on Table 20.

Table 20

Papers on Vacuum Sewers
Presented at WEF Conferences since 1990

Feature Project	Year	WEF Conference	Primary Author
Update of Operating Systems	1990	Washington, DC	Rich Naret, P.E. Cerrone & Associates
Salmon Beach, WA	1991	Toronto	George Norby, P.E PEI Barrett.
Queen Anne's Co, MD	1993	Anaheim	Gary Moore Queen Anne's County
Albuquerque, NM	1994	Chicago	E.D. Whitis, P.E. HDR
Englewood, FL	1997	Chicago	Jonathan Cole, P.E. Giffels-Webster
Beach Road MUD, TX	2000	Anaheim	George Neill, P.E. Neill Engineering
Provincetown, MA	2002	Chicago	James Sullivan, P.E. Metcalf & Eddy
Plum Island, MA	2002	Chicago	Theresa McGovern Camp Dresser & McKee
Sarasota Co, FL	2003	Los Angeles	Dan Burden, Ph.D, P.E. Hazen & Sawyer
Vashon Island, WA	2003	Los Angeles	John Wilson, P.E. PEI Barrett
Plum Island, MA	2004	New Orleans	Don Mauer, P.E. Camp Dresser & McKee
Albuquerque, NM	2006	Dallas	Robert Paulette, P.E. Wilson & Co

Most of the major trade journals have published articles on vacuum sewers. These include Water Environment & Technology (WE&T), Public Works, Civil Engineering, Civil Engineering News (CE News), Government Engineering, Underground Construction, Land Development Today and the National Small Flows Clearinghouse (NSFC).

Technical presentations

For consultants and prospective system owners to learn more about vacuum sewer systems, vacuum manufacturers typically provide technical training through presentations. These presentations range from planning (vacuum basics) to detailed design to construction and O&M.

Factory and project tours

In addition to the technical seminars, vacuum manufacturers also conduct factory tours and tours of operating systems. The intent of the factory tour is to increase the comfort level of those considering the use of vacuum technology. Specifically, the factory/project tour does the following:

- Provides a basic understanding of vacuum sewer system principles.
- Demonstrates the actual components used in a real system.
- Provides participants with firsthand knowledge of vacuum systems by visiting those who've designed, constructed, and operated these types of systems.

The primary reason for a Utility or its engineer to attend a factory/project tour is to find out firsthand whether or not they, as responsible officials, can recommend this technology for their particular situation. Feedback from these groups indicates that the visit to the factory and/or an operating system ultimately allowed them to make an intelligent, educated decision.

References

1. B.C. Burns et al. *Method and Apparatus for Conveying Sewage.* Patent No. 3,730,884, May 1, 1973.

2. *Alternative Wastewater Collection Systems.* EPA/625/1-91-024, U.S. Environmental Protection Agency, Cincinnati, Ohio, 1991.

3. AIRVAC Operation, Installation & Maintenance Manual, Rochester, IN., 2005.

Att. 5

Sarasota County Sewers

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- HOME
- Project Areas
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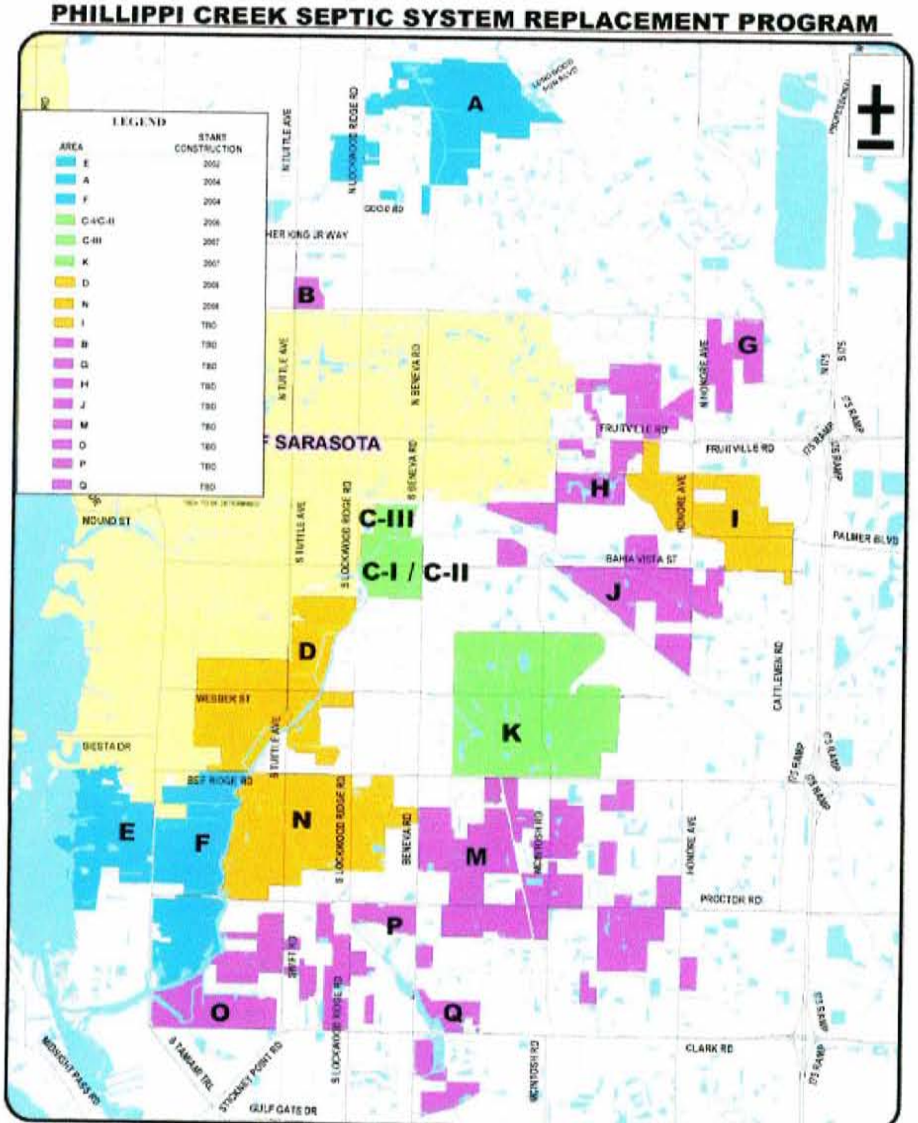
Sarasota County is in the midst of a multiyear utilities project to protect public health and safeguard our environment. The septic system replacement program was initiated to improve wastewater treatment for home and businesses.

Central sewer lines and other needed infrastructure are replacing individual septic systems and small, private package wastewater treatment plants in many Sarasota County neighborhoods. About 14,000 septic tanks will be replaced over the life of the project.

The map below shows the project areas. All properties within those boundaries will be assessed when the work is done. Click on the "Finance" tab on the left to learn more.

Click an area for sewer project details.

PHILLIPPI CREEK SEPTIC SYSTEM REPLACEMENT PROGRAM



OVERALL AREAS

SEPTIC VS. SEWER: A COST COMPARISON FOR COMMUNITIES IN SARASOTA COUNTY, FLORIDA

wef proceedings

Authors: Burden, Daniel G.; Anderson, Damann L.; Zoeller, Patrick
Source: Proceedings of the Water Environment Federation, WEFTEC 2003: Session 51 through Session 60 , pp. 319-343(25)
Publisher: Water Environment Federation

< previous article | next article > | view table of contents

Abstract:

In April 1997, the Sarasota Board of County Commissioners agreed that aging septic systems and small wastewater package plants were factors contributing to the pollution of Phillippi Creek, a major tributary to Sarasota Bay which has been designated as a National Estuary. In 1998, planning efforts were initiated whereby a total of sixteen (16) communities, within the urbanized, unincorporated area of Sarasota County were identified as requiring improvements to existing wastewater treatment practices to improve the water quality of Phillippi Creek and Sarasota Bay. Within the 50+ square mile watershed, a total of 14,000 parcels were utilizing septic systems, typically older systems situated on small parcels with sandy soils and a high groundwater table. These systems discharge wastewater volumes of approximately 3 million gallons per day (gpd) to the subsurface environment.

An assessment of available and applicable onsite wastewater treatment system (OWTS) upgrades and collection system technologies was completed to develop alternatives to improve the current wastewater treatment and disposal practices in these sixteen communities. Based on the assessment, cost comparisons of the various alternatives were made to determine whether existing OWTS should be upgraded or replaced by central sewer systems to provide needed water quality improvements in Phillippi Creek and Sarasota Bay. Cost analyses were performed based on the range of residential lot sizes in the area and included the following categories: Low Density (> 0.5 acre average lot size), Medium Density (0.25 - 0.5 acre average lot size), and High Density (< 0.25 acre average lot size). Three of the sixteen communities were selected as represent ative communities for low, medium, and high density communities, respectively.

The assessment of OWTS upgrade alternatives was completed based on their relative costeffectiveness, treatment performance and land area requirements within the specific limitations of the study area. The capital and O&M costs for the selected alternatives were estimated based on information obtained from equipment manufacturers and local contractors, recent bid information, and general engineering experience. All treatment system sizes were based on a 3- bedroom single family residence with a flow of 300 gallons per day (gpd).

Wastewater collection alternatives were reviewed on the basis of numerous factors including technical feasibility, compatibility with the existing infrastructure in the project area, public acceptance, and cost of implementation. Three sewer collection alternatives were selected for detailed cost analysis: (1) conventional gravity sewers, (2) low pressure/grinder pump systems, and (3) vacuum sewers. Conceptual layouts for the same three communities (low, medium and high density) were developed for all collection alternatives and detailed cost analyses were performed.

Based on a comparison of estimated uniform annual cost per connection, the most cost effective alternative for a community depended significantly on density of development. The collection system costs for the different communities varied widely, not only because of the effects of development density, but also due to the difference in the total number of connections and existing street layouts used in the analyses. The vacuum collection system was the most costeffective alternative for both the medium and high density areas, while the OWTS alternative (septic tank with mounded drainfield) was found to be the lowest cost alternative for low density areas. Results of this analysis were utilized for further definition of the collection system requirements under the preliminary design phase of the project. While selection of a wastewater alternative based on density was found to appropriate, this methodology did have limitations where development density is non-uniform and not contiguous. These situations required further detailed analysis during final design, considering existing infrastructure and the individual densities of sub-areas.

Considering the relatively dense urban development in the project area, Sarasota County selected central sewer collection systems as the design alternative for all 16 communities within the Phillippi Creek Study Area, with vacuum collection chosen for approximately 80% of the areas. The design, construction, and operation of central sewers proved to be the most costeffective option for improving the current wastewater treatment and disposal practices in the Phillippi Creek study area.

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< previous article | next article > | view table of contents

Back to top

Phillippi Creek Septic System Replacement Program (PCSSRP)
Quarterly Executive Summary
March 2008

Completed to Date:

Area E The Area E project, consisting of 578 connections, was completed in February 2003. As of March 31, 2008, 526 customers have connected to central sewer.

Area F The Area F project, consisting of approximately 1,063 connections, was substantially complete in October 2005. As of March 31, 2008, 955 customers have connected to central sewer.

Area A The Area A project, consisting of 1,125 connections, was completed in April 2007. As of March 31, 2008, 840 customers have connected to central sewer.

Construction Activities:

Area C The Area C project will make central sewer available to approximately 694 homes. Construction completion is scheduled for July 2008.

Area K The Area K project will make central sewer available to approximately 2,650 connections. The project is integrated with a Public Works sidewalk project. Wastewater flow from Area K will be pumped to the Bee Ridge Water Reclamation Facility with a transfer pump station located just south of the Atlantic Water Reclamation Facility. Construction of Area K, east of McIntosh Road, began in May 2007 and is expected to be completed in January 2009. Construction of the area west of McIntosh Road began in October 2007 and is expected to be completed in June 2009.

Ongoing Activities:

Area D The Area D project will make central sewer available to approximately 1,485 connections. The project will be bid and constructed in phases with the first phase construction anticipated to begin in the fall of 2008. Successive phases will be constructed as the designs are completed. A small, northern portion of Area D has some franchise territory issues with the City of Sarasota. An inter-local agreement for proposed sewer service in this northerly section of Area D will be drafted for the City of Sarasota's review once the design and estimated costs have been determined. The majority of this area is currently served by city water. It is expected that this area will be designed as a gravity system with collected flows pumped to either the future South Gate Master Pump Station or to the City of Sarasota, depending on the directives of the City/County inter-local agreement. The remaining areas will be served by vacuum collection and directed to the future South Gate Master Pump Station.

Area N The Area N project will make central sewer available to approximately 1,949 connections. Design of Area N began in June 2006. Construction is expected to start in early 2009 and be completed in late 2010. Wastewater collected from Area N will be pumped to an existing force main in Proctor Road and then directed to the Central County Water Reclamation Facility.

Area I The Area I project will make central sewer available to approximately 929 connections. The vacuum pump station and some main line vacuum are under design in order to determine the sizing requirements needed for the shared structure housing the Bahia Vista Street interconnect booster pump station. Construction of the vacuum pump station and the collection system are not funded at this time.

Area J The Area J project will make central sewer available to approximately 307 connections. The project has been moved outside of the current 5 Year CIP until additional funding is available.

Area O The Area O project will make central sewer available to approximately 809 connections. The project has been moved outside of the current 5 Year CIP until additional funding is available.

Area P The Area P project will make central sewer available to approximately 661 connections. The project has been moved outside of the current 5 Year CIP until additional funding is available.

Area B The Area B project, which includes approximately 106 connections, has been placed on hold and has been moved outside of the current 5 Year CIP until additional grant or supplementary funding is available.

Areas G, H, M and Q Certain sub-areas of Areas G, H, M and Q may be included in other project areas and will be analyzed on a case by case basis. Affected residents will be notified as these sub-areas are identified.

Wastewater Transmission & Treatment:

A number of critical transmission and treatment plant expansion projects are needed to collect and treat wastewater from the PCSSRP. The Central County Water Reclamation Facility will undergo expansion from 4.0 to 8.0 million gallons per day in two phases. Construction of the Phase 2 expansion began in April 2007 and is scheduled for completion in December 2008. The construction of Phase 3 will immediately follow the completion of Phase 2 and is scheduled for completion by December 2010.

Transmission projects include several new pump stations and force mains. The South Gate Advanced Wastewater Treatment Plant (AWWTP) is to be replaced with a master transfer pump station. Construction began in late November 2007 and scheduled to be in operation by June 2008. Construction of the Gulf Gate AWWTP began in late September 2007 and is also scheduled to be in operation by June 2008.

The Bahia Vista Force Main Project, from Hines Avenue to Cattlemen Road, is complete, including the booster pump station bypass. Construction of the booster pump station at Honore Avenue and Bahia Vista Street is expected to begin in late 2008.

Both phases of the University/I-75 Force Main project are complete. The wastewater transmission main begins east of I-75 near the center of Lakewood Ranch Corporate Park and extends southward along an extended Lakewood Ranch Boulevard, Tatum Road, Palmer Road, and Iona Road, ultimately ending at the County's regional Bee Ridge Water Reclamation Facility for treatment and reuse.

Construction started for the Area A Force Main Interconnect project in July 2007 and is scheduled for completion in April 2008. The project consists of construction of 7,850 linear feet of 12" parallel force main from North County Pump Station No. 1, inside Longwood Run Park, to Honore Avenue, where it will be connected to a parallel 12" force main and a single 18" force main to be constructed by the developer of the SIPOC property. The 18" force main will extend to North County Pump Station No. 3. The developer- constructed force main will continue south to connect to the University/I-75 Force Main project, which will transmit flow to the Bee Ridge Water Reclamation Facility.

Budget Activities:

Schedule A, attached, depicts the current PCSSRP Budget. As shown, the total Budget is $183 million, an increase of $27 million over the FY07-FY11 Budget. The increase is attributable to rising construction costs.

Funding Review:

Schedule A shows the total estimated funding for the PCSSRP by area. Areas E, A, F, C, and K (all complete or under construction) have a total cost to date of $65.1 million for an average cost per EDU of $10,664. The funding breakdown for these five areas is State Revolving Funds (SRF) debt 39%, grants 22%, Surtax 31% and rates 8%.

The current cost per EDU for Area K, reflective of the most recent construction cost, is $11,515.

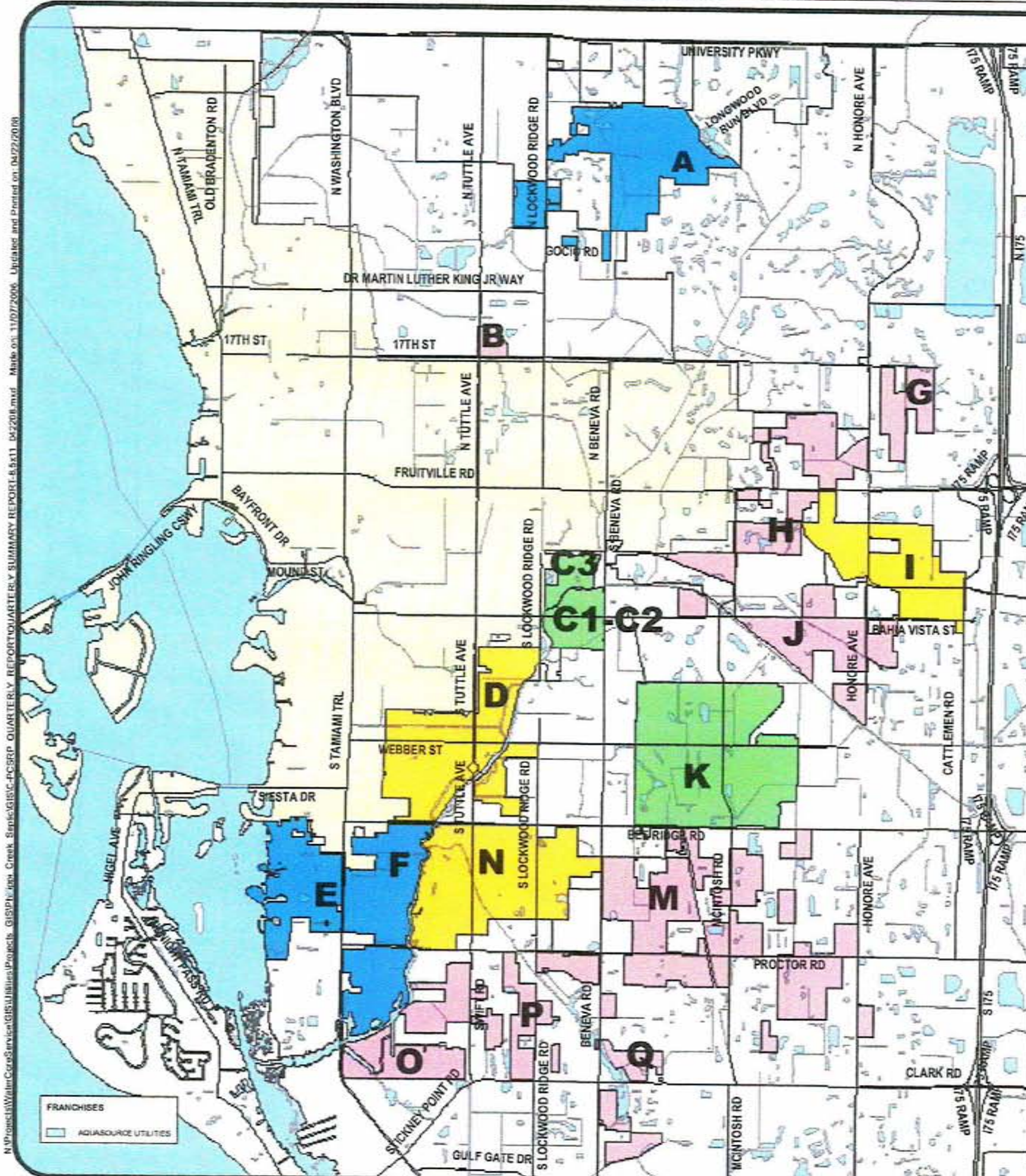
Rising construction costs and the uncertainty of future grant revenue are impacting this program. A recent program evaluation resulted in putting several areas on hold until further funding can be evaluated. These areas are shown on Schedule A.

SCHEDULE A
Executive Summary
PCSSRP Current Budget
March 2008

Budgeted Hookups	CIP #	Area	Design Start	Constr Start	Current Budget (1)	Projected Funding: Rates	Grants	Surtax	State Revolving Fund Preconstruction Loan	State Revolving Fund Construction Loan	Funding Undetermined	Total Funding
577	55900	E	Complete	Complete	4,805,563	381,281	-	3,708,325	715,957	-		4,805,563
1125	55901	A	Complete	Complete	9,723,133	3,747,718	3,334,353	1,428,112	1,212,950	-		9,723,133
1063	55924	F	Complete	Complete	9,680,550	274,297	1,458,672	2,048,094	196,462	5,703,025		9,680,550
694	55903	C	FY02	Under Constr	10,423,622	662,189	1,613,375	7,553,058	595,000	-		10,423,622
2650	55907	K	FY04	Under Constr	30,515,547	324,547	7,950,000	5,176,000	2,000,000	15,065,000		30,515,547
1485	55904	D	FY02	FY08	16,543,439	1,875,632	-	4,136,532	1,200,335	9,330,940 (3)		16,543,439
1949	55909	N	FY05	FY09	22,307,053	89,719	5,000,000 (2)	599,165	1,630,631	14,987,538 (3)		22,307,053
929	55906	I	FY07	FY09	10,751,009	261,907	5,000,000 (2)	982,971	1,000,000	3,506,131 (3)		10,751,009
307	Area J	J	TBD	TBD	4,216,729	-	-	-	-	-	4,216,729	4,216,729
908	55905	G & H	TBD	TBD	12,471,626	-	-	-	100,000	-	12,371,626	12,471,626
1893	55908	M	TBD	TBD	25,714,713	-	-	213,841	152,509	-	25,348,363	25,714,713
106	55902	B	TBD	TBD	1,635,885	102,000	-	-	305,000	-	1,228,885	1,635,885
809	55910	O	TBD	TBD	9,741,278	-	-	1,317,038	100,000	-	8,324,240	9,741,278
661	55911	P	TBD	TBD	7,959,190	-	-	875,975	100,000		6,983,215	7,959,190
260	55912	Q	TBD	TBD	3,571,171	-	-	-	100,000		3,471,171	3,571,171
15,416												
		Total Design/Construction			180,060,508							
	85908	Total Program Management			3,387,165	2,887,165	500,000	-	-	-		3,387,165
		Total CIP Budget			183,447,673	10,606,455	24,856,400	28,039,111	9,408,844	48,592,634	61,944,229	183,447,673

(1) Represents an increase of $27 million over the FY07-FY11 projection.
(2) Projected WRDA grant. Timing unknown at this time.
(3) Projected borrowing. Each will be a seperate loan application and evaluated individually by FDEP/SRF.

PHILLIPPI CREEK SEPTIC SYSTEM REPLACEMENT PROGRAM - QUARTERLY REPORT



Sarasota County

N.T.S.

AREA PROGRESS LEGEND

- (blue) COMPLETED CONSTRUCTION
- (green) AREA UNDER CONSTRUCTION
- (yellow) AREA UNDER DESIGN / AWAITING BID
- (pink) FUTURE DESIGN / CONSTRUCTION

TBD: TO BE DETERMINED

AREA-INFORMATION

AREA	HOOKUPS	SEWER TYPE	DESIGN START	CONST. START	DESIGN (%)	CONSTR. (%)
E	577	VACUUM	2001	2002	100	100
F	1,063	VACUUM	2002	2004	100	100
A	1,125	VACUUM, LOW PRESSURE, GRAVITY	2001	2004	100	100
C1-C2	495	VACUUM	2002	2006	100	95
C3	199	VACUUM	2002	2007	100	95
K	2,650	VACUUM	2004	2007	100	75
D	1,485	VACUUM, LOW PRESSURE	2002	2008	85	---
N	1,949	VACUUM LOW PRESSURE	2006	2009	35	---
I	929	VACUUM	2007	2009	---	---
O	809	VACUUM	2008	TBD	---	---
P	661	VACUUM, LOW PRESSURE	2008	TBD	---	---
B	106	LOW PRESSURE, GRAVITY	ON HOLD	TBD	90	---
G	521	LOW PRESSURE, GRAVITY	TBD	TBD	---	---
H	387	LOW PRESSURE, GRAVITY	TBD	TBD	---	---
M	1,893	VACUUM, LOW PRESSURE, GRAVITY	TBD	TBD	---	---
Q	260	LOW PRESSURE, GRAVITY	TBD	TBD	---	---
J	307	VACUUM	TBD	TBD	---	---
TOTAL:	15,416					

March 2008

Att. 6

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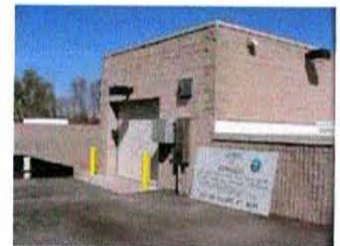
Vacuum Sanitary Sewer Systems

Albuquerque, New Mexico

Wilson & Company has been a technical leader in the development of vacuum sewer systems in the Albuquerque metropolitan area. Vacuum sewer systems are a cost-effective choice in areas of extremely flat terrain, high groundwater, or rocky soil. Where traditional sewers are located 8-10' in the ground and increase in depth at approximately a foot for each 250' of length (8" sewer at 0.4% slope), installation costs can be very expensive for installation. In addition, after ¼ - ½ mile, the depth of sewer becomes somewhat cost prohibitive. In such a case, sewage must be lifted by pumps to the more economical depth of 8-10', thus creating additional cost. Vacuum sewers utilize the common vacuum pump station to transport sewage and are much shallower. Generally, the vacuum sewer is approximately 5' deep and can maintain this depth for over 1 ¼ miles. This keeps the sewer shallow and eliminates the need for intermediate lift stations.



Area B & F Vacuum Station – Similar to the vacuum station proposed for Areas D & E

Wilson & Company has been involved with the development of vacuum systems throughout the metropolitan area since the early 1990's. We have assisted the city in developing 'standard' footprints for vacuum stations as well as establishing standards of design and construction City- and state-wide. Such standardization included overall building layout, two-vacuum tank design for reliability & ease of maintenance, uniform sizing of vacuum pumps City-wide for uniformity of spare parts, and compost biofilters for odor control. Our experience totals over has included:

Vacuum Sewer Construction in Area B & F

Location	Service Area	Services	Cost	Status (as of early 2004)
Areas B & F	North Valley	900	$3,500,000	In operation since 2000
Area E (sewer only)	North Valley	100	$900,000	In operation since 2003
Areas D	North Valley	950	$6,000,000	Complete late 2004 +
Area K	North Valley	440	$3,000,000	Vac Station under construction Vac Sewers under bid
La Cuentista (vac station only)	West Mesa	865	$1,100,000	In Design

Area B, F, D, E, and K are designated areas in the North Valley where shallow groundwater and flat terrain conditions are perfect for the application of vacuum systems. Areas B & F are served by a single centrally-located vacuum station and have 4 main vacuum sewer lines extending in a service area of 2 miles by 1 mile in size. The Area E project extended sewers from an existing vacuum station (previously constructed in 1995). The Area D project included over 18 miles of vacuum lines served by a single vacuum station. Area K included a vacuum station that needed to blend into the existing residential area, including extensive landscaping and building modifications. The La Cuentista vacuum system, located on the west mesa area, utilized vacuum sewers because of the extensive lava rock in the proposed subdivision. This design took a different approach to the vacuum station design, relying on a more slimmed down station with the tops of vacuum tanks at-grade for easier access.

Work included design and construction services as well as public information programs, environmental assessment and documentation, and startup assistance and system optimization.

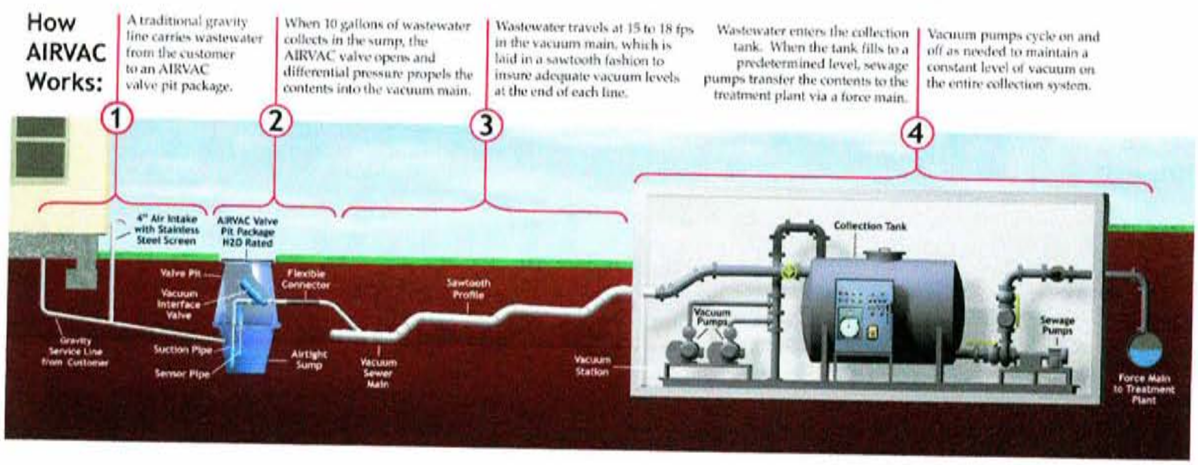
To Top of Page

design/construction was established. Several of these project areas did include gravity sewers, but the vast majority were vacuum sewer systems.

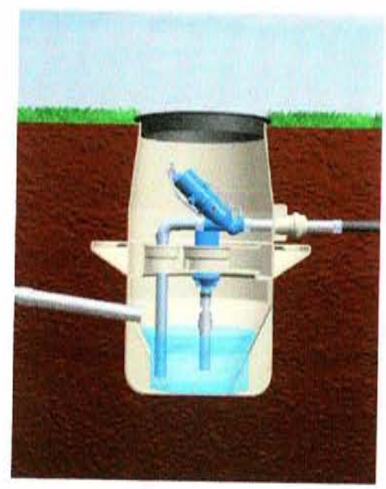
Overall, each vacuum sewer system generally extended approximately a mile in each direction. Where possible, the vacuum station was centrally located in order to provide collection in all directions.

VACUUM SEWERS – HOW THEY WORK

The concept of vacuum sewers has been around since the late 1800s and used in Europe for years, but only in the last 30 years has the technology been widely utilized in the United States. AIRVAC is the pioneer in vacuum sewer system technology. Their systems have been installed thoughout the US as well as many installations throughout the world. AIRVAC played a significant role in assisting the City and consulting engineers in the development of a high-quality comprehensive design for Albuquerque.



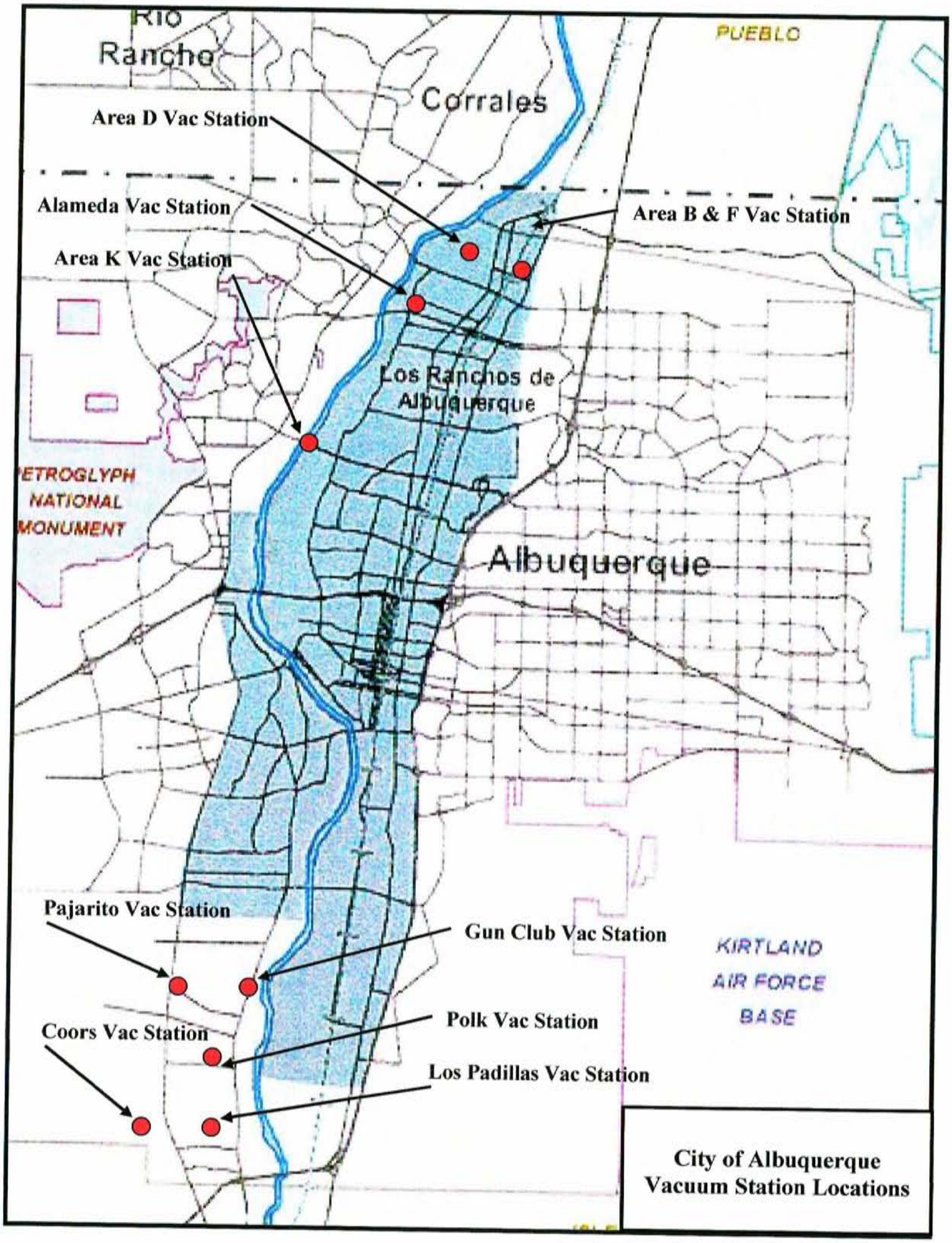
As shown in this AIRVAC figure, vacuum sewer systems first rely on gravity to move wastewater from each house to a nearby valve pit, usually located at the interface of Right-of-Way and the private property. The valve pit houses a collection sump and a vacuum/gravity interface valve. There is typically one valve pit for every two houses attached to a vacuum system, although each pit can usually service up to four residences. When wastewater in the sump reaches a predetermined level, usually about 10 gallons, the interface valve is activated and the sewage enters the collection line. One of the great features of the AIRVAC differential valve is that it works pneumatically, no electricity is required. That makes installation simpler. The valve itself is separated from the collection sump in a sealed fiberglass enclosure, so routine valve maintenance does not involve contact with raw sewage.



Differential pressure of about 16-20"Hg within the collection line propels the wastewater slug at relatively high velocity, about 15-18 feet per second, to the vacuum station where it collects in a tank. The velocity of the sewage slug through the line provides a scouring effect that prevents grease buildup common to gravity sewers. The wastewater collected at the vacuum station is then transferred through a force main to the nearest treatment plant.

One major benefit of the vacuum system is that it provides gravity flow from the residence while maintaining the vacuum conditions in the mainline in the street. This allows standard plumbing construction on the private property, and an understandable system for the property owner.

The differential air pressure associated with vacuum provides additional energy compared to natural gravity flow, thus level or even uphill transport is possible. The net result is that collection lines can be buried much shallower, typically about 3-5 feet. This was a significant design feature for the Albuquerque design team.


Rio
Rancho
Corrales
PUEBLO
Area D Vac Station
Alameda Vac Station
Area B & F Vac Station
Area K Vac Station
Los Ranchos de
Albuquerque
ETROGLYPH
NATIONAL
MONUMENT
Albuquerque
Pajarito Vac Station
Gun Club Vac Station
KIRTLAND
AIR FORCE
BASE
Coors Vac Station
Polk Vac Station
Los Padillas Vac Station
City of Albuquerque
Vacuum Station Locations

FUNDING PROGRAM FOR ALBUQUERQUE SEWERS

Municipal wastewater collection systems don't come cheap. They are typically big-budget, long-term projects. Accomplishing them requires vision and cooperation.

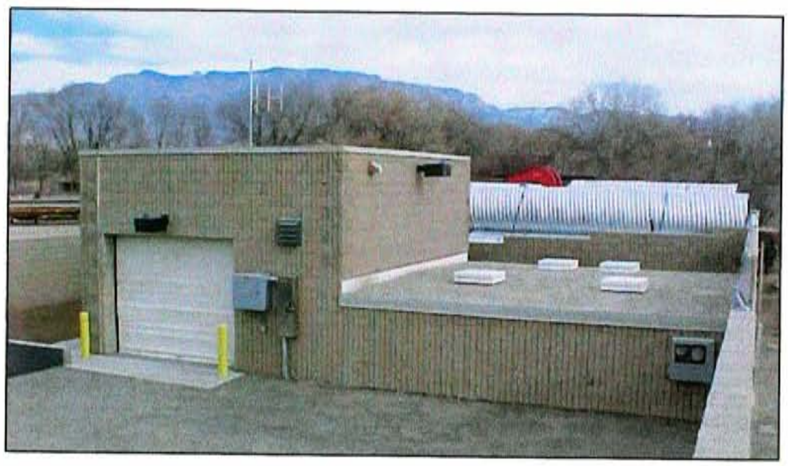
Albuquerque first began to address the wastewater problems in rural Bernalillo County in the 1970s, but the efforts typically were small band-aids when major surgery was needed. In 1993 the state legislature approved the first $12 million for a new sewer system, then followed it with $15 million more in 1994.

By 1995 there were three vacuum pumping stations on line, hundreds of homes connected and several more sewer and water projects on the drawing table. But the wave of money that was available in '93 and '94 became harder to come by in later years. With capital budgets tight, various state and local officials lobbied for funds to get work done in their districts, and competition for the funds became intense. The vision of sewering the valleys was faltering.

In 1999, a comprehensive plan was re-established for a phased approach to the monumental project. All water and sewer needs were identified valley-wide, combined into one project, and phased over several years. The phasing allowed other legislators to support both projects within their districts and the valley water/sewer program as well.

The 1999 estimated cost for needed water and sewer system extensions to serve existing development was $119 million. Thanks to those cooperative meetings, proposed fund sharing was set at $48 million federal, $20 million from the State Legislature, $30 million from Bernalillo County and $21 million from the City of Albuquerque. Unique legislative clauses were required to allow fund matching to be spread over the 10-year project life. Ongoing cooperation at all government levels toward this shared vision has proven very successful in prioritizing and completing Albuquerque's much needed water and sewer improvements.

Due to these efforts throughout the past 10-12 years, a much greater share of the water and sewer system are located outside of the City limits. To address the beyond-City-limits factor of the facilities, a change has recently occurred in the organizational structure of the public utilities. Several years ago, the state legislature mandated that the water and sewer systems be owned, operated and maintained by a combined City-County entity. Thus the Albuquerque-Bernalillo County Water Utility Authority was established to provide to the combined needs of City and County residents.

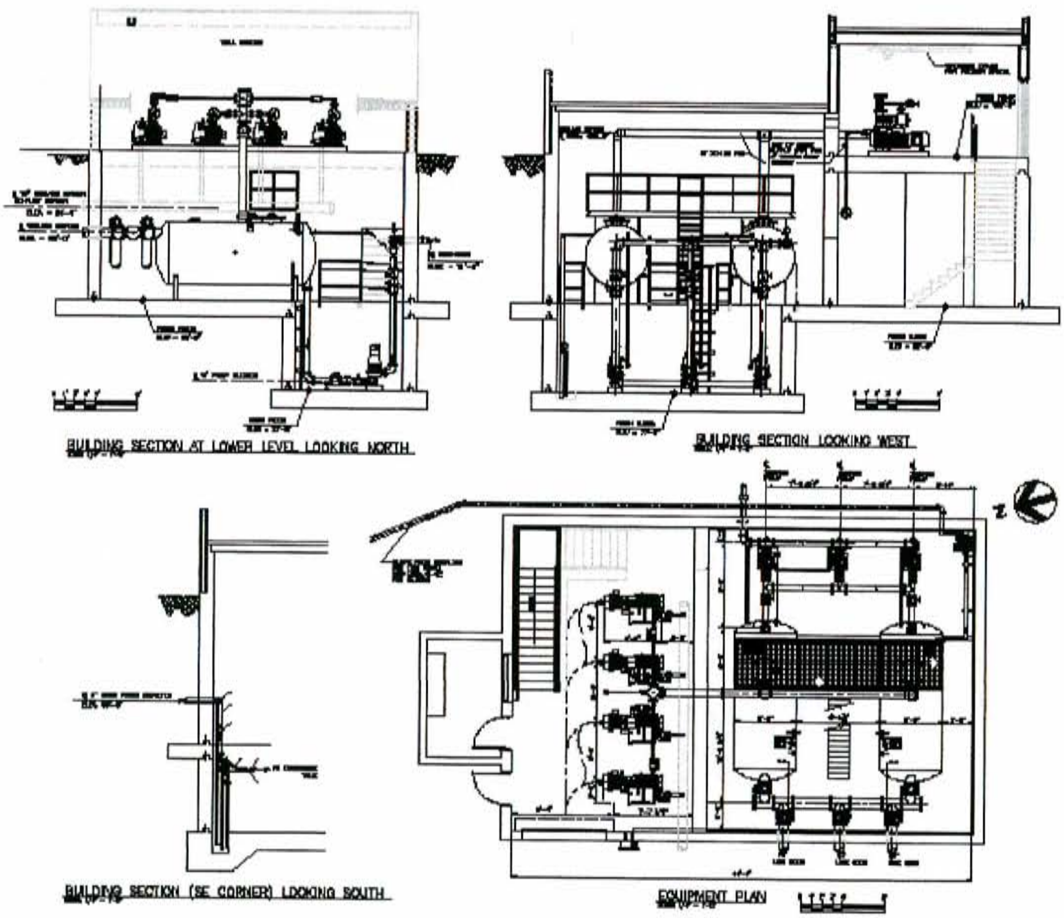


APPLICATION IN ALBUQUERQUE

Several unique applications of vacuum systems are found in the pump stations and sewer system in the Albuquerque facilities. There are several 'generations' of vacuum station layouts that are the product of design evolution as the City staff continued to operate and maintain the first vacuum stations. This evolution has produced several design issues that are fairly unique to the Albuquerque facilities.

Uniform Vacuum Pump Used

All the vacuum stations throughout the system utilize the same vacuum pump with a capacity of 430 cfm. Using this single vacuum pump throughout all facilities allows the City to minimize spares required.



Vacuum Tank Redundancy

Redundancy in vacuum tanks is also unique to Albuquerque. As shown in the figure on page 4, most vacuum stations rely on a single vacuum tank. The City concept evolved to provide two tanks each with about 60% of the capacity required for efficient operation. There are occasions when the vacuum tank is taken off line for cleaning (not often) or repair (has yet to occur after 10 years). When this occurs, the entire system can continue operation, although the cycling of vacuum pumps is much quicker due to the loss of the one tank.

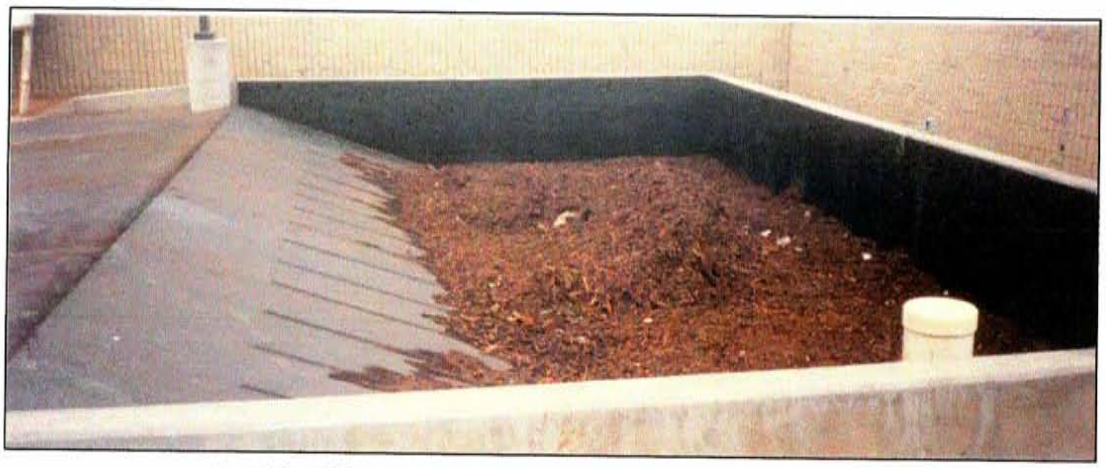
Sewage Pump Design

The Albuquerque vacuum stations are also deeper than other locations. The City has standardized generally on Flygt pumps which require a slightly higher NPSH for operation, and the NPSHR problem is compounded by the 5000 foot elevation of Albuquerque. In order to utilize Flygt pumps as the discharge pump from the vacuum station, they must be further below the vacuum tank than other pumps. Thus, the sewage pumps are set in a sump about 5-6 feet below the vacuum tank floor level. This is evident by comparing the AIRVAC figure on page 4 with the section drawing on page 7.

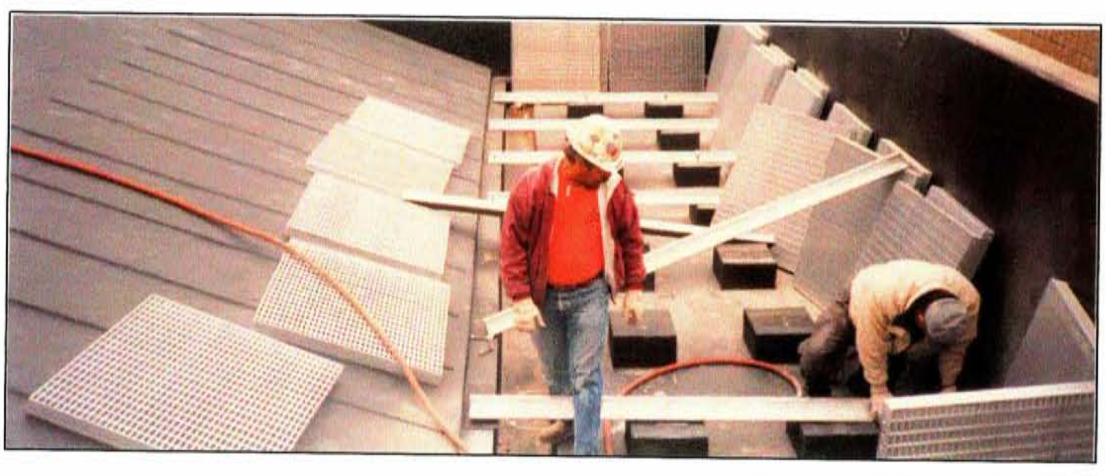
Odor Control

Odor control at each vacuum pump station is also fairly unique to Albuquerque vacuum stations. As the first few vacuum stations came into operation, odor control became an issue not previously anticipated. The vacuum pump stations concentrated the withdrawal of air from the sewerage system in one spot. When the sewage had been sitting in the vacuum sewers for a while, H_2S odors became a problem for residents adjacent to the vacuum stations. Various odor control methods were constructed and modified at the various locations. Biofilters using city sludge compost eventually became the 'standard' for use at each new vacuum station. The biofilters included concrete construction, corrosion resistant coating, and open side so that the compost material could be maintained and replaced at regular intervals. These facilities have worked well and seemed to have withstood the corrosive atmosphere, although use of fiberglass grating may be suggested for use below the compost bed rather than aluminum grating as shown in the photos below (used in the Area B/F vacuum station biofilter. The Area D biofilter abandoned the concrete structure and utilized a 4-foot deep compost bed heaped on an air piping system embedded in lava rock, all contained within a 60-mil polypropylene liner.

Looking North – Installing Aluminum Grating



Looking West – Most of compost in place



Area B & F Vacuum Station
Compost Odor Control Facility

With the success in odor control at the newer 'generation' vacuum stations, several of the vacuum stations were retrofitted with odor control facilities. At the Los Padillas Vacuum Station there was insufficient room to install the larger compost biofilter, so various evaluations were made and several types of odor control facilities were considered. Eventually the control equipment chosen was the use of circular tray type compost biofilters manufactured by EG&G, Inc under the name "Biocube™". Consisting of a series of large round trays filled with special compost material, air is pre-humidified then discharged through the compost trays in a down-flow pattern. Depending on the total airflow and total odors for removal, multiple Biocubes™ are used in series and/or parallel. The Los Padillas facility uses three Biocube™ modules connected in parallel. Each module contains five trays of media. One of the key reasons for choosing Biocubes™ at the Los Padillas facility was their relative compact size. Land availability at the time of decision was considered at a premium and such odor control equipment would fit within the land constraints of the station site.

However, the Biocube™ is designed for normal operation on the suction side of an air blower. The fouled air is, essentially, sucked through the trays, and the entire system is under a slightly negative pressure. This mode of operation tends to pull the trays together, tightening the seal of the O-rings between each tray. The operations at the vacuum station required that the Biocubes™ be placed on the discharge side of the vacuum pumps, placing the overall system under a slightly positive pressure. This tended to drive the trays apart and created air leaks at the O-rings. Tightening the units and various caulking arrangements were attempted, with limited permanent success. To remedy this, two spring-loaded pressure relief valves were installed in front of the Biocubes™ because experience indicated the airflow rate discharged from the vacuum pumps could be highly variable. At times the airflow rate exceeded the capacity of the Biocubes™.

Odors from the Los Padillas station have reportedly continued from several sources:

- HVAC discharge from the interior of the vacuum station itself
- Dry condensation traps in the interior of the station discharging odor into the station
- Occasional releases from the Biocubes™ on failure of the O-rings or caulking

On several occasions the Biocube™ units have been measured for the amount of actual H_2S discharged. Removal rates of H2S of 95-100% were observed. From these measurements, it appears that the Biocubes™ themselves are performing as designed, as long as the seals between the trays are working. One problem that has occurred, however, is when the vacuum station is taken off line for maintenance or repair to equipment. If the system is depressurized, initial vacuum pump flow rates have been much higher than the Biocubes™ were designed to receive, creating high headloss and thus higher pressures within the units. This tended to place more stress on the seals, sometimes creating leaks that would discharge odorous gasses. PLC operations changes have minimized the higher pressures by staggering vacuum pump startup times under such conditions.

Another component of the Biocube™ was a standard humidity control accessory called a Moisture Integrator. To assure the biota in the compost were at the optimum humid conditions, the humidity control system was intended to add humidity by bubbling incoming air through a water tray. However, the air being sucked from the vacuum sewers already had more than enough warm, moisture-saturated air. Thus use of the humidity control system was eventually discontinued.

Vacuum sewers are very adaptable to the narrow lanes of the North and South Valleys. In almost all locations, the vacuum sewer was the last utility to be installed. With many narrow lanes that were 12-15 feet in width, maintaining a 10 foot separation with water lines was impossible. The inherent characteristic of the vacuum sewers, however, is to maintain a constant vacuum into the sewer. Since this constant vacuum is maintained by the vacuum pumps which have redundancy backup, there is no real concern of cross contamination as one would find in a gravity sewer. Therefore, the New Mexico Environment Department (NMED), the state regulatory agency, has allowed installations of vacuum sewers as close as a foot to potable water lines – a real plus in the tight quarters of the North/South Valleys.

Los Padillas Vacuum Station

Alameda Vacuum Station

Gun Club Vacuum Station (note soil embankment on the side of building where vacuum sewers came above ground to enter the station)

Area K Vacuum Station

Synopsis of Vacuum Stations in the North/South Valleys

Vacuum Station	Status	COA No.	Residences Served Existing	Residences Served Ultimate	Vac Equipment Pumps	Vac Equipment Tank(s)	Sewage Pumps No.	Sewage Pumps Q (gpm)	Discharge To
South Valley									
Los Padillas	Complete 1995	63	610	750	3	2, 3000 gal	4	340 @ 264'	5 mi. force main
Gun Club 1	Complete 1995	61	545	600	3	1, 2400 gal	2	309 @ 51'	6,000' force main
Gun Club 2	Complete 1997	64	231	500	3	1, 2400 gal	2	309 @ 51'	for both 1 & 2
Polk 1	Complete 2002		444	600		2, 2400 gal	2	350 @50'	19,000' force main
Polk 2	Complete 2002		533	600		incl above			for both 1 & 2
Pajarito	Complete 2003		761	1000	4	2, 3,300 gal	3		5,000' force main
Coors	Under Construction		428	588					26,000' force main
North Valley									
Alameda/Area E	Complete 1995	62	628*	822	3	1, 2400 gal	2	272 @ 35'	
Area B/F	Complete 1999	65	391	1000	4	2, 1500 gal	2	350 @ 30'	10" grav. swr next to sta
Area D	Complete 2004		849	1000	4	2, 4000 gal	3		
Area K	Under Construction		202	1000		2, 2000 gal	3	220 gpm	400' force main
Total				8460					

Irrigation ditches criss-cross the valleys providing much needed water to the once rural North and South valleys. The ditches feeding irrigation water are higher and sometimes much higher than ground level in order to provide gravity flow of the irrigation water. However, the waste drains are often much lower than ground surface in order to drain away the unneeded irrigation water. The irrigation ditch system is vital to the area. Vacuum sewers, however, have the ability dive under the ditches, then climb back up through a series of lifts back to the same elevation and continue. This is one of the reasons that vacuum sewers were so conducive to this location – the ability for sewage to flow uphill.

OPERATION & MAINTENANCE

City of Albuquerque line maintenance and pump station maintenance staff quickly adapted to the requirements of operating and maintaining the vacuum sewers and pump stations. They have noted that the maintenance calls required average 4-5 per month. Most of these calls are minor adjustments to the automatic opening settings for the vacuum valve. If any major repair is required, the vacuum valve can be removed and replaced with a spare and further maintenance can be completed at the shop workbench. Most line maintenance issues are completed 15 minutes without ever coming into contact with the raw sewage. The City staff consider this a significant time savings in personnel cleanup as well as a smoothly running sewer system.

Operation/Maintenance of the vacuum stations has met similar success. Power failures are handled by the reserve capacity in the system itself – 10 gallon holding capacity at each valve pit, several thousand gallon holding capacity at the pump station itself. When all else fails each two pump stations are served by a trailer mounted electrical generator.

SUMMARY

Extensive use of vacuum sewers allowed the City of Albuquerque to develop a sanitary sewer collection system that would work effectively and cost efficiently in the unincorporated portions of Bernalillo County. Over the past 12 years, the City has implemented a program that ultimately has a construction cost of $140 million. The program will ultimately serve over 8,000 residences as the septic systems will all be demolished and the groundwater will be provided protection from human pollution. Implementation of the projects has been smooth and effective. Vacuum sewers played a key role in the success of 'sewering the valleys" in the Middle Rio Grande region of New Mexico. It is a innovative sewer alternative that should be considered whenever similar conditions exist.

Att. 7

Vacuum Sewer Saves York

As public works officials like to say, if the toilets flush, nobody cares about the sewers. True.

Most citizens don't know or care about the state of their sewer infrastructure unless there is a tax issue involved or they are buying or selling property. It's a classic case of out of sight, out of mind. Many professionals, however, sincerely appreciate the importance of properly functioning sewers.

Consider York County, VA. In the 1980s many York County residents had primitive wastewater treatment methods. Most had septic systems that were either ineffective or downright offensive to the senses and the environment. Homeowners often had to deal with sewer backups. Untreated wastewater regularly made its way into the creeks and rivers in the area, and from there, into the Chesapeake Bay. The pollution was so bad that it was illegal to harvest shellfish from many of the county's local waterways.

Today, many York County residents are connected to a state-of-the-art vacuum sewer system. There is no longer any stench from on-site sewage disposal systems. Shellfish harvesting has returned to some areas again. Property values have increased and more land is available for development. Real estate officials in York County estimate that more than 200 lots that were non-buildable due to sewer issues now have homes on them. All this came as a result of a modern cost-effective sewer construction effort.

"There have been a lot of intrinsic benefits associated with our new wastewater systems," said Mark Swilley, an engineer with the York County Department of Environmental and Development Services. "The neighborhoods are nicer, you don't have odors and puddles from septic tank systems. People don't have toilets backing up into their bathtubs. Most of the neighborhoods got new roads out of the deal and the rural aura of the neighborhoods remains intact. The prevailing thought around here is that even with the connection fee and the cost of installing a lateral pipe, the investment in new wastewater systems was money well spent."

A Better Alternative

York County has completed 12 separate vacuum sewer construction projects over the past 11 years in seven different communities. When engineer Michael Elam joined York County in 1984 the county was already trying to address its sewage problem. This was still four years before the Virginia legislature passed the Chesapeake Bay Preservation Act that mandated all Virginia counties bordering the bay and its tributaries to address their water pollution issues.

"We began by prioritizing the areas by need," said Elam. "Topography was certainly an issue. We have a lot of flat land and a high water table. For gravity sewers we were looking at a lot of deep trenches, a lot of dewatering and many pump stations."

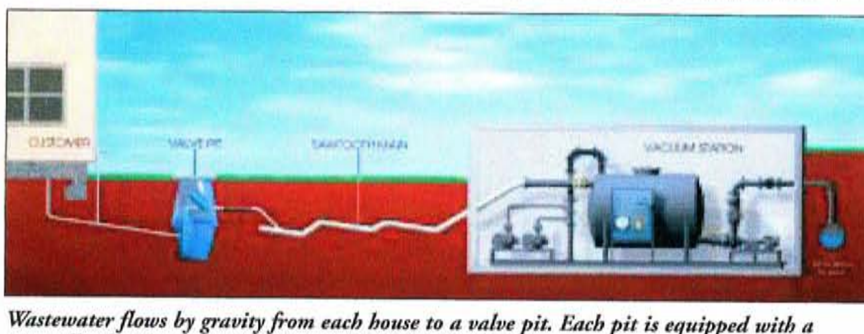
Elam said a cost projection was done in the early 1990s for a gravity-flow system. When the bids came in the cost worked out to about $10,000 per house connection. Elam had experience with vacuum sewer technology in a previous job and encouraged the county to examine vacuum sewers as an option. Another cost analysis was done and the vacuum system came in at about $7,500 per connection.

"With vacuum technology we saw significant savings, fewer maintenance requirements, and shallower trenches," said Elam. "Instead of four or five pump stations, we would need only one vacuum station."

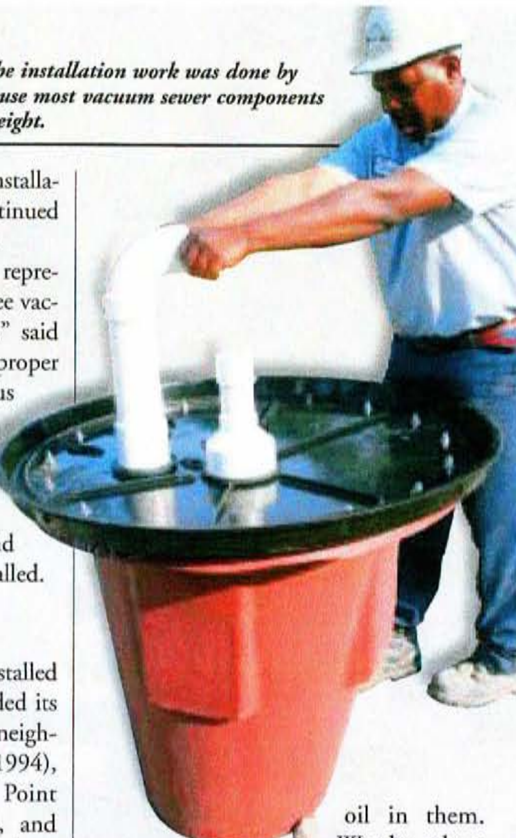
The number of pump stations required for a gravity sewer was a significant factor in the decision process. Property in York County is extremely expensive. Chief of Utilities Brian Woodward, P.E., explained the cost comparison.

"In many areas we would need three to five pump stations at a cost of $300,000 to $350,000 each," explained Woodward. "A single vacuum station can serve the same area at a cost of about $800,000. Obviously the vacuum system was more cost effective."

Much of the sewer construction work in York County has been accomplished in existing, mature neighborhoods. Vacuum lines can be buried much shallower than gravity lines, so the prospect of shallower trenches was also appealing. The York County engi-



Wastewater flows by gravity from each house to a valve pit. Each pit is equipped with a normally closed vacuum interface valve that prevents system vacuum from entering the house plumbing. When 10 gal of wastewater accumulate in the sump, the interface valve opens, the contents of the sump are evacuated, and the wastewater enters the vacuum main. Wastewater then travels through the vacuum mains to the vacuum station where it is collected and pumped to the treatment plant.



Much of the installation work was done by hand because most vacuum sewer components are lightweight.

neers also noted that much of the PVC pipe used for the vacuum systems was laid in place by hand.

"With vacuum technology you're digging trenches 5 or 6 ft deep compared to 20 to 25 ft deep for a gravity system," explained Jim Tobler, project manager for York County s Division of Utilities. "From my point of view I'd rather see a vacuum system any day compared to a gravity system because there is less disruption, you don't have the spoil piles, and there is a greater safety factor."

A Reliable Partner

AIRVAC (www.airvac.com), a pioneer in vacuum sewer technology, has been York County's supplier on all of the county's vacuum sewer projects since 1993. Vacuum sewers have been around for decades. In a vacuum sewer system, a central vacuum station maintains vacuum pressure within the sewer collection lines. Wastewater flows from each house by gravity line to a vacuum valve pit nearby. Up to four homes can be connected to a single valve pit.

Each valve pit is equipped with a vacuum interface valve that activates when wastewater in the lower sump reaches a predetermined level, typically 10 gal. When the valve activates, wastewater enters the collector line followed by a volume of air. The wastewater forms a slug that is driven by the air due to differential pressure. Operation of the valve pit is completely pneumatic, so external power is not required. The sewage moves so rapidly through the line that buildups of grease or sludge are rare.

"I was concerned about grease buildup in the lines," said Elam, recalling his thoughts in 1993. "The way the vacuum system works, the wastewater shoots through there so fast that there is no chance for grease to settle in the system and clog it up."

That initial project in York County was in the Seaford community in 1993. About 400 residents were connected to the new system that year. There were some small initial glitches with silt in the valve pits, but otherwise the first installations went smoothly and have continued to work well after a decade of use.

"We had AIRVAC field service representatives with us for the first three vacuum sewer systems we installed," said Tobler. "They taught us about proper installation techniques and gave us installation criteria to follow. Since then we've developed the criteria a bit to fit our own circumstances. We feel like our systems are some of the best around because of the way they were installed.

A Thing of the Future

Since the Seaford system was installed in 1993, York County has expanded its use of vacuum sewers to six other neighborhoods Dandy (1994), Dare (1994), Patrick's Creek (1996), Piney Point (1998), Calthrop Neck (1999), and Marlbank Farm in 2004. Today about 2,000 York County residences are connected to vacuum sewers.

The Utilities Department of York County estimates it maintains some 52 miles of vacuum sewer lines and five vacuum stations, with another about to go into construction. A crew of two to three personnel maintain the vacuum sewers, which operate 24/7 because each pump station includes standby power should commercial power go out.

"The vacuum sewers comprise about 25 percent of our sewer infrastructure. We have 36 people who are in operations, but only two or three are required for vacuum sewer maintenance," said Woodward, the county's utilities chief. "I would say the maintenance is less than we anticipated in the beginning."

Earl Stewart has been on the vacuum maintenance team for more than eight years. He was trained on vacuum sewer technology by the manufacturer's staff so he's thoroughly knowledgeable about the system's nuances.

"We do a station check three times a week, and each check takes about 30 minutes," said Stewart. "We take readings on the vacuum pumps and check the oil in them. We also take a little time to sweep and clean the station building. The rest of our time is spent doing inspections for new connections or an occasional repair of a vacuum valve. We do most of our own repair work.

"I see vacuum systems as being a thing of the future," Stewart continued. "I think more and more people will go to vacuum systems because it's a sealed system and if you have a problem you know about it right away. With gravity systems you usually don't know about a problem unless someone calls and complains."

Satisfied Customers

The most important endorsement of a product is always the customer. After ten years the citizens of York County are now completely familiar with the benefits of vacuum technology. "A lot of residents were skeptical of a vacuum sewer system at first," noted Tobler. "They just didn't understand how it works. We took the time to explain it. There are a lot fewer headaches from the resident's point of view. It's easier to install and it works well. The homeowners we've spoken with seem to like it very much." GE