Section 9
Biosolids Management

9.1 Introduction

This section considers the management of the biosolids produced in the wastewater treatment process. In recent years, there have been increasing public perception and regulatory issues associated with biosolids that have brought solids management to the forefront. A number of factors have led to increasing public concerns with land application of biosolids in California. Due to local pressures a number of counties have implemented or are considering implementation of regulations restricting or banning land application of biosolids. The aims for the biosolids management evaluation task include the following:

- Provide sustainable 20-year planning direction
- Evaluate biosolids markets and technologies
- Consider biosolids management options that may be suitable for the City to own/operate or for private vendors to operate

The approach used for conducting this task is depicted in Figure 9-1. First, the existing biosolids management situation was reviewed, including an analysis of drivers, current biosolids production and quality and current management contracts. Following this, the available technologies for creating biosolids products were reviewed in parallel with the markets for these products. This then led to development of the recommended planning direction and associated cost projections and identification of potential triggers for change. The recommended strategy aims to assist in providing direction for future biosolids management by the City in a manner that meets the goals and objectives of the City's Biosolids Environmental Management System (EMS) and outlined in this task.

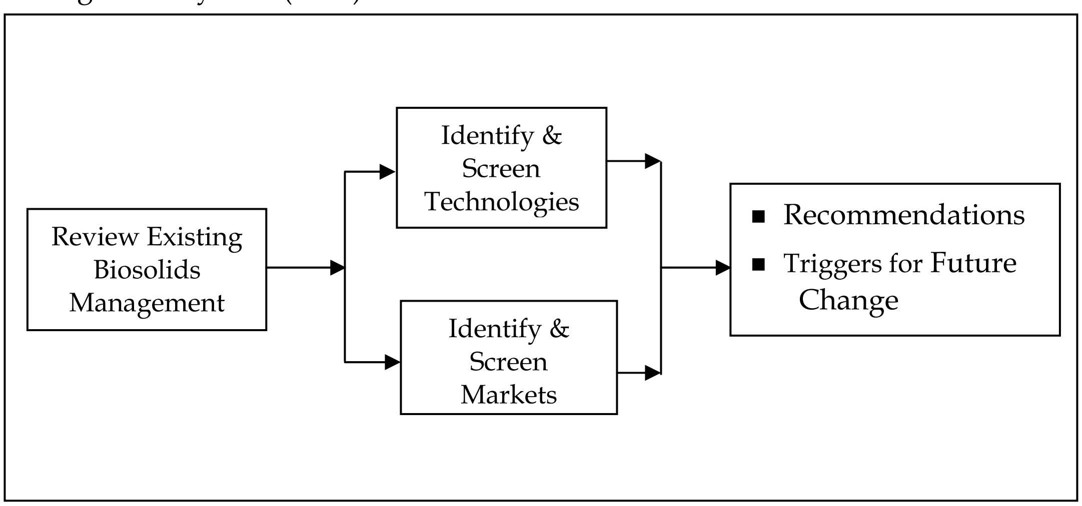

Figure 9-1
Biosolids Management Task Approach

9.1.1 Importance of Considering Biosolids in IRP

The City is one of three large wastewater treatment agencies in the Los Angeles/Orange County area, along with the Los Angeles County Sanitation District (LACSD) and the Orange County Sanitation District (OCSD). These large agencies have a high profile in Southern California regarding their biosolids management practices. Having three large agencies within the same region of Southern California has led to a large volume of biosolids being land applied within a few of the more rural counties, in particular, Kern, Kings, and Riverside Counties. All three counties are now implementing restrictions on land application of biosolids, as will be discussed below. Other rural counties in the area, such as San Bernardino and Imperial counties have actual or practical bans on land application of biosolids.

Due to the increasing restrictions in Southern California, several agencies, including the City and OCSD, have contracted to land apply biosolids in Arizona. Until recently biosolids from the City were being land applied in Maricopa County, Arizona. Nearby in La Paz County, the County supervisors recently decided to be the first county in Arizona to introduce a local ordinance on land application of biosolids. Other counties in Arizona may follow, especially as California increases the amount of biosolids being land applied there, which could raise the profile of this issue. These restrictions have not been based on science, but on perceptions.

As a leading agency in Southern California, effective biosolids management is necessary to maintain a positive perception of the City, within the City, in Southern California, and with the regulatory bodies involved with biosolids. Realizing the importance of biosolids management, the City was one of the first agencies nationally to take part in developing and implementing a Biosolids EMS. The City was also one of the first in Southern California to move toward improving the quality of biosolids, discussed below. However, as the EMS recognizes, effective management requires an on-going, proactive approach. Therefore, any long term plan, such as the City's IRP, needs to consider the direction for biosolids management to ensure that the City has in place effective options for the near term and the long term. The drivers that need to be considered when examining biosolids management options are discussed below.

9.1.2 Biosolids Management Goals

Several environmental goals were identified to guide the development of a sustainable biosolids management program. These goals are based on the City's Biosolids EMS as follows:

- Management should be in line with the Biosolids EMS
- Comply with all regulations, federal, state and local
- Provide good stewardship of resources - both biosolids and finances

- Maximize the reliability of the long-term biosolids management program
- Improve public perception and confidence
- Realize innovative, cost-effective & environmentally sound ideas
- Provide multiple processing options
- Maintain in-basin management options
- Continued use of private sector hauling and land application
- Diversify markets
- Identify and maintain back-up options

9.2 Drivers Affecting Biosolids Management

There are three key drivers that affect biosolids management – regulations, public perception, and product market options. These drivers are interrelated, because public perception is often a catalyst for regulation, particularly at the local level, and local regulations can impact the biosolids beneficial use market options. These factors impact cost, viability of management options, reliability and the need for diversification, all of which drive new technology options.

9.2.1 Regulations

The main regulation that governs the treatment and beneficial use of biosolids is the federal regulation, 40 Code of Federal Regulations (CFR) Part 503 (Part 503 Regulations). In Southern California, most solids handling has consisted of anaerobic digestion at mesophilic temperatures (≈ 98°F) to provide stabilization and pathogen reduction in the solids, followed by dewatering for volume reduction. This process generally achieves a "Class B" biosolids as defined by the Part 503 Regulations.

The City has implemented thermophilic digestion (≈ 128°F), achieving "Class A" pathogen densities and producing EQ (exceptional quality) biosolids, as defined in the Part 503 regulations for pathogens, metals and vector attraction reduction. After dewatering, the digested "cake" that meets the Part 503 regulation requirements is suitable for recycling and is termed "biosolids" as the solids are in a form that can be transported for beneficial use, typically through land application of the biosolids.

The recently completed National Academy of Science (NAS) report on biosolids stated that there is no documented evidence of the Part 503 regulations failing to protect public health or the environment. It also stated that the scientific basis for the Part 503 regulations must be updated. However, in some instances the report has been used negatively, has affected public perception of land application of biosolids and, in the case of Riverside County, and increased the pressure for restrictions on land application of biosolids.

The Part 503 regulations allow local jurisdictions to implement more stringent requirements. Although the State of California uses the Part 503 regulations as its foundation for the state regulations, counties are allowed to impose more restrictions on biosolids beneficial use than provided in the federal or state regulations. Several counties in California have done so using several methods, including the following:

- Banning land application of biosolids
- Imposing restrictive requirements on the quality of biosolids
- Limiting the area that can be used for land application
- Levying local charges such as road use fees.

Neither the State nor the counties are required to provide a science–based approach to biosolids regulations. Therefore, this trend makes land application of biosolids increasingly tenuous. The City's Green Acres Farm is located in Kern County, which has banned the use of Class B biosolids. There are also concerns by Kern Water Agency and some farming sectors with regard to the use of any biosolids over useable ground water and this has been brought to the attention of the county's Water Resources Commission and Board of Supervisors.

Air quality is also a key concern in Southern California and is highly regulated. Any biosolids processing technologies installed at the City's wastewater treatment plants will need to maintain emissions below the levels currently allowed in the City's air quality permits. Any off-site installations, whether owned by a private entity or a public agency, will need to obtain air quality permits. The Rule 1133 regulation was adopted by the Southern California Air Quality Management District (SCAQMD) in January 2003 regarding air quality impacts of composting facilities. In its present form, Rule 1133, is emissions-based rather than control-technology based - facilities must demonstrate significant reduction of volatile organic compounds (VOCs) and ammonia emissions from baseline emissions values. Alternatively, a complete enclosure can be installed and collected air treated using a control device that demonstrates adequate removal efficiency.

These are the key regulatory issues that need to be considered when evaluating the applicability of biosolids processing technologies for the City and Southern California. A more extensive list of current and future regulations that may impact biosolids management and processing facilities is provided in Appendix J. As newer biosolids technologies become more commonly used, it is possible new regulations may be developed in response to new issues that arise. Therefore, the technology evaluation must consider aspects that may be a trigger for additional legislation, such as odors, metal concentrations and air emissions.

9.2.2 Public Perception

Much of the drive behind implementing restrictive county land application ordinances has been public perception. Issues that impact public perception of a facility include odor, traffic and visual appearance of the facility and facility siting (NIMBY), in addition to previous negative attitudes to any project involving solids disposal. Odor and aesthetics of the biosolids have been key issues influencing public perception and have lead to questions about the health impacts and pathogen levels in the biosolids. Therefore, a goal is to identify technologies that provide a product that is more likely to be sustainable over the long-term. The resulting product should have the following attributes:

- Free of objectionable odor
- An aesthetically pleasing biosolids product that does not contain plastics or other large objects
- A product amenable to alternative beneficial use options

9.2.3 Product Market Options

Biosolids use in Southern California has largely been limited to land application of biosolids with Class B pathogen levels and some marketing of EQ biosolids compost. Recent restrictive regulation by counties has reduced the availability of Class B land application sites throughout California. Although there are opportunities for Class B land application in other states such as Arizona and Nevada, increased land application in these states may result in public opposition and legislation similar to what has occurred in California. Composting facilities have also experienced public opposition, primarily due to odors at the composting facilities themselves. In addition, more stringent air quality regulations have been adopted to control VOC and ammonia emissions from composting operations. These changes indicate that the biosolids processing technologies must be compatible with the market options and that new markets must be identified to provide a diverse range of recycling options for sustainable biosolids management. Technologies providing products with a long-term market demand and multiple market options will be considered preferable.

9.3 Existing Biosolids Quality

The City has four wastewater treatment plants, of which two, the Donald C. Tillman Water Reclamation Plant (TWRP) and the Los Angeles-Glendale Water Reclamation Plant (LAGWRP), do not have any solids treatment. Those two plants return the solids to the sewer, with the flows entering the Hyperion Treatment Plant (HTP).

HTP provides thermophilic digestion of the solids generated at the plant, and produces biosolids that meet the Part 503 regulations' EQ standards for pathogens, metals and vector attraction. The plant currently produces approximately 680 wet tons per day (wtpd) of dewatered biosolids, with a solids content of about 32 percent.

The City also operates the Terminal Island Treatment Plant (TITP), which receives wastewater flows from the San Pedro area and Terminal Island. The plant also has thermophilic digestion and the biosolids meet EQ standards.

Biosolids from both HTP and TITP are land applied. EQ biosolids that meet Kern County's pathogen requirement for both salmonella and fecal coliforms and meet Class A pathogen densities at the time of spreading may be applied at the City's Green Acres Farm. Although it is expected that the land application of EQ biosolids will continue to be allowed in Kern County, the trend in local ordinances is toward increasing restrictions. Until recently, biosolids from TITP had been hauled to land application sites in Maricopa County, Arizona, by Synagro (formerly BioGro).

9.3.1 Hyperion Treatment Plant Biosolids

Table 9-1 summarizes the regulatory standards for metal concentrations, and provides the average, minimum and maximum concentration of those metals in the biosolids produced at the HTP during the 12-month period from December 2001 to November 2002. As shown in Table 9-1, the metal concentrations in the biosolids produced from the HTP plant are well below the regulatory standards for the metals. As noted in the table, the United States Environmental Protection Agency (EPA) recently decided not to regulate dioxins under the Part 503 regulations. The levels of radioactivity in the City's biosolids are low and should not be a concern affecting beneficial uses.

The biosolids from HTP are regularly tested for fecal coliforms and salmonella, as indicator species for pathogens. The biosolids from the thermophilic digestion process meets both standards for Class A biosolids, with fecal coliforms <1000 MPN per dry gram of solids, and salmonella <3 MPN per 4 dry grams of solids. The biosolids are tested for helminth ova and enteric viruses and consistently are below the limit of 1 unit per 4 dry grams. As the biosolids meet the pathogen, vector attraction and metal concentration requirements, the biosolids are termed EQ. Under the Kern County biosolids ordinance, the biosolids should meet both fecal coliform and salmonella Class A pathogen criteria at the time of land application.

Since implementation of thermophilic digestion for all solids produced at HTP, the volatile solids destruction is around 59 percent and the dewatered cake has a solids content of around 32 percent.

9.3.2 Terminal Island Treatment Plant Biosolids

Table 9-2 summarizes the regulatory standards for metal concentrations, and provides the average, minimum and maximum concentration of those metals in the biosolids produced at the TITP during the 12-month period from December 2001 to November 2002.

Table 9-1
Regulatory Standards vs. HTP Biosolids Quality Data

Constituent/Parameter	Current/Proposed Regulatory Standards[a] Ceiling Concentration	Current/Proposed Regulatory Standards[a] Pollutant Concentration	Plant Data for 2001-2002 Minimum	Plant Data for 2001-2002 Maximum	Plant Data for 2001-2002 Average
Arsenic (mg/kg)	75	41	2.02	13.7	7.66
Cadmium (mg/kg)	85	39	9	26.9	14.8
Copper (mg/kg)	4300	1500	743	997	847
Lead (mg/kg)	840	300	29.6	50.8	39.4
Mercury (mg/kg)	57	17	1.09	3.62	2.34
Molybdenum[b] (mg/kg)	75	-	17	30.2	22.9
Nickel (mg/kg)	420	420	65.8	108	83.1
Selenium (mg/kg)	100	100	0.6	19	8.03
Zinc (mg/kg)	7500	2800	932	1180	1050
Dioxins [c]		NA	<11 ppt	<84 ppt	<35 ppt

Notes:
1. Based on Part 503.13 ceiling concentrations (Table 1) & average concentrations (Table 2)
2. A new concentration limit and cumulative pollutant loading rate may be introduced in the future
3. EPA has decided not to regulate dioxins in biosolids, proposed limit had been 300 ppt TEQ

Table 9-2
Regulatory Standards vs. TITP Biosolids Concentrations for Metals

Constituent/Parameter	Current/Proposed Regulatory Standards[a] Ceiling Concentration	Current/Proposed Regulatory Standards[a] Pollutant Concentration	Plant Data for 2001-2002 Minimum	Plant Data for 2001-2002 Maximum	Plant Data for 2001-2002 Average
Arsenic (mg/kg)	75	41	1.87	13.3	7.03
Cadmium (mg/kg)	85	39	0.62	3.28	1.92
Copper (mg/kg)	4300	1500	208	355	289
Lead (mg/kg)	840	300	5	63	33.5
Mercury (mg/kg)	57	17	1.02	3.32	2.09
Molybdenum[b] (mg/kg)	75	-	15.8	23.6	19
Nickel (mg/kg)	420	420	32.4	57.2	41.6
Selenium (mg/kg)	100	100	31.5	83.4	56.6
Zinc (mg/kg)	7500	2800	469	890	736
Dioxins [c]		NA	<11 ppt	<84 ppt	<35 ppt

Notes:
(a) Based on Part 503.13 ceiling concentrations (Table 1) & average concentrations (Table 2)
(b) A new concentration limit and cumulative pollutant loading rate may be introduced in the future
(c) EPA has decided not to regulate dioxins in biosolids, proposed limit had been 300 ppt TEQ

As shown in Table 9-2, the metal concentrations in the biosolids produced from TITP are well below the regulatory standards for the metals. In past years, the plant had experienced elevated levels of zinc, molybdenum, copper, and selenium. The City's Industrial Waste Management Division worked with the local industrial dischargers to reduce these discharges.

The biosolids from TITP are regularly tested for fecal coliforms and salmonella, as indicator species for pathogens. The biosolids from the thermophilic digestion process meets both standards for Class A biosolids, with fecal coliforms <1000 MPN per dry gram of solids, and salmonella <3 MPN per 4 dry grams of solids. The biosolids are also tested for helminth ova and enteric viruses and consistently are below the limit of 1 unit per 4 dry grams.

For the 12 month period ending June 2002, volatile solids destruction in the digesters averaged 51 percent, with the hydraulic detention time for the three operational digesters ranging from 16 to 23 days.

9.4 Solids Production

A summary of the current and projected biosolids production at the HTP and TITP treatment plants is provided in Table 9-3. These estimates are based on the wastewater treatment modeling task, detailed in Section 7, with a correction factor applied to the HTP final cake volume, as per a memo dated February 27, 2004 (see Appendix I). TITP flows and solids production are not anticipated to increase significantly by 2020. However, the flows and solids production at HTP are expected to increase around 26 percent, from 681 wtpd to 861 wtpd. This is based on continuing the current biosolids handling practices, with upstream plants returning solids to the sewer system to the HTP influent, and with continued thermophilic digestion and centrifuge dewatering at HTP.

Table 9-3
Current and Projected Biosolids Production

Parameter	Current Capacity				2020 Projections	
	HTP		TITP			
	Rated	Operational	Rated	Operational	HTP	TITP
Flow, MGD (annual average)	450	335	30	17	450	19
Biosolids, dtpd	-	217	-	11	275	12
Solids concentration %	-	32	-	22	32	22
Dewatered biosolids wtpd	-	681	-	50	861	56

Note: HTP data presented are based on the Pro2D modeling with biosolids correction factor. TITP data from plant staff.

Primary and secondary treatment options at the different wastewater treatment plants will effect the volume and characteristics of the solids produced. Chemically enhanced primary sedimentation produces a greater amount of primary solids and reduces the amount of secondary solids produced. Primary solids are more easily biodegradable in the digestion process and typically improve dewaterability. In contrast, secondary solids are less easily digested and reduce the dewaterability of the digested solids. Process changes that impact the ratio of primary to secondary solids will therefore have impacts on the biosolids quantity and quality. For instance, biological nutrient removal processes tend to produce fewer secondary solids than conventional activated sludge processes and would therefore have a positive impact on biosolids handling.

Although there are no process changes proposed to digestion or dewatering, if alternate processes are considered in the future, they could have an impact on biosolids management options and costs. If enhanced digestion, such as thermophilic digestion or alternative options is discontinued, it is likely that dewatered cake dryness will drop, which will increase the total weight of biosolids produced. Changes to the dewatering process technology could also impact the total weight of biosolids. Belt press dewatering typically will not produce as dry a cake as centrifuge dewatering, although there are two-stage dewatering processes now being offered by some suppliers, such as Andritz, that could produce a drier material. Other technologies, such as vacuum and heat assisted dewatering are also available, which could produce a drier cake of around 60 percent solids content. These have not been implemented at a large scale plant like HTP. Future changes to the solids handling process may therefore change the volume of biosolids and therefore the total cost of managing the biosolids would be impacted.

Increasing the dryness of the cake would reduce the cost associated with a number of the biosolids product technologies, such as heat drying and composting. Note that it is important to avoid producing biosolids that have a solids content in the range from 35 to 40 percent. Biosolids with a solids content in this range tend to be "sticky", which creates material handling problems. Conversely a reduction in the cake dryness will increase the cost of many of the product technologies.

Although changes in the weight of biosolids and characteristics may impact the total biosolids management program costs and may impact the cost of different technology options, the City will continue to produce a large amount of biosolids. The actual amount is not likely to affect the recommended biosolids management strategy. It is important to maintain the highest quality of biosolids processing, so that the marketability of the final products is maintained. This includes continuation of effective screening at the wastewater treatment plants to reduce the presence of non-biodegradable materials in the biosolids, and continuation of an effective digestion process that produces stable biosolids.

9.5 Current Biosolids Management Options

This section provides a brief review of the current biosolids management options for the City. These are primarily based on existing contracts, supplemented by proposals received by the City in reply to various biosolids management Request for Proposals (RFPs) that were issued in recent years. Technologies received in the proposals were included in the evaluation of a wide range of biosolids product technologies, as described in Subsection 9.7.

9.5.1 Existing Biosolids Management Contracts and Markets

Currently, the City contracts with Responsible Biosolids Management Inc. (RBM) to haul and land apply biosolids at the City's Green Acres Farm. They recently terminated the contract with Synagro for land application at other sites. The existing 10-year contract with RBM commenced in September 2000 and requires the City to provide a minimum of 547 wtpd for hauling, at the cost of $23.44/wet ton.

The City recently received proposals in response to a Request for Proposals (RFP) for operation of the Green Acres Farm. The new contract will be for a three-year term. Management has been conducted by Fanucchi Brothers Farming on an interim basis. The City also intends to hire a farm manager as a City employee to oversee activities and contractors at the farm.

9.5.2 On-file Biosolids Management Proposals

The City issued three RFPs during the year 2001 for processing biosolids produced at the HTP and/or the TITP that meet the Class B pathogen and vector attraction reductions requirements and metals standards for beneficial use in accordance with the Part 503 regulations. The RFPs were for private contractor facilities including biosolids drying operations, generation of Class A biosolids products and management of Class B biosolids.

Contracts awarded under these RFPs would supplement as practically as possible the biosolids beneficial recycling contracts that were already in place. As part of the complete system, proposers were to define the development and financing using a full-service contract approach, with the proposer bearing all costs of the design, permitting, financing, construction and operation of the system. It was intended that the process be developed in an environmentally and economically sound manner. The contract term for each RFP was to be for a period of three years. There would be two three-year renewal options available, pending appropriate approval.

In response to the RFPs listed above, the City received proposals from sixteen companies. A panel of City staff was set up to review the proposals that passed the City's Good Faith Effort requirement and a number of proposers were interviewed by the panel. Proposals that were reviewed included California Soils Products, Hondo Chemical, Transnational Environmental Corporation/N-Viro, US Filter/Professional Services Group and Waste Markets for chemical stabilization, Minergy for vitrification, San Joaquin Composting for composting and land application, Synagro for composting, Terralog Technologies for slurry fracture injection for energy recovery and TPS Technologies for composting and drying. Following the review, the City entered into discussions with Terralog Technologies to further consider the feasibility of slurry fracture injection for energy recovery. This has led to development of the Terminal Island Renewable Energy (TIRE) project, to conduct testing of this new application of the technology.

9.5.3 Summary of Other Western U.S. Practices

Within California, there is increasing pressure on land application, particularly of Class B biosolids. In response to this, many agencies are considering methods of producing Class A biosolids, as well as diversification of the biosolids product markets, to reduce the dependency on land application routes. Table 9-4 summarizes the direction being considered by some of the agencies in Southern California. It must be noted that most agencies are at different stages in developing biosolids management plans in response to the current regulatory climate, and that the summaries provided in Table 9-4 are subject to change. Composting and pelletization appear to be considered the most favored options for agency-owned biosolids processing facilities, and allow diversification of the product away from land application. In addition, there are a number of private facilities being proposed in Southern California, and there is increasing interest in options for energy and fuel recovery, as an alternative to the cropping market options such as land application and horticulture.

Table 9-4
Direction of Biosolids Management in Southern California[1]

Agency	Biosolids Management Direction (Tentative)
Los Angeles County Sanitation District (LACSD)	Composting at various potential locations
Orange County Sanitation District	Diversified, considering composting, drying, energy
City of San Diego	Landfilling
Inland Empire Utilities Agency	Composting, on-site (joint facility with LACSD)
City of Riverside	Regional pyrolysis facility
City of Corona	Thermal Drying (pellets), on-site
Encina	Thermal Drying (pellets), on-site
San Bernardino	Thermal Drying (pellets), on-site or regional
Santa Barbara County	Composting, in-county

Note:
[1] As of April 2004.

9.6 Evaluation of Biosolids Markets

A number of biosolids markets were identified, which are compatible with the range of products available from the biosolids processing technologies described in the next subsection. Nine cropping markets and eight non-cropping markets were identified. Table 9-5 shows the viable technologies identified in the pre-screening step (Subsection 9.7) and the related products from these technologies. Table 9-6 shows the markets available for the different biosolids products. Brief descriptions of the markets are provided below, followed by a summary of key aspects of the different markets, such as legal restrictions, market size and public perception.

Table 9-5
Viable Product Technologies Related to Biosolids Products

Products			Alkaline Stabilized Products						
Technologies	**Compost**	**Dry Pellets & Granules**	**pH >11**	**pH ≈ 7**	**Chemical Fertilizer**	**Construction Materials**	**Non-Construction Materials**	**Fuel Products /Energy Recovery**	**EQ Cake**
Composting	X								
Heat Drying		X			(X)*	(X)*		X	
Chemical Treatment			X	X	X				
Pyrolysis								X	
Super Critical Water Oxidation						X	X	X	
Gasification								X	
Combustion						X	X	X	
Renewable Energy Recovery								X	
Thermophilic Digestion									X

Note:
* with additional processing or blending

Table 9-6
Biosolids Products and Available Markets

Products / Markets	Compost	Dry Pellets & Granules	Alkaline Stabilized Products pH >11	Alkaline Stabilized Products pH ≈ 7	Chemical Fertilizer	Construction Materials	Non-construction materials	Fuel Products/ Energy Recovery	EQ Cake
Cropping Markets									
Land Application for Non-food crops									X
Land Application at City Farm, EQ biosolids	X	X		X	X				X
Horticulture - City Uses	X	X		X					
Horticulture – ornamental & nursery	X	X		X	X				
Horticulture – blending & bagging for retail	X	X		X	X				
Silviculture – Shade Tree Program	X	X		X	X				
Biomass/Ethanol crops	X	X		X	X				X
Citrus, avocado, vineyard & orchard		X			X				
Ag-Lime Applications			X						
Non-Cropping Markets									
Direct Energy		X						X	X
Erosion Control	X								
Direct Landfilling		X				X	X	X	X
Landfill Partnering – Daily Cover	X	(X)*	X	X					(X)
Construction Market		(X)*				X			
Non-construction Market							X		
Dedicated Land Disposal		X				X	X	X	X
Fuel usage		X						X	X

Note:
* requires further processing or blending

9.6.1 Land Application for Non-food Crops

A common biosolids market is spreading on land used to grow non-food crops. The decision to use biosolids only on non-food crops is not based on regulation, but on a decision by the City in recognition of the sensitivity of the food industry to public perception of food safety. Land application of biosolids has many documented benefits, including provision of slow-release organic nutrients, improvements in water retention and soil structure. Recently in Virginia there was a move to ban biosolids land application, which was overturned due to support from the farming community for biosolids land application. However, in Southern California many counties have moved to ban land application of Class B biosolids. Kings County has an ordinance that bans land application of any biosolids except compost from 2006. Other counties have considered similar ordinances. Riverside is implementing an ordinance that classifies EQ biosolids into three tiers, with different restrictions for each tier. Although it appears that at present Kern County and Riverside County will not ban EQ biosolids, the trend is towards increasing restriction on land application. Public perception issues and political constraints need to continue to be managed to enable use of land application into the future.

9.6.2 Land Application at City Farm

Land application of EQ thermophilically digested biosolids for non-food crops at the City's Green Acres Farm in Kern County has been a cost-effective management option. The City has been working with Kern County to maintain the option to beneficially use biosolids at the Green Acres Farm. The ability of the county to regulate land application means this market is not guaranteed, although public outreach and good stewardship by the City can be used to showcase the farm as a beneficial use of resources. Land application has been witnessed by the two newest Supervisors, who commented that the neighboring dairy smelled, but not the City's farm. However, issues being raised by the Kern Water Agency and some in the farming community with regard to the use of biosolids over useable groundwater will need to be addressed. Maintaining good management practices and documentation, as per the City's Biosolids EMS, will assist in supporting the science and benefits of land application of biosolids.

9.6.3 Horticulture- Blending & Bagging For Retail

This market involves producing considers the potential for compost and dried products for use in retail blending and bagging operations. The benefits of using organic residuals, such as compost and dried products, to amend soils and improve growth of crops are numerous and well documented. Thirty-six facilities produce over 1.6 million tons per year of compost products throughout southern California. These companies take in over 2.5 million tons per year of raw material that is processed into these products.

In the southern California marketplace, four suppliers dominate sales at the retail level. Kellogg Garden Products, Scott's Hyponex, Western Organics, and Whitney Farms control the majority of shelf space. The City has not had success in working with compost wholesalers in the past. The products are sold in displays featuring the products as topsoil or soil amendments. A total of eleven compost product manufacturers and suppliers are known to be operating in the local retail marketplace. Several of these manufacturers supply products to K-Mart, Target, and Wal-Mart for their own in-house promotion and brand. Of these manufacturers, three firms, Kellogg Garden Products, Western Organics, and Scott's Hyponex, utilize biosolids in their product formulations.

The biosolids portion of the Southern California marketplace appears to be dominated by Kellogg Garden Products. Of the eight different products produced by Kellogg, seven contained composted biosolids. In the case of Scott's Hyponex, fifteen different products were available and only one product contained composted biosolids. A significant portion of the biosolids used by Kellogg and Scott's Hyponex is obtained from the Inland Empire Utility Agency's existing compost manufacturing facility. The relative quantities of biosolids-based compost moving through the distribution chain of these two companies remains proprietary information. Most prevalent in these products was some type of animal manure. There appears to be a long-term deficit of compost product of approximately 95,000 tons per year from four primary firms. These firms expressed a desire to partner with biosolids generators to fill this deficit.

9.6.4 Silviculture - Shade Tree Program Assisting Residential Development

Although silviculture refers to the cultivation of trees, the term is often used with regard to a plantation or forest application. These markets are not available in southern California, but a program for planting shade trees in residential areas may be considered as a market for biosolids products such as compost or dried pellets. A healthy sustainable urban forest provides many benefits to its community:

- Natural urban shading and cooling, reducing air conditioning and associated costs
- Reduced energy use, thereby lessening air pollution from electricity generation
- Sequestering up to 26 lbs. of carbon dioxide per mature tree each year, a key factor in the rate of global warming
- Water conservation and reduced stormwater runoff along with associated flooding and pollution (mature trees are able to trap and hold up to 50 gallons of water each)
- Demand for trees, mulch, compost, and recycled water to grow and maintain the forest

Los Angeles DWP is partnering with the Los Angeles Unified School District and the following five non-profit groups to provide a citywide, community based tree planting program. Cool Schools plants trees around school buildings to create shade and cool the classrooms. The US Forest Service determined that for each dollar spent on the program, $2.37 was returned in the form of reduced energy expenditures and improved air quality, increased property value, and improved human health. The program includes an environmental curriculum, including biology, botany, horticulture and related topics. Funding for the program comes from DWP's Public Benefits programs. The program has been running for five years and close to 10,000 trees have been planted. This is not likely to be a large market, but it could be a good public relations recycling option, while providing additional benefits to the City.

LADWP also launched "Trees for a Green LA" in 2002, which will plant over 200,000 trees primarily on residential property within their service area. The Bureau of Sanitation would benefit by participating in the existing shade tree programs and/or by leading the development of a new shade tree program through cooperation with other departments. The benefits would include:

- Positive public relations regarding the recycling of beneficial products
- Community outreach with a number of public and private non-profit and for-profit partners expanding its base of support in the community
- Green areas provide better infiltration of storm water
- Leveraging the existing environmental and educational programs within the District's communities with overall goal of creating better, healthier communities.

9.6.5 Biomass/Ethanol Crops

An opportunity exists to land apply biosolids products to facilitate production of crops used in the production of ethanol as a renewable fuel source, or in support of fiber crop production. An option would be for the City to partner with a private sector farmer with enough land available to consumptively use all, or a substantial portion of, the annual biosolids products for the growing renewable energy type crops.

Banning MTBE in California and switching to ethanol would result in significant increases of ethanol consumption in California. It is estimated, based on projected gasoline consumption, that California would consume an average of about 880 MG/year of ethanol from 2003 through 2005, as compared with only about 60 MG/year in 2000.

Creating a viable in-state ethanol industry to capture these benefits, however, poses major challenges. The cost of producing ethanol remains high, requiring continued government price support to make it a competitive fuel additive. Developing a California ethanol industry will also require a state government role to overcome economic, technical, and institutional barriers and uncertainties. California-produced ethanol fuel will face stiff competition from out-of-state ethanol supplies and in-state petroleum products. Commercializing new technologies for converting biomass to ethanol raises uncertainties and presents challenges that must be overcome to foster and nurture a commercial ethanol industry in California.

There are companies that have started ventures for developing crops for ethanol production. One farm of around 80,000 acres would be able to supply approximately 25 percent of the California demand for ethanol as a fuel oxygenate. This provides a significant opportunity for beneficial use of biosolids. However, to date, much of the land that has been considered is located on marginal land in Imperial County and San Bernardino County, both of which do not allow land application of biosolids. Whether the counties will allow the use of EQ biosolids products to support the development of a new industry within the counties has not been explored in much detail. It is likely that this issue will be brought up, once the ethanol crop companies have further developed their ventures.

9.6.6 Citrus, Avocado, Vineyard, & Orchard

Fruit tree production has developed into a highly specialized and intensive production system that tends to exploit the soils to its maximum productivity. Recently the limited use of manure and soil organic amendments, lack of crop rotations, the frequent use of clean cultivation, lack of cover crops, little fallow time, increase in traffic of orchard machinery, and intensive inorganic fertilization and herbicide programs have accelerated soil exploitation.

To help better provide this growing environment the concept of sustainable agriculture, defined as the "long-term use of resources without degradation", has become a major subject of study. From this research, principles and guidelines have been developed focusing on the preservation and promotion of long-term soil fertility through sustainable agriculture. Biosolids products can provide this organic matter. A significant quantity of heat dried products have been used in the citrus industry in Florida. In Southern California, 210,000 acres are in orchards of various crop types. It is not known precisely how many of the acres are available for product application. The theoretical market capacity at an application rate of 20 tons per acre would equal about 4.2 million tons per year.

This market is especially vulnerable to fertilizer demand and public pressure. This highly seasonal market is only available during spring fertilization season before fruit set. Biosolids demand would also depend upon the cost and availability of fertilizer alternatives. Since farming is such a low margin industry, it would be unlikely that a farm would use biosolids in the face of any public pressure. Any stigma attached to the farmer's food would lower the price they could charge for its produce. For this market to be effective public protest and perception would have to be controlled. Segments of the public may be particularly unwilling to allow biosolids used in production of their food. They are concerned about any potential contamination or disease spread that could occur through their food. In addition, the City does not apply biosolids to food crops and would therefore not pursue this market.

9.6.7 Ag-lime Applications

The Ag-lime application market consists of the application of high pH biosolids products containing lime to agricultural land. Ag-lime products are typically used to increase the pH of acidic soils. There has been limited development of the market for alkaline stabilized products in the western U.S. Most of the growth has been in the eastern U.S., where the soils are acidic and can use lime. Alkaline soils common in southwestern states will not benefit from addition of a high pH product. Addition of a high pH product to alkaline soils can impair the soil properties and the availability of essential plant nutrients. An alternative use that has been suggested is in remediation of sodic soils, which are typically treated with a heavy dose of gypsum to release the salts. However, most biosolids products that contain lime or gypsum, do not have a sufficiently high proportion to assist in remediating sodic soils effectively.

9.6.8 Direct Energy Generation

Direct energy production markets refers to the market for power generated by the exothermic combustion or oxidation of biosolids, or through renewable energy recovery through slurry fracture injection as in the proposed TIRE project. Renewable energy recovery aims to provide methane recovery and possibly fuel oil recovery that could be used to for generation of electricity. Although digested biosolids have a lower calorific value than undigested solids, exothermic oxidation can still be achieved in a well designed process such as incineration, or, potentially, super critical water oxidation. Power is typically generated through waste heat recovery, although combined heat and power (CHP) systems that are more commonly used in Europe can provide higher efficiency than steam boilers that have been used in the U.S.

In Southern California, power generation from anaerobic digester gas is widespread, however, this only recovers a portion of the energy value of the biosolids. The focus of biosolids recycling has been on recovering the nutrient value of the biosolids through land application, due to ease of implementation and cost-effectiveness. However, in Europe, Canada and other regions of the U.S. where land application is limited for various reasons, direct energy production through combustion of biosolids has been successfully implemented. Recent changes in land application regulations and in power costs in Southern California have increased the focus on renewable energy sources.

The power industry is a multi-billion dollar industry. At present the renewable energy contribution is not significant, with around three percent of the DWP supply being generated from renewable, and there is a move to increase the contribution of renewable energy sources. The market size relative to the capacity that could be generated from biosolids is very large.

9.6.9 Burned Land Rehabilitation & Erosion Control

Erosion of soil is a common problem associated with any land that has limited vegetative cover whether due to natural causes or human activity. Erosion can be driven by wind or rainfall runoff. Agriculture, arid land, burned land, cleared and undeveloped land and steep slopes have historically experienced significant problems with erosion of topsoil and sub-soils. Erosion control is a factor in several other compost markets including agriculture, landfill cover, disturbed site reclamation and urban landscaping. This assessment does not include these markets. The use of compost products in roadway construction and maintenance and to minimize erosion from construction activity are included in this assessment. Compost is the biosolids product with the best structure to assist in preventing erosion. The objectives of using biosolids products for erosion control are twofold:

- To provide physical containment of soil particles. A coarse wood mulch provides a structure against the soil that protects soil particles from the impact of falling rain and the resulting runoff along the soil surface.

- Plant growth nutrients that assist the development of healthy plants and root system, which provide long term protection, and containment of soil.

The target market for roadway uses are primarily state and local governmental agencies. For construction projects both private developers and public agencies would be the target markets. Local permitting agencies and the landscaping and construction industries would be a focus for any marketing effort. For burned land rehabilitation, the Bureau of Land Reclamation would be the lead agency. To assist with the use of biosolids products in these markets, biosolids needs to be added to the list of permissible or preferred products. The City has already undertaken to start this process. The California Department of Transportation (Caltrans) has a program that supports the use of compost for erosion control. Since compost is an EQ product, there should not be any local restrictions on its use in most local jurisdictions. Bid Los Angeles Basin prices paid by Caltrans during 2001 ranged from $ 520 to $ 555 per ton of compost in place (CDOT, 2002). Even with the cost of transportation and blower truck application, the revenue potential for this use appears to be considerable.

Use of compost for preventing erosion during and following construction or for burned land rehabilitation would likely require action by the Regional Water Quality Control Boards and/or the local development permitting agencies in order for a market to develop. Runoff quality, odors during application, dust, ammonia release during application, and potential for public contact may be issues raised during an environmental review.

Primary efforts to use compost for erosion control have occurred in Oregon, Washington, Texas and California. The States of Washington and Minnesota have developed Standard Specifications for use of compost for erosion control in highway construction projects. California has developed draft specifications.

9.6.10 Direct Landfilling

Landfilling of biosolids under the current system of dry landfills cannot be considered a beneficial use of biosolids, and therefore does not satisfy the IRP guiding principle of 100 percent recycling. If regulations in the future allowed the wet landfills that could be operated as landfill bioreactors with organic wastes included rather than diverted (as per AB 939), landfilling could be considered as a beneficial use of biosolids for generation of landfill gas.

At present, however, there may be occasions when a landfill could serve as an failsafe or backup option. Of a total of 102 landfills in Southern California, 17 landfills are permitted to receive biosolids. The theoretical biosolids capacity for the Southern California landfills is about 16.6 million cubic yards (7.5 million wet tons). This is not the realistic operating capacity. The operating capacity reflects the daily allowable throughput at the landfill. Additionally, the operating capacity was reduced to reflect only those landfills with sufficient remaining capacity (typically in excess of 1 million cubic yards) that would make the contracting effort worthwhile. Applying these criteria reduced the number of landfills to seven and the throughput capacity to about 9,200 tons per day. Following the 10:1 ratio, at these landfills the available spare capacity is estimated to equal 920 tons per day of biosolids. Beyond California, there are landfills available in Arizona. Regulations have been implemented to reduce the volume of waste being sent to landfills, and to achieve the diversion requirements, it is preferable not to landfill biosolids.

9.6.11 Landfill Partnering- Alternative Daily Cover

Under current regulations, owners or operators of all municipal solid waste landfill units must cover disposed solid waste with a minimum of six inches of compacted earthen material or alternative material at the end of each operating day, or at more frequent intervals if necessary, to control vectors, fires, odors, blowing litter, and scavenging. Compost, co-compost, and chemically fixed sewage sludge, which meet the performance standards for cover material, can be utilized as alternative daily cover (ADC) and shall be limited to up to 25 percent of landfill cover materials or landfill cover extenders as required under Public Resources Code (PRC) 42245, and the new CIWMB ADC regulation. The 25 percent limit applies on a quarterly basis to the total daily and intermediate cover or cover extender use. Landfill cover means compost, co-compost, or chemically fixed sewage sludge blended or mixed with soil. There is significant competition with other wastes for use as ADC, including green waste, auto shredder waste, shredded tires and construction & demolition waste. It is anticipated that regulations may be proposed to prevent the excessive use of ADC as a means of meeting the landfill diversion targets. Landfill ADC may be considered a back-up market for biosolids products.

9.6.12 Construction Material Markets

There are a number of different types of construction material products than can be generated from biosolids. These range from dried biosolids and soil mixtures, to glass aggregate, and inert, sandy materials. The primary markets available for these products are as construction fill, road fill and for use in the manufacture of cement. This review will provide an overview of the construction material market, rather than going into detail on specific markets.

The construction industry market has not been widely used as a potential market for biosolids, largely due to the relatively low number of facilities that produce biosolids products that would be suitable for this market. However, discussions with American Remedial Technologies and TPS Technologies that are involved in the recycle of non-hazardous, contaminated soils indicate that there is a large market for soil type materials for use as fill in construction and development projects.

One company that has developed a process for converting waste materials, including biosolids, into a glass aggregate product that is marketed to the construction industry is Minergy Corporation. The product from a mixed waste process is a light weight glass aggregate that may be used in the marketed as a material for use in the manufacture of lightweight structural concrete, lightweight concrete masonry, insulating concrete, as a lightweight and fire resistant mineral filler, or as landscaping ground cover. Glass aggregate from a biosolids only process is most likely to be marketed as pavement and construction fill material. Other construction and non-construction material markets could be developed, including floor tiles, abrasives, roofing shingles and decorative landscaping, but would require a higher level of marketing effort in California, according to Terrence Carroll, a Regional Manager with Minergy.

The inert ash or sandy material from incineration or super critical water oxidation process can also be used in the construction industry. These materials typically pass the EPA leach test and are therefore not considered hazardous. The Minneapolis, Ohio, biosolids incineration ash has been used for cement manufacture and building product manufacture over the last nine years. The most viable market has been as an admixture in cement kilns, where there is some evidence that the metals in the ash act as a catalyst.

The overall aggregate market exceeds 3 billion tons per year in the United States. At an average product price of $4.83 per ton the market size exceeds $14 billion per year (U.S. Geological Survey, 2001). The U.S. Geological Survey estimated that the recycled aggregate market sector is growing rapidly and will continue to do so.

9.6.13 Non-Construction Material Products

Non-construction materials include items such as bricks and tiles that may be used in buildings. Several products are feasible in this category. Combustion and super critical wet oxidation processes produce an inert sandy material that can be used as in the manufacture of products such as tiles and bricks. Vitrification processes, such as the Minergy glass aggregate process, produce a hard, granular, black, glassy product that can be used in the manufacture of tiles, bricks, roofing shingles and other products. This is a more lucrative market than the construction materials market. However, it will be a more difficult market to penetrate as many of the materials will be used in residential structures and in forms with which people will be in close contact. The potential for negative public perception may restrict this market to a few industrial uses or roofing products.

This is not a market that has been widely considered for biosolids products. Minergy claim that their glass aggregate products from the biosolids or mixed waste vitrification processes may be used in non-construction material manufacturing. However, in discussions with Minergy, it appeared that their first target market in California would be the construction material market as the product would be more acceptable. In Japan, processes similar to Minergy were developed by Tsukishima Kikai (TSK) Corporation. TSK supply thermal treatment processes and incineration facilities for treatment of wastes and developed a process for biosolids vitrification or melting. TSK formed the molten biosolids into brick and artificial stone. However, lack of acceptance of the product and process economics have led to TSK removing the process from their list of supplied technologies.

Although a number of biosolids aggregate or inert ash products could feasibly be used as non-construction materials, acceptance has been a primary draw. The market for non-construction material products is strong. However, the market for biosolids products as a non-construction product material is likely to be considerably smaller than for construction materials, due to the lower acceptance of biosolids products for such applications. If biosolids could be sold into these markets, the product value would be in the range of $15 to $25, according to Minergy.

9.6.14 Dedicated Land Disposal

Since 1931, the Holloway Company has been mining gypsum from property near the intersection of Interstate 5 and State Highway 46 in Kern County, California. These operations have left many hundreds of acres of open pits over 55 feet deep. It has been proposed by GeoManagement LLC to allow the filling of these pits with 2,000 wet tons of biosolids per day. According to GeoManagement, the property, has enough capacity to accept biosolids at this rate for over 40 years. The first open pit to be filled is 150 acres in surface area and has an average depth of 55 feet. This pit will take over 15 years to fill. Other wastes will be accepted, including auto shredder waste and construction and demolition debris. Upon delivery, the biosolids will be air dried and then combined with ash and local material in large mixers, already on site from the mining operation. This mixture will be landfilled over a 48-hour cover cycle.

The site received a negative declaration for CEQA compliance, but has not yet obtained all the required permits and approvals. The facility is an unlined landfill. It sits atop a layer of 120 feet of impermeable clay that sits upon a very small and poor quality water table. A leachate collection system will be required. It is expected that all potential contaminants would be contained by this clay layer.

The economics of disposal at the facility are composed of a tipping fee and transportation cost. The tipping fee is estimated to range from $10 to $35 per wet ton plus line haul transportation up to $20 per ton[1]. Being a disposal option, this does not fit the goal of 100 percent beneficial use of biosolids.

9.6.15 Fuel Usage (Oil, Char)

Fuel usage markets are considered for the fuel products, char or oil, generated by pyrolysis and gasification processes, which then need to be marketed to facilities that can use the fuel. The total heating value of the products cannot be greater than the calorific value of the feed solids. The feed biosolids calorific value is typically around 6,500-7,500 Btu/lb dry solids for digested biosolids and 9,000 Btu/lb dry solids for undigested biosolids. The form of the fuel products, the moisture and the actual heating value of each product will vary depending on the process. In addition, thermally dried biosolids may be combusted as a fuel product, and would have a calorific value of around 7,000 Btu/lb if digested biosolids were used. Through the rest of this discussion, the term char will be deemed to include heat dried biosolids granules.

Some processes produce a low grade oil, similar to a kerosene type product, or a No. 7 oil. Industry experience indicates that the oil product is difficult to market and may processes avoid producing it. The char solids content may vary from 50 to 95 percent. Local uses for the char are in cement kilns and biomass waste to energy plants. Cement kilns prefer a char with maximum moisture content of 8 percent for use in the clinker zone. Char used in the pre-calciner zone can have higher moisture content of up to 50 percent. Utilization of alternative fuel sources in cement kilns or other energy facilities has been practiced for decades.

Fuel char, at 6,500 to 9,000 Btu/lb is a low to mid-range energy value product compared to tires that contain 12,000 to 16,000 Btu/lb. In comparison, bituminous coal has energy values ranging from 11,000 to 13,000 Btu/lb., fuel oil (No. 6) has 18,000 to

18,500 Btu/lb, wet wood (hogged fuel) has 4,000 to 5,000 Btu/lb, and agricultural waste has 5,000 to 8,500 Btu/lb (CIWMB, 1992). The use of char by a cement kiln will depend on the design of the cement plant and the BTU of the fuel normally used.

[1] For a haul distance of 200 miles one way at $2.50 per mile (one way distance) the cost per load equals $500. At 25 tons per load the unit cost of transportation equals $20 per ton.

9.6.16 Summary of Biosolids Product Markets

The markets described above were evaluated based on a number of factors, such as regulatory restrictions, market risk, public perception, and political constraints. The summary of this evaluation is presented in Table 9-7. To assist the review of the markets, color-coding was used, with red indicating high risk aspects of a market, yellow indicating aspects requiring caution and green representing low risk. Landfilling and ADC markets were not color coded as these should be considered as failsafe or back-up options. Market categories that are colored in red will not be considered further.

9.7 Introduction and Pre-Screening of Product Technologies

The approach to evaluation of the biosolids management options has focused on co-ordinating two key aspects, the biosolids markets and the product technologies that can process the biosolids to form a product that is compatible with the available markets. Sustainable biosolids management needs to consider a business-type approach, where suitable markets are first identified and then the steps necessary to provide suitable products are implemented. This evaluation of biosolids management, therefore, first pre-screens the available biosolids product technologies to identify any that are inappropriate for further consideration in the IRP, and to identify the types of products provided by the range of technologies. This was followed by a more detailed ranking of the main product technology categories, to assistance in developing planning recommendations.

There are a wide range of technologies available for biosolids treatment and production of a biosolids product. As discussed in Subsection 9.5.2, the City has received a number of proposals from vendors of different product technologies in response to Class A and drying RFPs. These were considered in the product technology evaluation. The team also added appropriate technologies for which the City has not received proposals, but that may be feasible. The product technologies were assigned to eleven broad categories.

The technologies were initially reviewed to identify any fatal flaws, such as processes that are not identified in the Part 503 regulations as meeting Class A pathogen densities. Any process that can produce Class A pathogen density levels only under Alternatives 3 and 4 (by testing for pathogens in the product) will be discounted from detailed evaluation as there have been indication that these may be deleted from the regulations in the future. In addition, any processes that do not provide a stable product without offensive odor will also be considered to be inappropriate for further

Table 9-7
Biosolids Cropping Markets Summary & Evaluation

	History	Market Strength	Current Market Size	Estimate of Future Markets	Competitors	Legal Restrictions	Perceived Market Risk	Public Perception Issues	Product Limits & Preferences	Economics	Political Constraints	CEQA	Backup Option – Assessment of Implementation
General land application for non-food crops at City farm ⊖	Substantial & Proven	Fair ⊖	292,000 WT/yr[1]; 36,500 WT/yr[2]	Uncertain ⊖	Increasing ⊖	Tenuous ⊖	Somewhat risky ⊖	Negative ⊘	Normal	$22-35/ton cost ⊖	Tenuous ⊖	General Order under litigation ⊖	Feasibility will decline over next 2-3 years
Land application for non-food crops at City farm ☺	Substantial & Proven	Good ☺	150,000 WT/yr	150,000 WT/yr ☺	None ☺	Manageable ⊖	Low – need to manage loading rates ☺	Uncertain, needs to be managed ⊘	Normal ☺	$22-25/ton cost ⊖	Manageable ⊖	None ☺	Feasible with biosolids 'products'
Horticulture – City use ☺	Substantial & Proven	Good ☺	31,000 WT/yr	31,000 WT/yr ☺	Many; current local suppliers ⊖	None ☺	Somewhat risky ⊖	Good ☺	Normal ☺	$0-30/ton revenue ☺	Low ☺	None ☺	Feasible; demonstrations; inter-dept. co-ordination; sales mgt.
Horticulture – ornamental & nursery ☺	Substantial & Proven	Good ☺	Uncertain	240,000 WT/yr[3] ☺	Many ⊖	None ☺	Somewhat risky ⊖	Good ☺	Normal ☺	$0-88/ton revenue ☺	Low ☺	None ☺	Feasible; demonstrations, sales mgt.
Horticulture – blending & bagging for retail ☺	Substantial & Proven	Good ☺	1,600,000 WT/yr	1,700,000 WT/yr ☺	Many ⊖	None ☺	Somewhat risky ⊖	Good ☺	Normal ☺	$0-7/ton revenue ☺	Low ☺	None ☺	Feasible; demonstrations, sales mgt.
Silviculture – Shade Tree Program ☺	Substantial & Proven	High ☺	0	600 WT/yr ⊖	Few ☺	None ☺	Somewhat risky ⊖	Good ☺	Normal ☺	$55-100/tree cost ⊖	Low ☺	None ☺	Feasible; demonstrations, sales mgt.
Biomass?Ethanol crops ☺	Substantial & Proven	Good ☺	0	1,400,000 WT/yr[4] ☺	Few ☺	May fall under land application bans ⊖	Somewhat risky ⊖	Good ☺	Normal ☺	Uncertain ⊖	May fall under land application constraints ⊖	None ☺	Feasible; highly challenging; water use issues; need big project partner
Citrus, avocado, vineyard & orchard ☹	Substantial & Proven but SE U.S.	Poor & failing ☹	Uncertain	Uncertain ⊖	Conventional & organic fertilizers ⊖	Severe & worsening ☹	Very Risky ☹	Strongly Negative ☹	Poor farmer acceptance; highly salt sensitive ☹	$0-Uncertain ⊖	Severe & worsening ☹	None ☺	Low feasibility
Ag-Lime Applications ☹	Substantial & Proven but MW & SE U.S.	Poor ⊖	0	Very little ☹	None ☺	None ☺	High ☹	Strongly Negative ☹	Poor farmer acceptance ⊖	Poor ⊖	Severe & worsening ☹	None ☺	Low feasibility

Legend: ☹ High Risk "red flag" ⊖ Caution ☺ Low Risk

1 RBM contract
2 Synagro contract
3 Based on potential California demand for landscaping, delivered topsoil, container nurseries, filed nurseries & sod reduced by 50% for southern California portion of market and using a 40% biosolids compost
4 Based on one proposal for 70,000 acres at 20 tons/acre, supplying up to 25% of state ethanol

consideration in the IRP. Any biosolids product technology that does not provide a product equivalent to an EQ biosolids standard will also not be further evaluated. As defined by the EPA, EQ biosolids meet all of the following criteria, which refer to the Part 503 regulations:

- Should be below the maximum pollutant levels in Part 503 regulations, Table 1
- Should be equal to or below the average pollutant levels in Part 503 regulations, Table 3
- Should meet Class A pathogen density levels
- Should satisfy one of the first eight vector attraction reduction requirements

A summary list of the product technologies and the preliminary screening conducted is provided in Table 9-8 followed by a brief description of the different categories. The range of products that can be produced from the technologies that passed the pre-screening stage were shown previously in Table 9-5. These products were considered when identifying the markets available for biosolids recycling.

Table 9-8
Summary of Initial Screening of Biosolids Product Technologies

No.	Process	Appropriate for IRP
1	Thermophilic Digestion	Y
2	Composting	Y
3	Heat Drying	Y
4	Solar Drying	N – footprint, pathogen reduction control
5	Bactericides	N – not EQ process, handling & dosing of toxin
6	Chemical Treatment	Y
7	Combustion	Y
8	Super Critical Water Oxidation	Y
9	Gasification	Y
10	Pyrolysis	Y
11	Renewable Energy Recovery	Y

Note:
* For processes identified to be inappropriate, details were provided in the text below

9.7.1 Thermophilic Digestion

The City has converted the anaerobic digestion systems at both HTP and TITP to thermophilic digestion at around 128°F. For the City, this has proven to be a cost effective option for changing from Class B to EQ biosolids. In order to meet Class A pathogen requirements by the Part 503 regulations Alternative 1, the digestion process needs to include a batch holding step to provide the time-temperature holding time. Alternatively, pathogen kill may be demonstrated by testing, and approval obtained by the EPA Pathogen Equivalency Committee. Pathogen regrowth may be an issue and has been noticed to coincide with use of high speed centrifuges for dewatering. The City has taken steps to insure that at the time of land application pathogen regrowth has not occurred in the biosolids. Thermophilic digestion may increase odors at the plant site, particularly if the digester head space is not adequately sealed, and also from the dewatering process and filtrate. Final product odors may be reduced compared with Class B digested biosolids.

Thermophilic digested biosolids that do not undergo further processing maintain a higher level of plant nutrients, including nitrogen and phosphorus, than compost products, where additional biological activity is conducted. Thermophilic digested biosolids may be further processed by any of the other technologies listed, as an additional step to convert the biosolids to a different product form, such as pellets or char. The City is currently employing a successful thermophilic digestion process, with the biosolids used for bulk land application to non-food crops.

9.7.2 Composting

Composting refers to the biological, aerobic stabilization of biosolids with an amendment to improve texture. The process is typically autothermal and generates sufficient heat to maintain temperatures over 55°C for at least three consecutive days, thereby producing an EQ product. There are a number of different composting processes including:

- **Vermicomposting**: composting with the addition of worms;
- **Aerated Static Pile:** composting in piles that have forced aeration, and therefore do not require turning as with windrows; and
- **In-vessel composting:** these require the construction of defined cells in which the composting takes place. The depth of the beds varies from around 8 ft to 24 ft depending on the specific process.
- **Windrow composting:** not considered to be long term sustainable for large facilities due to the air and particulate emission issues with this method, the difficulty of process control and the draft Rule 1133 regulations that will effectively eliminate this as an option for processing biosolids in parts of Southern California.

9.7.3 Heat Drying

Heat drying processes use a fuel source to significantly reduce the volume and mass of biosolids produced at the facility and reduces pathogens and vector attraction. This provides a much more rapid process than the traditional sludge drying bed approach, which used natural heat and sunlight for drying. Heat drying processes that are considered here for treating biosolids are less complicated than the Carver Greenfield type of process, as the biosolids are dried in air, not in hot oil, and therefore there is no oil recovery process. In addition, the movement of biosolids is conducted by mechanical means, rather than by pressure differentials. Heat dried biosolids meet requirements of the Part 503 regulations for vector and pathogen control and the biosolids are classified as an EQ product. The heat drying process is based on reduction of water content in dewatered biosolids by evaporation. This process produces heat dried pellets that are typically used as soil fertilizers and can be spread on agricultural land, golf courses, or park land to provide the soil with nutrients and minerals. Dried biosolids may also be used as a fuel source for energy recovery. Many of the existing municipal heat drying facilities in the United States secure long-term contracts with private biosolids management companies for year-round recycling of dried biosolids. The pellets can be hauled off in bulk in trucks, or the solids can be bagged and marketed to retail outlets as organic soil fertilizer.

Several support systems are required to provide a complete and safe operating heat drying system. When considering any heat drying process, it is important to consider vendors that provide the entire system as a complete package, to ensure that all components of the system work together as a whole. Heat dryers can be classified into two main categories, direct and indirect. In addition, the City has received proposals from facilities that would dry biosolids with heat-treated soil, and this specific category has been added to the evaluation of heat drying. A more thorough analysis of heat drying is presented in Appendix K.

- **Direct Dryers:** dewatered biosolids come into direct contact with hot air. The hot air can be direct exhaust air from a gas burner or can be produced in a heat exchanger. The predominant method of heat transfer in direct drying systems is convection. Direct drying systems include rotary drum dryers, belt dryers and flash dryers. There are over 40 direct rotary drum dryer installations in North America, the largest of which is at the 180 mgd Louisville wastewater treatment plant.

- **Indirect Dryers:** the heat transfer medium (steam, hot water, oil) is used to transfer to metal surfaces that contact the biosolids. Indirect heat drying equipment includes paddle heat dryers, disk type heat dryers, and multiple-hearth heat dryers. Fluidized bed dryers can be arranged both as direct and indirect type systems. There are over ten indirect dryers in North America, and a large number in Europe. The Komline Sanderson paddle dryer is the most common and may be more cost effective at small plants than rotary drum dryers. The STORD dryer is a disc dryer that was not successfully applied to biosolids processing. Four facilities installed this dryer in the 1990s, including the City, but all have been shut down due to operational and odor issues.

- **Indirect Drying with Heated Soil:** biosolids are mixed with soil at temperatures over 500°F that have been heated in a rotary drum dryer for treatment of non-hazardous organic compounds. The biosolids should be well mixed in an enclosed chamber, with the off-gases vented to the thermal oxidizer used to treat vapors from the soil treatment process. The biosolids provide moisture and organic content to the treated soil, which improve the soil characteristics.

9.7.4 Solar Drying

There are two sub-categories under solar drying:

- Green house solar drying; and
- Open air solar drying.

Greenhouse Drying
Enclosed green house solar drying uses solar energy, enhanced through green house construction and air circulation control, to provide faster and less odorous drying than conventional solar drying beds. It is claimed by the manufacturer (Parkson) that the process produces Class A pathogen levels, but it does not fit any of the Part 503 regulations alternatives for Processes for Further Reduction of Pathogens (PFRPs). An estimate provided by Parkson Corporation for a solar drying system required 20 acres to treat 188,000 wet tons per year of digested and dewatered biosolids. At the City's current solids production of around 850 wet tons per day, the footprint required would be over 30 acres. This option is considered to have a fatal flaw due to the following reasons:

- Large footprint and number of modules required; and
- Currently meets Class A pathogen requirements only under Part 503 regulations Alternative 3 or 4 .

Open Air Drying
The Yakima Company has proposed open air solar drying of the biosolids cake at the La Paz Landfill in Arizona, with the biosolids cake dried to approximately 90 percent over a four-week period and used as alternative daily cover (ADC) for the landfill, or for composting. Although the site at present is considered sufficiently remote to not raise objections to odors or flies, this alternative will not be considered further for the following reasons (This option, however, may be considered as a failsafe, backup option for biosolids processing and recycling):

- Biosolids would be managed outside of California, where the City would have no say in future regulations. La Paz County has recently started to consider a ban on Class B land application;
- The option may meet Class A by Alternative 3, but not as a PFRP and reliability of the pathogen kill is questionable;

- These could be environmental impacts and emissions from the long-hauling distance and no process emission control; and
- Odors and flies may eventually raise objections from locals or from landfill workers.
- Management of the environmental impacts, nuisance and containment of leachate does not appear to be adequate.

9.7.5 Bactericides

Treatment with bactericides requires the addition of toxic chemicals in sufficient quantity to the biosolids to effect the required pathogen kill. The dose can be controlled to provide Class A or Class B level of pathogen kill. This does not fit any of the Part 503 regulations alternative for PFRPs and would need to be routinely tested for Class A compliance under Alternative 4. The review of this options is based on information provided by Evergreen Organics regarding their use of the bactericide Busan 1236 (sodium N-methyldithiocarbamate) and technical experience gained in tests done by Atkins in the U.K. using borates for pathogen kill in digested biosolids. A dosing requirement stated in the information provided by Evergreen Organics was 0.5 percent metam sodium and 1 percent potassium hydroxide per wet ton of biosolids. At the current biosolids production of 681 wet tons per day, this would require a chemical consumption of 3.4 tons per day metam sodium and 6.8 tons per day potassium hydroxide, which is a considerable amount. Based on the review of available material this option is considered to have a fatal flaw for the following reasons:

- Can only qualify for Class A pathogen standards under Part 503 regulations Alternative 3 or 4
- Does not meet the Class A requirement for vector attraction reduction to be conducted simultaneously to or after the pathogen reduction step[2]
- The bactericides are extremely toxic and require special training and personal protective equipment (PPE) for handling. Permitting of such chemicals at the City's wastewater plants would be extremely difficult, particularly given the amount that would be required
- Improper dosing would result in a negative impact on the land to which the biosolids are applied. To meet Class A pathogen levels, given the variability in feed pathogen concentrations, it would be difficult to maintain the correct dose. The process would be more suitable for Class B pathogen requirements

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[2] Documentation from Evergreen Organics stated that the process meets VAR since the final moisture content is less than 25% after blending with bulking agents and has a specific oxygen uptake rate (SOUR) that meets VAR requirements. However, the vendor has misinterpreted the VAR requirements, as the 40 CFR 503 VAR Option 4 on SOUR is only permitted for sludges from aerobic treatment processes and Option 7 requires a dryness of 75% before blending with other materials.

- Addition of bactericides does not improve long term stability of the product. Since the cake would need to be stored until the bactericide concentrations are below the toxic limit, there is the potential for odor generation from the stored biosolids and pathogen re-growth

9.7.6 Chemical Treatment

9.7.6.1 Alkaline Stabilization

There are a wide range of alkaline treatment processes available and the three sub-categories reflect the key process differences:

- **Neat alkali (quick lime) processes:** these require the addition of a high quality lime product such as quick lime;
- **Fly ash and waste alkali processes:** these processes use lower quality, but potentially cheaper, alkaline waste products such as fly ash from cement kilns; and
- **Neutralization processes:** these processes use an alkali with sulfuric acid to provide a product with a neutral pH.

Some of the alkaline stabilization processes also include a drying step, which may be optional, to produce a drier, potentially better quality product. There are a large number of alkaline stabilization processes and facilities. Most are in areas where the soil has a low pH, as this provides a market for bulk land application of high pH biosolids.

9.7.6.2 Chemical Fortification

Chemical fortification processes include the addition of chemicals and biosolids, to produce a high end fertilizer with specific properties that can be sold to the retail agricultural or consumer market. Typically a base such as anhydrous ammonia and acids such as sulfuric acid or phosphoric acid are used, producing an exothermic reaction. The level of fortification may be low, medium or high, depending on the local market requirements and process economics. There are few chemical fortification facilities in North America.

9.7.7 Complete Combustion

Complete combustion is the oxidation of organics in the presence of sufficient oxygen for complete combustion. The net fuel production depends on the heating value and the moisture content of the feed substrate. It includes the following categories:

- **Combustion:** the flue gas temperature must be raised to a minimum of 1,400°F for complete oxidation. Operating temperatures inside the reaction chambers are usually higher. Afterburners in California normally must be operated at 2,000°F for two seconds to reduce total hydrocarbons. To be autogenous (no addition of supplemental fuel) using undigested sewage solids, cake solids concentrations must be greater than 28 percent. Alternatively, co-combustion can be conducted using biosolids and a fuel source with a higher calorific value, such as wood waste.

- **Plasma Assisted Oxidation:** uses a plasma arc to sustain the oxidation process by generating UV radiation and ionic radicals, which catalyze the oxidation and cracking reactions at lower temperatures of 1,100°F and with feed organic concentrations as low as 20 percent, depending on the calorific value of the feed.

- **Vitrification:** or the melting of biosolids is conducted at high temperatures in the range of 2,600-2,900°F and at atmospheric pressure, in the presence of oxygen. The inorganic fraction melts, while the organic fraction burns to produce heat. The molten solids are then cooled to form a hard glass aggregate or granular product.

Raw primary solids have the highest heating value. The use of chemically enhanced primary treatment and digestion reduces the BTU value of the biosolids.

9.7.8 Super Critical Water Oxidation

Super critical water oxidation (SCWO), also known as wet oxidation or wet combustion, is the oxidation of organics at super critical pressure and temperature in a liquid state (for water, critical temperature = 705°F, critical pressure = 3,200 psi), with the addition of compressed air or oxygen into the pressure vessel. The process is highly exothermic. The degree of oxidation is dependent on the temperature and pressure. Sub critical wet oxidation, such as the Zimpro process, does not fully oxidize the organics and produces difficult to treat waste streams. Therefore, sub-critical wet oxidation will not be considered in this evaluation. For SCWO, temperatures are typically in the range of 700 to1,100°F and pressures in the range of 3,200 to 4,000 psi. The process configuration may be a below ground well type system or an above ground pressure reactor system.

9.7.9 Gasification/Starved Air Combustion

Gasification is a combination of complete combustion and pyrolysis, with better control of air emissions and lower particulates than complete combustion. However, it is not yet well understood, particularly for feed substrates such as biosolids, and the yields of off-gases and residues must be determined by pilot testing. The products are combustible gases, which usually have a fairly low heating value, tars, oils and a char with a heating value. This process has been conducted in multiple hearth furnaces with sewage solids to produce a gas that is subsequently combusted in the afterburner to provide the needed temperature to lower hydrocarbon emissions. Air or steam can be injected into the lower hearths to completely oxidize any tars or char.

9.7.10 Pyrolysis

Pyrolysis is the conversion or cracking of biosolids at high temperatures, in the absence of oxygen. As most organics are thermally unstable, they are split by a combination of thermal cracking, and condensation reactions into gaseous, liquid and solid fractions. The process is highly endothermic, but usually produces a char and sometimes an oil that have heating value. The products depend on the temperature at which the process is conducted. Pressures may range from 0 to 3,000 psi. The following subcategories will be considered in this analysis:

- **Low temperature pyrolysis:** takes place at temperatures < 600°F, and typically does not produce an oil stream;
- **Mid temperature pyrolysis:** takes place at temperatures in the range of 800 - 1,000°F, and typically does produce an oil stream, as well as a char with fuel value.
- **High temperature pyrolysis:** takes place at temperatures in the range of 1,200-1,800°F and typically produces an ash rather than a solid fuel.

Pyrolysis processes are being developed, with much work being conducted in Europe and Asia. It is not yet considered a proven technology for biosolids.

9.7.11 Renewable Energy Recovery (TIRE)

Renewable energy recovery is the placement of liquid biosolids through deep wells that connect with depleted oil and gas reservoirs at depths of 5,000 ft or more, using a technique know as slurry fracture injection (SFI). It is anticipated that biosolids can be used for enhanced oil and gas recovery and will also continue anaerobic biodegradation. Bench–scale tests conducted by the City and by the University of California in Los Angeles (UCLA) to simulate conditions in the deep formations have shown that significant amounts of methane are produced. The carbon dioxide produced will preferentially dissolve in the formation waters at the high pressure, while high quality (90 percent), high pressure methane can be recovered from gas wells, while providing carbon sequestration. SFI is an established technology for disposal of oil field brine and slurries.

The City has identified a suitable formation below TITP and is developing a demonstration project, known as the Terminal Island Renewable Energy (TIRE) project, to develop this technology. The City has been working with EPA staff to ensure that the well design, monitoring instrumentation and safety features are of the highest standard. The formation in which the biosolids will be placed has at least a dozen impermeable confining zones between it and the nearest potable water quality aquifer. The initial economics appear to be favorable, while providing many advantages such as energy recovery for green power generation, minimizing odor and diversification into alternate uses of biosolids. If successful, this technology could provide cost-effective biosolids management for many agencies in California and other areas where there are depleted oil reservoirs.

9.7.12 Summary

The results of the initial screening step are provided in Table 9-8 and show that of the 11 broad categories of product technologies, two have been considered to have fatal flaws, while nine categories will be carried forward for more detailed evaluation of the viable technologies.

9.8 Biosolids Product Technology Screening Criteria

To evaluate the wide range of available biosolids product technologies, four broad objectives were identified that should be met by any product technology. These objectives listed below reflect key issues of concern for the City, the IRP, and biosolids management in Southern California :

- Protect Public Health and the Environment
- Provide System Reliability
- Enhance Cost Efficiency
- Implementation/Quality of Life

In order to assess how well the technologies met these objectives, a number of criteria were developed under each objective, by which each technology could be evaluated. Each objective was considered equally important. The criteria are in keeping with the management goals identified in this task and in the City's Biosolids EMS. Each technology will be assigned a score between one and five to reflect its performance for each criteria. A score of 1 indicates a low performance and reflects negatively on that technology. A score of 5 reflects a high score and reflects positively on that technology. The technology score for a particular criteria will be multiplied by the importance weighting for that criteria and the sum of all the results for a the technology will be used to rank it in comparison to the other technologies.

9.8.1 Protect Public Health and Safety

For the biosolids evaluation, four criteria were selected under the objective of protecting public health and safety. These include:

9.8.1.1 Long Term Regulatory Compliance

Long term regulatory compliance criteria considers current, emerging and proposed regulations, as well as considering the regulatory 'crystal ball' and the City's Biosolids EMS. Potential federal, state and local regulations and ordinances are covered by this criteria. For any process to be sustainable in the long term, current and potential regulatory issues must be minimized.

9.8.1.2 Traffic

Traffic is a critical issue for environmental impacts and public acceptance of a new facility. Processes that reduce the traffic impacts will score higher on this criteria, this may be through location on or adjacent to the wastewater treatment plant site, or through reduction in the volume of product for final recycling.

9.8.1.3 Air Quality and Odor

Air quality is very important for environmental impacts, regulatory compliance and permitting. Odor is another critical issue for public acceptance and the long term sustainability of a facility and has to be considered so technologies that have odorous processes or products can be rated lower compared with processes that minimize odors.

9.8.1.4 Environmental, Health & Safety Benefits

The environmental, health and safety benefits is a broad reflection of benefits to the environment and to public and operations staff health and safety. These benefits may include implementation of processes that reduce impacts, such as net energy use, use of chemicals or provide a better quality product. This is an important criteria in maintaining good stewardship and conforming to the Biosolids EMS.

9.8.2 Provide System Reliability

For the IRP biosolids evaluation, four criteria were selected under the objective of providing system reliability. These were:

9.8.2.1 Industry Experience

Industry experience refers to the level of development and the number of successful, currently operational installations, with the highest score being given to technologies that have similar sized installations to the City. As this is a long term master plan promising emerging technologies should be considered, and these were compared with each other in a separate listing of emerging technologies.

9.8.2.2 Process Reliability

Process reliability refers to operational experience with the technology at past or present installations. For technologies that do not have full-scale installations, a technical evaluation of the process and the equipment will be conducted to rank the anticipated process reliability of the technology. Unreliable processes not only cause operational problems, but also have impacts on other factors such as reliable use of the product, prevention of biosolids being stockpiled, public perception and regulatory compliance.

9.8.2.3 Owner/Operator Options

Technologies that are flexible from an owner and operational perspective are preferable with regards to flexibility of the options for the City. For example, a composting facility could be owned and operated by the City, it could be owned by the City and operated by a contractor, or the City could contract with a privately owned composting facility for a per ton fee. The City could also participate in a regional facility.

9.8.2.4 Production of Difficult Waste Streams

Processes that produce difficult to treat waste streams would score low on this criterion. Examples of difficult waste streams include:

- High nutrient loads such as ammonia and phosphorus;
- High strength loads such as BOD, COD or TSS;
- Ash that may be classed as hazardous; and
- Air emissions that would require extensive treatment for compounds such as dioxins or mercury.

The impact of these waste streams may increase treatment costs and could result in the facility being difficult to site.

9.8.3 Enhance Cost Efficiency

For the biosolids evaluation, four criteria were selected under the objective of enhancing cost efficiency. These include:

9.8.3.1 Capital Costs

Facilities with high capital costs result in more of the risk being carried up front, prior to process being implemented. High capital costs may also affect the ease and the cost of obtaining financing. Cost information has been obtained from a number of vendors that cover the range of biosolids product technologies and were used as general guides for comparison of the technologies. Processes that typically have higher capital costs will be score less than those with lower costs.

9.8.3.2 O&M Costs

Facilities that have high O&M costs may have higher life cycle costs. In addition, O&M costs are impacted by changing prices for consumables, such as gas prices. These factors can affect the long term economics of a facility, and therefore facilities with higher O&M costs score lower in this regard.

9.8.3.3 City's Investment Risk

Investment risk is a reflection of the level of risk that the City takes when investing in a technology option and will consider the level of investment in conjunction with the risk associated with that investment. Although investment risk is an important factor, as it is an anticipated future level of risk based on technical judgment. Technologies that are only suitable for private ownership and financing score high on this criteria, as there is little investment required from the City. Technologies that are suitable for ownership by the City may score lower on this criteria, based on the estimated level of investment that would be required, and the level of risk associated with the facility.

9.8.3.4 Compatibility with Existing Facilities

Technologies incompatible with existing facilities would be ranked lower in the evaluation. The City is committed to maintaining anaerobic digestion and maximizing biogas recovery to reduce on-site electrical costs. Technologies that have an adverse impact on the existing facilities such as recycle streams, large footprints, or feed requirements will be assigned a lower score. This is an important issue in terms of site complexity, operations and land use, however it is not as critical as other factors that can make or break an option, as for most technologies, these issues can be managed.

9.8.4 Implementation/Quality of Life

For the biosolids evaluation, four criteria were selected under the objective of ease of implementation and maintaining quality of life. These include:

9.8.4.1 Public Perception of the Facility

Public perception and acceptance and adhering to EMS requirements are key issues in Southern California and are also factors in siting and implementation of a facility. Technologies such as incineration, or facilities that have a tall stack, may have negative public perception due to aesthetics and health concerns about stack emissions, unless they are situated in remote or heavily industrialized areas. This issue is considered critical, as public perception is key to the successful siting and implementation of a facility.

9.8.4.2 Ease of Siting In Southern California

Ease of implementation and siting ties in a number of factors that will affect the ability of a facility to be located in Southern California, including location, public perception, regulations, permitting and land requirements. Facilities that would be difficult to site in Southern California reduce the probability of implementation and continuing operation, and could attract negative publicity for the City. This is considered a key issue in evaluating the technology options.

9.8.4.3 Product Compatibility with Markets

Any process technology must provide a product that is compatible with a reliable market and the product must be meet standards required by that market. This is considered a critical issue to long term sustainability of an option.

9.8.4.4 Product Acceptability

The physical characteristics of the product must be acceptable to the general public since many local regulations have been driven by perception issues.

9.8.5 Summary

Table 9-9 provides the criteria used in the evaluation and the importance weighting factor. The criteria were developed in a workshop with City staff and the consultant team and reflect local biosolids issues and City concerns regarding biosolids management technologies and with reference to the City's Biosolids EMS. As all the issues are of importance for a successful biosolids facility, each objective was weighted equally, at 4 points, and each criteria was also weighted equally. The maximum score that can be achieved by any technology is 80 points.

Table 9-9
Biosolids Options Ranking Criteria

No.	Criteria	Score[1]	Importance[2]
1.	**Protect Public Health & the Environment**		**4**
1.1	Long term regulatory compliance	1 – doubtful; 5 - likely	1
1.2	Traffic	1 – high; 5 - low	1
1.3	Air quality and odor	1 – high; 5 - low	1
1.4	Environmental, health & safety benefits	1 – low; 5 - high	1
2.	**Provide System Reliability**		**4**
2.1	Industry experience	1 – none; 5 – similar size	1
2.2	Process Reliability	1 – questionable; 5 - reliable	1
2.3	Owner/operator options	1 – contractor; 5 - flexible	1
2.4	Production of difficult waste streams	1 – strong; 5 - none	1
3.	**Enhance Cost Efficiency**		**4**
3.1	Capital Cost	1 – high; 5 - low	1
3.2	O&M Cost	1 – high; 5 - low	1
3.3	LA Investment Risk	1 – high; 5 - low	1
3.4	Compatibility with existing facilities	1 – low; 5 – v. compatible	1
4.	**Implementation/Quality of Life**		**4**
4.1	Public perception of facility	1 – negative; 5 - acceptable	1
4.2	Ease of siting in S. CA	1 – difficult; 5 - easier	1
4.3	Product compatibility with markets	1 – not; 5 – v. compatible	1
4.4	Product acceptability	1 – low; 5 - high	1
Total			**80**

Note:
[1]Score – 1 = negative or low score, 5 = positive or high score

9.9 Viable Product Technology Options

The product technology options that are not considered to have fatal flaws were ranked based on the objectives and criteria described above. Evaluating the technologies was based on information from City staff and the IRP team with regard to specific technologies, experience with specific technologies and knowledge of the status of development of technologies. The rankings are shown in Table 9-10. As the categories evaluated are broad there may be specific processes within each that would score differently on certain evaluation criteria, and continuing developments may also change the scoring. However, the aim of the evaluation is to identify the broad direction of biosolids planning, given the current status of these technologies and the City's approach to biosolids management.

Thermophilic digestion is a technology that will provide compliance with the Part 503 regulations for production of EQ biosolids. However, some counties in California are beginning to regulate EQ biosolids, which will impact feasibility and cost of bulk land application of thermophilic digested biosolids in these areas such as Riverside County and Kings County. Therefore, this technology scores a four for regulatory compliance. Thermophilic digestion reduces the volume of biosolids leaving the plant, and therefore the amount of truck traffic, due to improved dewatering characteristics. Although thermophilic digestion is not widely practiced in North America, the City has proved that the technology can be successfully implemented at a large scale and therefore this scores highly in the process reliability criteria. As this technology maximizes use of existing assets, including digesters and biogas, it scores highly in the cost criteria. The City has rectified the issues related with initial odor problems and has worked to improve public perception of the facility.

Composting with biosolids is a well established technology, with over 100 facilities of various sizes in North America, and therefore scores high in process reliability. Regulatory aspects of composting include air and odor, classification of fertilizer and general use of compost. Rule 1133 implemented by the SCAQMD has impacted the type of facilities that may be constructed in the L.A. area and has set a precedent that may in the future be followed by other Southern California air quality districts. The federal government recently included biosolids compost in the list of approved recycled material that may be used in government projects. However, biosolids compost is excluded from the fertilizers that may be used on organic crops. Due to the wide range of current and potential regulations related to compost, composting scores a three on regulatory compliance. As Rule 1133 has increased the cost of composting within the SCAQMD, it is likely that the more cost-effective facilities will be located further from the City. Composting plants also require delivery of amendments and bulking agents. Therefore composting does not score highly on the traffic criterion. Compost has a well established market in Southern California, but there are concerns with saturation of this market as more agencies in Southern California implement composting for conversion of Class B biosolids to an EQ product.

Heat drying for production of pellets or granules provides a wide range of market options, including those that use the pellets for nutrient value and those that use them for energy production. This ability to diversify the end use makes this option more resilient to regulations and it scores high on this criterion. However, at present the market for pellets in Southern California has not been developed as it has been in Florida, and therefore there will some work necessary to gain product acceptability. Although there is a number of heat drying facilities in North America, the equipment and process are complex and require a high level of operator training and safety awareness, therefore this scores a three for the process reliability criterion. Heat drying facilities have fairly high capital and O&M costs compared with digestion, or windrow composting operations, although they have a smaller footprint. O&M costs may also be reduced if a facility can be sited where waste heat or biogas is available to reduce energy costs. Siting of a heat drying facility close to a wastewater treatment plant also has benefits in reduced truck traffic, as drying removes most of the water that is still present in digested cake. Due to site restrictions, it is not anticipated that heat drying would be located at the HTP plant site and therefore this is scored three for traffic.

Chemical treatment can produce biosolids that meet EQ standards. However, the addition of highly alkaline products to the biosolids volatilizes ammonia, which can cause odor problems if not properly contained and treated. The need to add chemicals also increases traffic, with the impact depending on the type of process and the ratio of chemicals to biosolids. Use of chemicals may also be viewed as detrimental to the environment and poses health and safety issues. This technology therefore scores two on odor, traffic and environmental benefits. Many chemical treatment processes are well established, including the N-Viro and RDP processes, while some processes are newer and less proven. Therefore this category has been scored a neutral three for experience and reliability. In Southern California the soils typically have a high pH, therefore there is little demand for products with high pH, or with lime or gypsum additives. Processes that provide a high end fertilizer product are likely to be more acceptable, but these processes typically use larger amounts of chemicals and have less industrial experience.

Combustion of biosolids is technology that has been in use for decades. New fluidized bed technology and air quality equipment has enabled combustion to meet increasingly strict emissions regulations. In Europe the share of biosolids being processed by combustion is increasing and in some countries it is the only technology that may be used. This technology therefore scores highly under regulatory compliance. However, in Southern California, siting of a new combustion facility is expected to be difficult, and existing biomass power plants that could be used for biosolids combustion are situated some distance from the City, in Imperial County or northern Kern County. This option therefore scored a two for traffic. Building a new combustion facility or rehabilitating an older biomass power plant is capital intensive. The cost effectiveness of combustion options will also be impacted by federal and state regulations on renewable energy with regard to qualification as a renewable energy facility and renewable energy credits.

Table 9-10
Ranking of Biosolids Product Technologies

No.	Criteria	Weighting	Thermophilic Digestion Score[1]	Composting Score[1]	Heat Drying - Offsite Score[1]	Chemical Treatment Score[1]	Combustion Score[1]	Super Critical Water Oxidation Score[1]	Gasification Score[1]	Pyrolysis Score[1]	TIRE Score[1]
1	**Protect Public Health & the Environment**	**4**	***14***	***10***	***15***	***10***	***13***	***15***	***14***	***14***	***18***
1.1	Long term regulatory compliance	1	4	3	5	4	4	4	4	4	5
1.2	Traffic	1	3	1	3	2	2	4	3	3	4
1.3	Air quality & odor potential	1	3	3	4	2	4	4	4	4	4
1.4	Environmental, health & safety benefits	1	4	3	3	2	3	3	3	3	5
2	**Provide System Reliability**	**4**	***17***	***17***	***14***	***12***	***12***	***9***	***8***	***7***	***11***
2.1	Industry experience	1	4	5	5	3	4	1	2	1	1
2.2	Process reliability	1	4	4	3	3	4	1	2	2	1
2.3	Owner/operator options	1	5	3	2	2	1	2	1	1	4
2.4	Does not produce difficult waste streams	1	4	5	4	4	3	5	3	3	5
3	**Enhance Cost Efficiency**	**4**	***17***	***15***	***11***	***13***	***13***	***11***	***12***	***12***	***15***
3.1	Capital cost	1	5	3	2	2	2	2	1	2	4
3.2	O&M cost	1	4	3	1	3	3	3	3	3	4
3.3	LA investment risk	1	3	4	3	3	3	1	3	3	2
3.4	Compatibility with existing facilities	1	5	5	5	5	5	5	5	4	5
4	**Implementation/Quality of Life**	**4**	***14***	***15***	***16***	***13***	***14***	***14***	***12***	***14***	***16***
4.2	Public perception of facility	1	4	4	4	3	3	3	3	3	4
4.3	Ease of siting in S. CA	1	4	3	4	3	3	4	3	4	3
4.4	Product compatibility with markets	1	3	4	5	3	4	4	3	4	4
4.5	Product acceptability	1	3	4	3	4	4	3	3	3	5
TOTAL		**80 [2]**	**62**	**57**	**56**	**48**	**52**	**49**	**46**	**47**	**60**

Notes:
[1] Score – 1 = negative or low score, 5 = positive or high score
[2] Maximum score

Super critical water oxidation is an emerging technology. Although it holds promise for regulatory compliance – the products are an inert sand and a high quality effluent and minimal air quality impacts – the process reliability and experience have been the main drawbacks to implementation of this technology. This technology therefore scores highly on the protection of public health and environment criteria, but low on the system reliability criteria. Based on the current state of technology development, the capital costs are estimated to be high.

Gasification is a technology that is being developed in Europe and Asia for management of various waste streams. The products may include a biogas stream, a char, a biodiesel or ethanol type product, and a low grade oil. However, gasification of biosolids is not yet a well understood process and the quality of gas and oil streams has not been of a high quality.

Pyrolysis processes typically produce a char and may also produce an oil or biogas stream. There do not appear to be any significant regulatory compliance issues with pyrolysis processes, although appropriate air emissions control such as a regenerative thermal oxidizer or burning of the off-gases will need to be included. There is little industrial experience with biosolids, therefore this scores low on the system reliability criteria. Product acceptability will depend on the type and quality of product produced. The char made from digested biosolids will have a lower BTU value than coal and will therefore need to find niche markets.

Renewable energy recovery through the TIRE project is a new application of slurry fracture injection. Although this technology therefore scores fairly low on industrial experience and reliability for this application, it has a number of potential advantages. These include regulatory compliance (the only product is expected to be a high quality biogas), traffic reduction as biosolids from TITP do not leave the site and biosolids from HTP may in the future be conveyed by pipe, and minimal odor as it is an enclosed system. Initial cost estimates appear to be favorable. Although siting for such a facility for other agencies may be more difficult due to the need for suitable geological sites in underground oilfield reservoirs, the City has been fortunate to have an ideal site below TITP. The City has conducted an extensive public outreach program and the project has been well accepted by the local neighborhood councils around TITP. Implementation of the proposed demonstration TIRE project will allow corroboration of the scoring provided in this initial assessment.

Table 9-11 summarizes the total scores for the established and emerging technology categories. In the established technologies, thermophilic digestion, as currently conducted by the City, ranked the highest, with composting and heat drying being next ranked technologies. The TIRE project was the clear winner among the emerging technologies. These processing options may be conducted after thermophilic digestion, unless in the future the City selects an option to handle a sufficient volume of digested or undigested solids to allow some or all of the City's biosolids to be processed without prior thermophilic digestion and/or dewatering. This may be the case if the TIRE demonstration project is successful.

Table 9-11
Summary of Initial Screening of Biosolids Product Technologies

No.	Established Technologies	Score	Emerging Technologies	Score
1	Thermophilic Digestion	62	Renewable Energy Recovery (TIRE)	60
2	Composting	57	Super Critical Water Oxidation	49
3	Heat Drying	56	Pyrolysis	47
4	Combustion	52	Gasification	46
5	Chemical Treatment	48		

9.10 Recommended Strategy

9.10.1 Summary of Viable Management Options

The following recommendations are made for long term direction of biosolids management, based on the above evaluation and ranking of the biosolids product technologies, the evaluation of biosolids product markets, and consideration of the City's Biosolids EMS:

1. Continue thermophilic digestion and bulk land application at the Green Acres Farm:

- Application at the farm should be restricted to 550 wtpd (as per initial estimate for 50-year farm life), unless a different suitable nutrient and metal loading rate is determined for long term sustainability;
- Conduct a detailed evaluation of agronomic uptake rates and groundwater interactions at the farm;
- Identify and implement farm improvements to maximize nutrient uptake, plant yields and revenues, such as addition of gypsum to sodic soils;
- Provide biosolids storage facility at the farm for conditions when spreading is limited by adverse weather or other conditions; and
- Conduct demonstration projects to showcase benefits of biosolids land application and encourage the use of biosolids for non-food farming.

2. Implement the TIRE demonstration project to determine true feasibility and costs for renewable energy recovery. If successful it is anticipated that the TIRE facility will be able to treat the equivalent of 200 wtpd digested cake on average, with a maximum capacity of 400 wtpd for a short duration. This will provide diversification with an energy-based biosolids management option, rather than reliance on options that use the nutrient value of biosolids

3. Diversify biosolids management through consideration of other biosolids management options, such as private or City-owned composting or heat drying facilities. Although the current volume of 750 wtpd can be managed with the above two options, management of projected future increases to over 900 wtpd will require additional capacity. For an agency such as the City, which produces large volumes of biosolids, heavy reliance on one management option can contribute to public perception issues and leaves the City more vulnerable to changes in regulations or other factors that may impact costs of a biosolids management option.

9.10.2 Biosolids Management Costs

The biosolids management cost projections for the IRP were based on the above recommendations, with 550 wtpd allocated to the Green Acres Farm, 200 wtpd allocated to the TIRE project and the remaining 166 wtpd allocated to an alternative option that may be composting or drying. Costs for thermophilic digestion and dewatering are not included in these costs as they are on-site treatment costs and have been included in the wastewater treatment plant costs. Biosolids management options that reduce the need for onsite treatment (for example, implementation of the TIRE project would eliminate the need for dewatering) may claim a credit for the reduced on-site solids treatment costs. See subsection 9.4 for discussion of 2020 biosolids projections.

O&M costs for the Green Acres Farm were based on information provided by staff at HTP, including estimates for fiscal year 2004/2005 and the estimated cost of the new farm management contract, and are summarized below in Table 9-12. Based on this information, the IRP farm O&M costs were $28/wt. As the IRP needs to include long-term costs, additional capital costs were included to accomplish other aspects included in the recommendations above, such as a nutrient management study, detailed groundwater monitoring, and gypsum addition.

Table 9-12
Estimated Farm O&M Costs FY 2004/2005

Item	Volume wtpd	Unit cost $/wt	Annual O&M Cost $/yr
Hauling & spreading	650	$23.40	$5,551,650
Farm management	650	$9.69	$2,300,000
Farm revenue	650	($5.73)	($1,360,000)
Total		$27.36	

Table 9-13 provides a high level estimation of these costs. As the scope of this work has not been defined and much will depend on the findings of the nutrient management study, and decisions by the City with regard to aspects such as storage capacity and the type of demonstration programs, the estimates are based primarily on discussions with staff involved in the 'Review of Biosolids Loading Rates at Green Acres Farm' (CH2M HILL, September 2002).

Table 9-13
Green Acres Farm Capital Costs Projected till 2020

Item	Cost Estimate
Nutrient Management Study (2-year project)	$300,000
Gypsum/sulfur amendment	$500,000
Additional monitoring wells (90-125 ft depth)	$100,000
Additional sampling (over 3 years for soil, groundwater, plant tissue)	$100,000
Farm demonstration & outreach program	$125,000
Biosolids storage*	$175,000
Total	$1,300,000

Note:
* Store 2 day's cake (density 1,800 lb/cy, pile height 10-ft) - 3,300 sf roofed pad ($50/sf) w/ 60-ft push wall ($150/lf).

The TIRE project is being developed by the City in conjunction with Terralog Technologies, who have the technology know-how and who will be operating the facility. Initial proposals by Terralog Technologies to the City provided an O&M cost range of $15-18/wt. Due to the level of monitoring that will be installed at this facility, and the degree of uncertainty associated with any new application of a technology, City staff agreed that the higher end of this range would be an appropriate planning cost to use. The O&M cost used, therefore, was $18/wt, with an additional $4/wt for the HTP biosolids portion to cover hauling.

The City will be contributing some of the capital costs associated with the TIRE demonstration project and future permanent facility, if approved by the EPA and other permitting authorities. The City's portion of the capital costs for the demonstration facility are estimated at $3.33 million, including provision of piping for liquid biosolids from the TITP digesters to the TIRE facility, and other support facilities. The demonstration project is expected to be conducted for up to 5 years, after which additional costs will be incurred to upgrade to a permanent facility. Preliminary upgrade cost estimates by City staff are for $5.4 million, with an additional 30 percent contingency. The total City capital cost estimates are therefore $10.35 million for the next 20 years.

The third biosolids management option is based on the City sending biosolids beyond the capacity of the above options to a regional composting, drying or other facility. An O&M cost of $55/wt was allocated for this option, as it is most likely that this option would be conducted under a private vendor management contract, since it is unlikely that these types of biosolids management options will be sited at a City wastewater plant. The cost was based on a median of the range of costs that are currently being quoted by private vendors in Southern California for proposed composting and drying projects. Siting and hauling distance will also have an impact on the cost, and therefore actual costs for different vendors will vary depending on distance to the site. Costs at regional compost facilities, such as the proposed Synagro South Kern Industrial Center facility and the San Joaquin Composting facility, would be expected to be just under $50/wt, while a drying facility cost would likely be around $60/wt, depending on hauling distance.

Biosolids management costs projected through 2020 are summarized in Table 9-14. The annualized cost is projected to be $9.6 million. Key aspects that could impact the actual cost will be the performance of the TIRE project and future decisions regarding diversification to a third management option.

9.10.3 Triggers for Change

Biosolids management is a very dynamic area, with changes in regulations, public perception, technologies and costs. The City needs to balance good stewardship of the environment with sound financial management, for which the Biosolids EMS provides the framework. The above strategy provides a cost-effective approach, with diversification into three management options with biosolids products being used for both their nutrient and energy value. However, biosolids management plans also need to provide flexibility to respond to changing situations. Triggers for change that would lead to a re-consideration of the biosolids management strategy include:

- Changes in local county ordinances, particularly Kern County;
- Changes in the Part 503 regulations
- Increasing need for diversification
- Successful demonstration of the TIRE project
- Support for regional biosolids processing facilities

Table 9-14 Preliminary Cost Estimates for Biosolids Management through 2020			
Option	**Volume wtpd**	**Annual O&M Cost $/yr**	**Capital Cost $**
Farm Costs			
Net Cost	550	$5,621,000.00	$1,300,000.00
TIRE Costs			
TITP	56	$367,920	
HTP	144	$1,156,320	
Subtotal	200	$1,524,240	$10,350,000
Other Product Option Cost			
Remainder of total vol.[1]	166	$1,666,225	
Total Costs			
Annual O&M		$8,811,465	
Present Worth O&M Costs		$109,810,000	
Capital			$11,650,000
Total Present Worth	916		$121,460,000
Annualized cost			$9,618,987

Notes:
Capital Period (years) 20
Interest Rate:5%
[1]. O&M cost based on average production, assuming linear increases till 2020

Section 10
Alternatives Analysis

10.1 Approach

The IRP has identified planning parameters that will result in the need for new programs, infrastructure and facilities to meet the 2020 needs. These planning parameters, or drivers, include population growth, increased wastewater flows, increased dry and wet weather runoff flows, increased demands for drinking water and current and future regulations to protect water quality in the basin. In addition, the IRP has an established set of Guiding Principles to guide future planning, which includes such objectives as producing and using as much recycled water as possible from existing and planned facilities, increasing water conservation and increasing the beneficial use of runoff.

Alternatives are the means of accomplishing the objectives (which include options from each service function). They answer the question, "How are we going to accomplish the objectives?" In the Sections 8 of this document, the potential treatment options (or projects) for meeting these drivers were discussed, and the options for water and runoff were discussed in the Facilities Plan *Volume 2: Water Management* and *Volume 3: Runoff Management* respectively. To meet the 2020 needs, the IRP needed to develop integrated alternatives, which include combinations of wastewater, recycled water and runoff options into complete alternatives. By considering the system using an integrated watershed approach, more holistic alternatives could be identified and evaluated.

As shown in Figure 10-1, the IRP team used a multi-step process to create and evaluate alternatives: (1) develop preliminary alternatives, (2) evaluate preliminary alternatives, (3) refine alternatives and develop hybrid alternatives, (4) evaluate hybrid alternatives and (5) screen to final alternatives for environmental analysis. Additional discussion of the alternatives and the evaluation process is presented in the Facilities Plan *Volume 4: Alternatives Development and Analysis*.

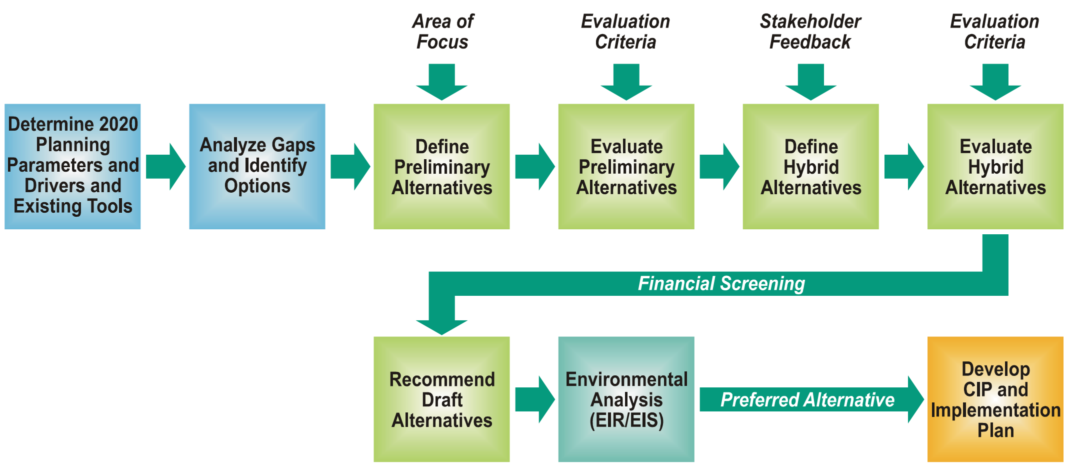

Figure 10-1
IRP Approach to Creating Alternatives