SUSTAINABILITY INDICATORS FOR THE CITY OF LOS ANGELES DEPARTMENT OF PUBLIC WORKS INTEGRATED RESOURCES PLAN

Robert Vos, Ph.D. (University of Southern California)
Joseph S. Devinny, Ph.D. (University of Southern California)
Adel Hagekhalil (City of Los Angeles)
Hyginus Mmeje (City of Los Angeles)
Heather Boyle[1] (CDM)
Kathleen Bullard (CH2M HILL)

[1]CDM
555 W. Fifth Street, 31st Floor
Los Angeles, California 90013

ABSTRACT

The City of Los Angeles Department of Public Works funded an independent assessment of the sustainability of alternatives proposed under its Integrated Resources Plan (IRP) for the Wastewater Program. The IRP describes capital improvements and management measures for wastewater collection and treatment, biosolids, dry and wet weather runoff, recycled water, and water conservation. It is the intent of the City of Los Angeles that the plan and the resulting capital improvement program, environmental documentation, financial approach, and public outreach program promote a sustainable future for the City. The Department's activities are considered sustainable if their social, economic, and environmental impacts do not degrade the abilities of future generations to serve their needs as we serve ours.

Indicators were designed and implemented for a wastewater treatment system that handles sanitary wastewater, stormwater, and dry weather runoff. The indicators cover a complex system comprising many facilities, large and small, distributed over a large area. Measurements cover a large variety of procedures, from detailed treatment plant operations to development of an advertising program that will discourage littering. Further, the indicators seek to capture the impacts on social, economic, and environmental systems that extend throughout the watershed of the Los Angeles River and smaller adjacent systems. The purpose of the study was to develop a set of indicators that will help managers evaluate the sustainability consequences of their decisions. Such indicators must measure the sustainability of the system as it currently exists and predict the sustainability of alternatives considered under the Integrated Resources Plan. This paper discusses the results of using these indicators to assess the sustainability of the alternatives in the Integrated Resources Plan.

KEYWORDS

Sustainability, indicators, wastewater, stormwater, recycled water, urban ecology.

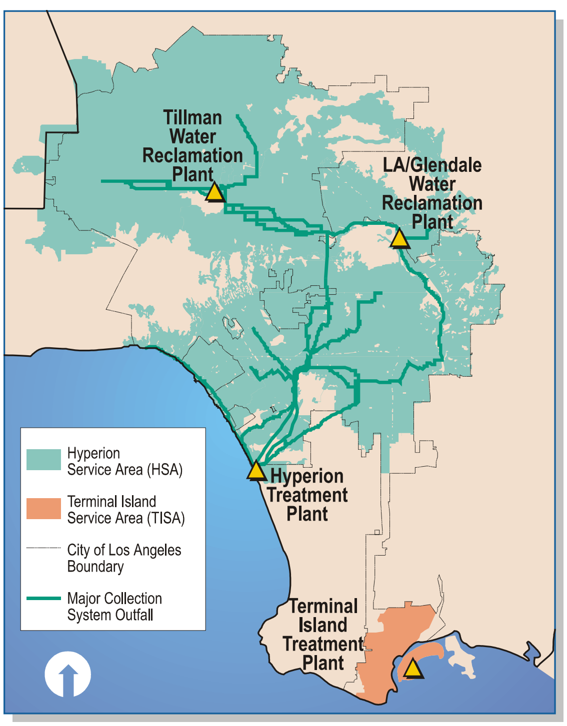
INTRODUCTION

In 1999, the City of Los Angeles embarked on a program to develop an Integrated Resources Plan (IRP) that would anticipate the needs of the City projected out to 2020 for the treatment and storage of wastewater, stormwater runoff, and recycled water. CH2M HILL and CDM (CH:CDM) were contracted to assist in developing the plan. Against the backdrop of increased population, the plan needed to address increasing water quality regulation through issuance of Total Maximum Daily Loads (TMDLs) that affect the discharge of effluent, and target stormwater runoff. Recognizing that the effluent from the wastewater treatment plants was of sufficient quality to be used in non-potable application, the plan also includes a recycled water master plan.

City of Los Angeles Wastewater System

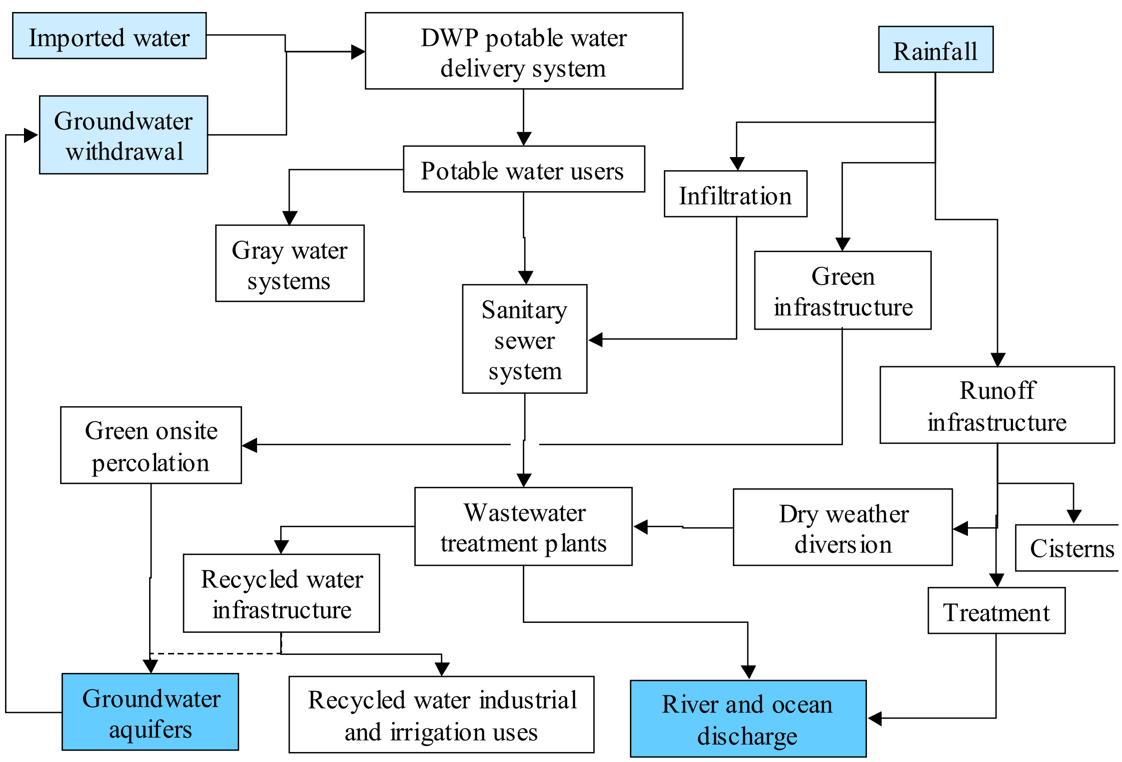
For purposes of developing alternatives, the IRP looked closely at primarily three of the City's wastewater treatment facilities: Hyperion Treatment Plant on the coast that discharges to the ocean; Donald C. Tillman (Tillman) Water Reclamation Plant that discharges first to a series of constructed lakes, then ultimately to the Los Angeles River; and the Los Angeles/Glendale Water Reclamation Plant, jointly owned with the City of Glendale, that discharges directly to the Los Angeles River. Both the Tillman and Los Angeles/Glendale plants also deliver recycled water to non-potable uses, such as landscape irrigation and industrial process water. Figure 1 presents a map of the City's wastewater facilities.

Figure 1 - Map of City of Los Angeles Wastewater System



A schematic of the interrelationships in the City's wastewater treatment system (WWTS) is defined in Figure 2. The figure depicts flows of water through the system for eventual discharge to surface waters (rivers and the ocean) and for reuse. Each box in the figure denotes infrastructure or programs for the known alternatives for wastewater management: water conservation (i.e., source reduction), wastewater treatment, distributed infrastructure that captures and recycles water, green infrastructure that reduces urban runoff, and reused water infrastructure constructed at major wastewater treatment plants.

Figure 2 – Schematic of Water, Wastewater and Stormwater Infrastructure



IRP Alternatives

Through a comprehensive stakeholder process, a number of alternatives were examined for their impact on local neighborhoods, the ability to maximize use of recycled water, maintenance of habitat that now is dependent upon the effluent discharge, environmental justice, and cost, among others. Stakeholders were briefed on the current system and its capacity and through a decision system analysis, were polled for their highest priorities (e.g. cost vs. degree of water quality desired). The result was four alternatives for system expansion. The four draft alternatives for the IRP were defined in the Bureau of Sanitation "IRP Facilities Plan" (CH:CDM 2004). The differences among the draft alternatives were significantly reduced from the preliminary alternatives that were evaluated in the IRP stakeholder process. Table 1 presents a summary of the four alternatives.

Table 1 – Summary of IRP Recommended Draft Alternatives

IRP Alternative	Description
Alternative 1	Hyperion expansion, moderate potential for water resources projects
Alternative 2	Tillman and Los Angeles/Glendale Water Reclamation Plant expansions, high potential for water resources projects
Alternative 3	Tillman Water Reclamation Plant expansion, moderate potential for water resources projects
Alternative 4	Tillman Water Reclamation Plant expansion, high potential for water resources projects

All of the alternatives will increase water conservation through the use of "smart" irrigation systems and will divert coastal dry weather runoff to the WWTS. All of the alternatives include development of projects for recharge of some wet weather runoff, with Alternative 3 proposing the greatest effort for "neighborhood recharge". All of the alternatives include construction of three sections of a new sewer to provide increased capacity. All of the alternatives include some infrastructure to provide for increased irrigation and industrial reuse of recycled wastewater. Alternatives 2 and 4 are projected to provide more recycled wastewater than Alternatives 1 and 3.

The IRP will set into motion a substantial capital improvement program designed to meet the needs of the City of Los Angeles for wastewater, recycled water and runoff water systems. It will describe capital improvements and management measures for wastewater collection and treatment, biosolids, dry and wet weather runoff, recycled water, and water conservation.

OBJECTIVES

It is the intent of the City that the IRP planning process and the resulting capital improvement program, environmental documentation, financial plan, and public outreach program promote a sustainable future for the City. A systems-based approach for assessing the interactions between the wastewater, runoff management and recycled water systems, and comparing various alternative technologies and approaches in the context of sustainability was needed to allow continued improvement in the performance of the wastewater treatment system.

Toward that end, the Bureau of Sanitation (Bureau) in the Los Angeles Department of Public Works requested an independent assessment of the sustainability of alternatives proposed under its IRP. The team of Joseph S, Devinny, PhD, and Robert Vos, PhD, both from the University of California Center for Sustainable Cities, Ian T. Penn of E2, Inc, and Stephanie Pincetl, PhD of the University of California, Los Angeles, Institute of the Environment, developed the indicators and analysis for the four alternatives.

The sustainability analysis provided: 1) sustainability measure indicators 2) a benchmark measure of the sustainability of the current system; 3) measurements of the four IRP alternatives; and 4) recommendations for future measurement, analysis, and reporting as IRP implementation is undertaken. In this paper, we will discuss the results of applying sustainability measure indicators.

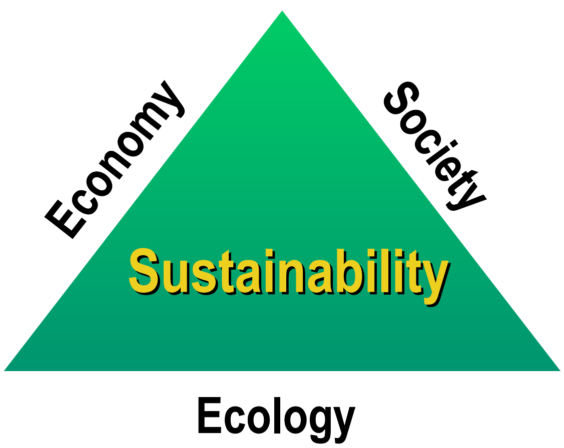
METHODOLOGY

Defining a Sustainable Wastewater and Stormwater System

Sustainability has been defined many ways. In 1987, the World Commission on Environment and Development defined sustainability as "meeting the needs of the present generation without compromising the ability of future generations to meet their own needs (WCED, 1987.) Lundin et al., (1999) have provided a definition of sustainability for urban water systems: they should "not have negative environmental effects even over a long time perspective, while providing required services, protecting human health and the environment with a minimum of scarce resource use".

More specifically, sustainability is not a fixed state, but is rather an emergent property of a complex system (Allenby, 1999; Ashley et al., 1999). To encourage a more sustainable direction, the City should provide the framework to set into motion an iterative process in which the needs of a city that is developing socially and economically are met, without increasing demands on natural resources or outputs of pollution above levels generated by the existing wastewater system (Task Committee, 1997; Loucks and Gladwell, 1999). Therefore, as shown in Figure 3, the analysis defined and measured sustainability against three over-arching categories: economy, ecology, and society.

Figure 3 – Definition of Sustainability



To effectively define and measure sustainability, it was necessary to take a view beyond the core infrastructure and conveyance aspects of the wastewater and stormwater system. The ecological, social, and economic systems impacted by the WWTS extend throughout the watershed of the Los Angeles River and smaller adjacent systems. The interactions among the elements in these systems can be strong. Development changes the quantity and quality of wastewater and stormwater flows, construction of new facilities reduces (or improves) the quality of life for nearby residents, community behavior changes runoff water quality, and economic prosperity in the region requires effective and economical wastewater and runoff management. Indeed, it can be argued that impacts of the system extend far beyond these boundaries: water conservation efforts within the system will reduce water withdrawals and their ecological impacts in Northern California, and trash control in the stormwater system will reduce the severity of plastics pollution in the central Pacific Ocean. To specify all of these elements and impacts was beyond the scope of the analysis. Instead, evaluation of environmental impacts was confined to the local watershed and just some of the most critical external impacts are evaluated in general terms.

Criteria for Selecting Indicators

Because sustainability is a broad concept, with many components, it is important to have indicators that can be applied periodically to gauge progress and to assess planning options for the future. Indicators should be designed to function as part of a process of continuous improvement. The sustainability indicators for this analysis have been designed to meet several specific criteria. They were intended to be:

- Genuine measures of sustainability. Efforts by the Bureau to improve its scores on the indexes should have the effect of improving the sustainability of their facilities and procedures.
- Comprehensive. The important aspects of sustainability should be covered so that desired performance characteristics or outcomes are not ignored. If used consistently, they should provide early warning of developing issues.
- Applicable to the range of alternatives being considered. In particular, they must reflect the performance of the Bureau in the many environmental systems in which the Bureau plays a part.
- Meaningful and relevant to all stakeholders. If the Bureau can say that it has improved its ratings, the evidence should be clear and convincing for the people of Los Angeles (not just to sustainability specialists) that sustainability is being improved. Overly complex or obscure indexes might create confusion and distrust—indeed, the public may consider them opaque simply because there are too many of them (Ashley and Hopkinson, 2002).
- Relevant over time. The Bureau will use the indicators to strengthen and adapt its planning to changing technological and environmental conditions. They will also allow for different levels of analysis, from general assessments to detailed information on particular technologies or programs.
- Convenient to use. This assessment of the Bureau's performance with respect to the indexes should utilize data that are currently being collected. The analysis also identified a number of data elements that are more directly related to measuring progress toward sustainable operations. Thus, when necessary, the indicators should shape future information gathering so that the data needed to assess and design for sustainability will be available.

Developing the Indicators Framework

A multitude of indicator frameworks exist, and they seek to examine sustainability at many scales, including global, national, local, and project levels. At global and national levels a common approach is to create absolute measures of sustainability. These measures attempt to relate damage to ecosystems to the levels of population and mix of technologies employed at a certain scale.

For a number of reasons, the use of absolute indicators is not appropriate to evaluate the sustainability of the IRP or the WWTS. The Bureau does not operate at a scale where it is possible to fully identify and separately define direct and indirect impacts on ecosystems. Such impacts are caused by Bureau activities, but they are part of long chains of impacts created in tandem with other agencies, local business, and public activities.

A leading alternative to an absolute indicator is a scoreable index indicator. The typical approach for a scoreable index is to generate a list of desired outcomes, and measure progress towards those outcomes. A scoreable index is more appropriate than an absolute indicator to the scale and tasks of evaluating the wastewater treatment system operated by the Bureau. Based on the best currently available information and a number of assumptions about future impacts, a scoreable index approach allows the analysis to reflect more accurately the performance of the Bureau and the IRP alternatives than other modeling techniques.

To accomplish the goal of measuring continuous improvement toward sustainability, a baseline measure must be created for each indicator. Trends toward or declines away from sustainability in the IRP could then be projected to the extent that the nature of the future system could be anticipated in each indicator category. In the analysis, a recent "baseline" year was chosen, and where data allowed, anticipated improvements or declines in sustainability that will occur by the year 2020, which is the target date for planning in the IRP. Because much financial and performance data for departments in the City of Los Angeles are gathered on the basis of the fiscal year, the fiscal year was chosen as the unit of measure for the analysis. The baseline year was Fiscal Year 2002/2003, which for the City of Los Angeles corresponds to July 1, 2002 through June 30, 2003.

OVERVIEW OF THE SUSTAINABILITY INDICATORS

The index developed for the analysis of the IRP consists of seven categories of indicators adapted from the literature for the IRP. The seven categories are: 1) Social Impacts, 2) Economic Development, 3) Natural Resource Consumption, 4) Pollution, 5) Urban Ecology, 6) System Flexibility and Adaptability, and 7) Institutional Capacity. In terms of quantification, the choice of the seven categories is important because it enables a more detailed analysis of each major aspect of sustainability in the City's wastewater treatment system. The significance of each category and brief description of what it measures are given below.

Indicator 1: Social Impacts

The first indicator measures the relationship of the residents of Los Angeles to the wastewater system. In particular, the analysis examined whether the burdens and benefits of the system are equitably distributed, as well as the extent of stakeholder involvement in the IRP process and other wastewater system activities.

Indicator 2: Economic Development

This category measured how the wastewater system contributes to the economy of the city. One important measure was the degree to which the system generates employment. Another important measure was the contribution the system makes to the city's economy through its own economic efficiency and provision of valuable services.

Indicator 3: Natural Resource Consumption

The consumption of natural resources is an important indicator of sustainability. In the case of non-renewable natural resources (such as fossil fuels) it is necessary to reduce and eventually eliminate consumption over a time horizon of several decades to allow industrial systems to adapt to new, renewable sources without going out of business. In the case of renewable resources such as water, sustainable use would not exceed replacement or regeneration rates of the resources that are being consumed.

Indicator 4: Environmental Pollution

Environmental pollution generated by the system is an important indicator of sustainability. Accumulation of global climate forcing gasses in the stratosphere, for example, threatens to change climates on a global scale. Also, air pollution is of particular concern in the Los Angeles region. Reducing pollution of local water resources is already recognized as a primary mission of the Bureau.

Indicator 5: Urban Ecology

This indicator assesses the ways in which the footprint of the City relates to its native ecosystems. It includes provision of parks and open spaces for residents of the City and habitat that supports biodiversity in the City (Shane and Graedel, 2000). The IRP represents a significant opportunity to achieve both clean water goals and urban ecosystem improvements through approaches to integrated design. The analysis sought to measure some of these integrated benefits.

Indicator 6: System Flexibility and Adaptability

This indicator measures the flexibility and adaptability of systems to changing environmental and technological conditions (Loucks and Gladwell, 1999). It is an important measure of sustainability because it encourages continuous improvement and promotes innovation, while embracing the unpredictability of future environmental and technological conditions. It builds in a step-by-step approach that leaves room for assessment and changes along the way if the unexpected occurs.

Indicator 7: Institutional Capacity

The final indicator category recognizes that the IRP and the drive for sustainability represent a new focus for wastewater management and policy. The sustainability of the IRP depends ultimately upon building the institutional capacity and political will to support this process. Such capacity comes from staff training and commitment, public education, pricing signals, data development, and interagency partnerships.

ASSESSING THE IRP ALTERNATIVES

The sustainability analysis involved 6 steps:

1. Review of the literature to find which indices have been used in the past to assess the sustainability of water, wastewater, and runoff infrastructure.

2. Selection of a subset of the indicess that were appropriate for the systems managed by the Bureau and for the local conditions.

3. Choice of a short list of indices that were applicable.

4. Interviews with Bureau personnel, personnel in other City departments, and stakeholders to gather data to support index calculation.

5. Evaluation of data and calculation of indicators for the baseline year.

6. Evaluation of the likely performance of the four IRP draft alternatives, and scoring IRP performance relative to the baseline year.

Because the sustainability analysis sought to assess the impacts of WWTS activities over a wide range of criteria, the indicator framework includes both qualitative and quantitative indicators.

Quantitative Indicators

Given the definition of sustainability, the objective of the sustainability analysis was to measure erosion or improvement of the system with respect to the baseline over time. Thus, the index is quantified relative to the benchmark measure established for the City's WWTS during the baseline year (fiscal year 2002/2003). The IRP alternatives were assessed for fiscal year 2020.

The seven indicator categories were treated equally. There are uncertainties and assumptions inherent in the use of weighting factors. To be truly effective, weighting factors must reflect both the perception of IRP process stakeholders and take into account local and regional issues. A weighting factor would also face the difficulty of making meaningful comparisons across very different objectives (e.g., reducing air pollution to creating interagency partnerships). As a result, and due to a significant number of data gaps and uncertainties, the analysis did not seek to weight the indicators or to otherwise represent any difference in their importance.

Qualitative Indicators

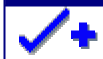
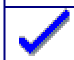
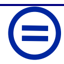
Although some indicators could be empirically measured based on current information, there were others that did not lend themselves to easy quantification. In particular, the flexibility and institutional capacity indicators historically demonstrated themselves to be difficult to quantify. However, qualitative analysis can lead to subjective quantification, and it is important to provide values for these indicators so that they are not disadvantaged in providing the overall assessment of sustainability.

One issue that deserves careful analysis is the sensitivity of the overall WWTS to population growth. Although it was assumed that the WWTS must be made sustainable no matter how much the population of the City of Los Angeles grows, the ability to achieve continued sustainability will become increasingly difficult as population increases. The sensitivity of the indicators to population growth projections was considered, and the analysis reported these findings along with the indicators for each IRP alternative.

Scoring the IRP Alternatives

Table 2 describes the scoring methods that were used in analyzing IRP alternatives. These symbols were developed as an alternative to a weighted index approach. The analysis used symbols to score the IRP alternatives relative to the baseline year for each sub-indicator. The symbols were chosen to raise public and official understanding of the sustainability challenge for the WWTS. The goal was to clearly and effectively communicate the results of the analysis. The symbol for insufficient data is particularly useful for highlighting uncertainties in the analysis. Many details of the IRP were not set out in the Alternatives Development and Analysis, and will be resolved during implementation. Also, the City of Los Angeles tracks most, but not all of the data required to measure indicators for the baseline year. The score for insufficient data covers both of these cases.

Table 2 – Sustainability Scoring Symbols

Analysis Symbol	Symbol Explanation
	Strong Positive Trend: Analysis indicates substantial progress will be made towards sustainability over the baseline
	Positive Trend: Analysis indicates substantial progress will be made towards sustainability over the baseline
	Same as Baseline: Analysis indicates future outcomes are likely to be equivalent to the baseline (no deterioration)
	Negative Trend: Analysis indicates future deterioration from the baseline
	Additional Planning Needed: Analysis indicates that additional planning is necessary to estimate progress against the baseline
	Insufficient Data: There are currently insufficient data or models to measure baselines or outcomes reliably

For purposes of illustration, the discussion below of beneficial impacts is an example of how one of these indicators was applied to the project. The actual analysis and discussion is more lengthy in the original analysis.

Beneficial Neighborhood Impacts

At first glance, the IRP may be seen to have mostly adverse impacts on those neighborhoods in the City where new treatment plants or conveyance infrastructure are constructed. However, the IRP also offers potential positive impacts for neighborhoods. IRP green infrastructure designed to recharge groundwater and treat or reduce stormwater runoff may benefit neighborhoods. If the Bureau works in partnership with other agencies to create green wastewater infrastructure, many such projects could double as fields, pocket parks, and riverside green space.

The Bureau has an important opportunity through the IRP to increase overall access to parks and open space. In fact, the opportunity for the IRP to make measurable change against the city-wide baseline in the area of equity in park access is actually greater than in per capita open space overall. Even small amounts of open space that are carefully targeted can increase the proportion of census tracts with at least some 1/4-mile access. Similarly, in tracts with 1/4-mile access to only 0-2 acres of open space per 1,000 people, a few acres of IRP projects could make a substantial difference for residents in those areas.

Actual sites for open space projects will be chosen during IRP implementation. Thus, there are not yet data available with which to reliably measure the performance of the alternatives against the baseline. The measures reported in Table 3 reflect this need for data development during IRP implementation. However, initial planning reflected in IRP meetings indicates that increasing equity in access will be taken into account during implementation. In general terms, IRP planning already identifies small acres of remnant or vacant land that are likely to be available in areas where residents have low access to parks. These sorts of lands are under primary consideration.

Table 3 - Example Sustainability Score Card for Beneficial Neighborhood Impacts: Equity in Park Access

Alternative	Increased Access Due to IRP Projects
IRP Alternative 1 ✓	
IRP Alternative 2 ✓	
IRP Alternative 3 ✓+	
IRP Alternative 4 ✓	

It was recommended that maps indicating areas without 1/4-quarter mile access be created and used during implementation to choose open space sites with an eye to increasing park access. If maps were maintained, in future versions of the sustainability indicators the Bureau's role in increasing access may be quantified. The Bureau could also look more deeply into equity in access by racial and ethnic group.

USE OF LIFE-CYCLE ASSESSMENT

The analysis used Life-Cycle Assessment (LCA) methodologies to capture the indirect impacts of the WWTS. LCA is a comprehensive environmental impact methodology that was initially designed to trace the environmental impacts of products and processes. The purpose of the LCA model is to drive design of products with lower overall environmental impact. The primary advantage of LCA is that it moves beyond "end-of-pipe" assessments that miss equal (and even larger) amounts of pollution generated by a particular product upstream of the system (Curran, 1996). Increasingly, LCA is being applied beyond products and for assessment of infrastructure or urban waste management systems (Tukker, 2000; Powell, 2000).

SYSTEM-WIDE MEASUREMENTS OF ENERGY, WATER, AND MATERIALS

To have data that will drive indicators within the natural resource consumption and pollution categories, it is necessary to calculate the net use of energy, water and materials on a system-wide basis. It is crucial to measure the net use, because the WWTS may both consume and produce energy and water. The energy and materials data become inputs to LCA models to develop life-cycle inventories for resources and pollution. In the pollution output category, these figures were added to end-of-pipe calculations for specific facilities or processes.

RESULTS OF INDICATOR ANALYSIS

Social Impacts (Indicator 1)

A system is functioning in a socially sustainable manner if its presence contributes to the welfare of society, if those who are affected by it have some control over its actions, and the impacts of the system are distributed with a reasonable degree of equity. Facilities and procedures that are not managed in a way that is fair and equitable will be unsustainable because they will lack political support from the public. Further, actual or potential impacts should be transparent. Decisions must be made with public input, and in such a way that the input is given serious consideration. It is inevitable that the external burdens of the system will not be distributed exactly as the benefits are, but indexes can be developed to ensure that the inequities are not excessive and that they do not reinforce existing patterns of inequity.

- The study focused on four specific indicators of social impacts:
- Beneficial neighborhood impacts,
- Adverse neighborhood impacts,
- Customer satisfaction, and
- Public input in Bureau operations and the IRP process.

For the majority of sub-indicators in this category, there is either too much uncertainty in what might happen through IRP implementation or it was assumed, based on the best available information, that IRP implementation would generate results for all four alternatives that would be comparable to the baseline.

Economic Development (Indicator 2)

Traditional economic indicators focus on the economy in isolation from other areas of people's daily lives — such indicators often measure all economic activity without regard to whether the activity is helping or harming quality of life or the quality of the local environment. Other categories of indicators in this set tackle broad questions of quality of life and environmental quality. For this indicator, the analysis sought to connect choices made for the WWTS to local economic development. The analysis focused on three specific indicators that seek to connect choices made for the WWTS:

- Effect on local employment, both direct and indirect,
- Efficiency of the Bureau's investment, and

- Operation and maintenance (O&M) activities.

All four IRP alternatives are either expected to perform the same for the sub-indicators examined as part of this analysis or there was too much uncertainty to make a reasonable determination of which alternative will perform in the most sustainable fashion. The only clear differences are in potential indirect employment.

Natural Resource Consumption (Indicator 3)

The third sustainability indicator assesses natural resource consumption. Natural resource consumption refers to the use of fuel, water, minerals, and materials that are provided by nature and consumed in WWTS activities. While the WWTS uses many kinds of resources, two are of dominant concern when considering sustainability: water and fossil fuel. Both are expensive, both are subject to rising demand and tightening supplies, and both are associated with substantial land/habitat degradation and pollution problems. The natural resource consumption indicator therefore focused on water used each year within the City and the consumption of fossil fuel resources through WWTS activities.

The analysis focused on these subindicators to measure sustainability:

- Water Usage
- Fossil Fuel Use

Because of the uncertainty in future energy use among the four IRP alternatives, it is not possible to say that any of the four alternatives would perform in a manner more sustainable than the baseline. All four would be expected to consume natural resources in excess of the current baseline. Because fossil fuel consumption is tied to the mix of energy sources from the grid, future air emissions could be lower if more renewable sources are used to generate electricity for WWTS activities. Reducing or changing the type of treatment chemicals could also reduce the total amount of natural resource consumption of any IRP alternative.

Environmental Pollution (Indicator 4)

Environmental pollution is an important category both because of local air pollution problems and because the primary mission of the Bureau is to reduce pollution loadings to receiving waters. As a consequence, there are several sub-indicators in this category:

- Criteria air pollutants that contribute to regional smog,
- Global climate forcing gases,
- Wastewater effluent,
- Runoff discharges to receiving waters, and
- Biosolids management, including handling, transportation and reuse.

The alternatives are expected to have nearly equal performance for environmental pollution. Two of the alternatives will release more criteria air pollutants and global warming gases because they use more electricity. But that electricity will be used for pumping reclaimed wastewater for uses that will supplant additional importation. All of the alternatives will contribute to a well-established long term trend of reducing pollutant discharges from wastewater outfalls. All include provisions for some improvement in runoff management,. Runoff management overall suffers from a lack of information on the effectiveness of the technologies, concentrations and distributions of the pollutants, and the difficulty and expense of implementing solutions region-wide.

Urban Ecology (Indicator 5)

The issue of "urban ecology" has been identified as an area of critical importance by IRP stakeholders, and is also a key indicator of urban sustainability in general (Larkin, 1999; Shane and Graedel, 2000). As defined in the analysis, urban ecology includes parks and open space, river revitalization, native habitat, and protection of urban marine ecosystems. The IRP presents a significant opportunity to improve urban ecosystems while meeting clean water goals. The social impacts category measured the equity in the distribution of parks in the City of Los Angeles. Here the focus was on aggregate amounts of land that the Bureau and IRP alternatives can transform to improve the urban ecosystems of Los Angeles as part of city-wide water management.

To accomplish this, the analysis measured the following types of urban ecosystems:

- Parks, open space, and habitat restoration,
- River revitalization, and
- Effects on marine ecosystems.

In general, additional effort is needed to complete our understanding of the causes and effects of stormwater and dry weather runoff pollutants. How source control measures and runoff management will reduce pollutant concentrations, and then how reductions in pollutant concentrations will affect ecosystemsis not yet fully understood.. The U.S. EPA definitions of impaired receiving waters and the resulting TMDLs may be used as an answer to the second point: at this time, it is a reasonable procedure to assume that if pollutant loads are less than the TMDLs, effects will be negligible. However, predictions of how remedial efforts will improve runoff quality are currently quite uncertain, and further research is greatly needed.

System Adaptability and Flexibility (Indicator 6)

Moving WWTS operations and management in a more sustainable direction is a complicated process that will not have a definitive endpoint and which will depend in part on how IRP project elements are implemented. Such a path will require innovative technologies, some of which are perhaps not yet imagined. It will also depend on cost and technical issues that are currently poorly understood. To achieve sustainability in the future, it is important for the Bureau to identify and test new approaches to prepare for future demands. Sustainability also will require a readiness to adapt to changing environmental conditions, including emerging threats to clean water. As a consequence, the Bureau should have systems that track, identify, and respond to these challenges as they emerge.

This sustainability indicator explored a number of pertinent questions related to resiliency or flexibility in the current operation of the WWTS and the IRP alternatives.

The following list was not exhaustive, but served as a starting point to assess the current system and to facilitate future planning and activities:

- Groundwater protection and stormwater runoff infiltration
- Demand-side management (as opposed to traditional supply side management)
- Emerging issues

For the majority of subindicators in this category, there was either too much uncertainty in what might happen through IRP implementation or it was assumed, based on the best available information, that IRP implementation would generate results for all four alternatives that would be comparable to the baseline. However, the awareness of the need for the Bureau to remain flexible and adapt to emerging issues, as well as advances in monitoring and treatment technologies, may improve sustainability, whether or not it can be quantitatively measured.

Institutional Capacity (Indicator 7)

Moving the WWTS in a more sustainable direction will also require building the capability to make continual sustainability improvements in operations at many scales, from the plant level, to the Bureau, to the entire City government and finally reaching out to the citizens of Los Angeles. This last indicator category sought to measure capacity for sustainability improvements at these levels. It was recognized that these indicators refer to the Bureau as a whole and therefore did not distinguish among the four IRP Alternatives. However, they represent important characteristics of the Bureau that will inevitably affect the sustainability of whatever alternative is pursued.

The particular subindicators used were:

- Interagency Partnerships
- Data Availability
- Public Education Efforts
- Price Signals and Full Cost Accounting
- City of LA Green Buildings
- Continuous Improvement at the Facility Level

Both the City and the IRP process itself have made important progress toward sustainability in several of these areas. Some of the public education that occurs is outside the Bureau and performed by non-profits with funding from the Bureau. This is a good example of how strengthening one sub indicator can benefit another – more such partnerships can lead to greater education efforts. There are also important needs for further data development related to achieving IRP objectives and for future sustainability analysis.

CONCLUSION

For the first time in a major infrastructure planning project, sustainability has been made an explicit part of planning. Through this analysis, a baseline was defined that could be used for tracking sustainability. This assessment will allow the City of Los Angeles to guide progress towards sustainability during implementation. As next steps, it was recommended that the City address missing data and areas where more planning is needed; consider sensitivity analysis during implementation; and maintain stakeholder involvement in implementation. For continuous improvement, these indicators should be used to track progress along the road to sustainability.

By examining a variety of impacts from social to economic to natural resource use, the stage is set for identifying how and why certain kinds of data should be gathered and analyzed. The analysis was developed for the City of Los Angeles, and as such, was dependent on available data. Other municipalities may find that they have more specific data for some of the indicators and less for others, as compared to the City of Los Angeles. Perhaps even more significant, if a municipality or agency is contemplating revision of their wastewater or stormwater facilities plan in the near future, the analysis may help them to begin to collect data now, in anticipation of such a planning effort.

The science of sustainability analysis is still in its infancy and there are many variables and interactions difficult to quantify. At this time, there is no “cookbook” method for determining whether decisions and actions will be truly be sustainable in the future, or be victim to unforeseen unintended consequences. The science is still largely in the conceptual phase of development, but by trying to tackle the issue of whether a complex program such as the IRP’s alternatives are sustainable in the year 2020, the broader discussion of sustainability is expanded, and hopefully, points to directions that will lead us to improving, rather than degrading our natural resources for future generations.

ACKNOWLEDGMENTS

The IRP would not have happened without the strong leadership within the Department of Public Works and the Bureau of Sanitation and the Department of Water and Power in the City of Los Angeles. Specifically, we would like to thank Rita Robinson, Varouj Abkian, Tom Erb and Bill Van Wagoner for their vision and leadership. We also thank our community volunteers in the Steering Group, Advisory Group and Information Group for dedicating their time to participate in the project. Lastly, we would like to thank the cohesive team of City and consultant staff who worked on the IRP.

REFERENCES

Allenby, Braden and Thomas Graedel. 1999. Industrial Ecology. Prentice Hall.

CH:CDM, A Joint Venture. 2004. "City of Los Angeles Integrated Resources Plan: Volume 4: Alternatives Analysis." Prepared by CH:CDM for the City of Los Angeles, Department of Public Works and Department of Water and Power.

Curran, Mary Ann. 1996. Environmental Life Cycle Assessment. New York: McGraw Hill.

Haggin, Leslie. 1991: Building Sustainable Communities, an Environmental Guide for Local Communities: Water Quality, Protection and Remediation. San Francisco, CA: Global Cities Project.

Shane, Megan A. and Thomas E. Graedel. 2000. "Urban Sustainability Metrics: a Provisional Set". *Journal of Environmental Planning and Management*. 43(5): 643-663.

Task Committee on Sustainability Criteria. 1997. "Sustainability Criteria for Water Resource Systems." Report of the Water Resources Planning and Management Division , ASCE and Working Group, Unesco/IHP IV Project M-4.3.

Tukker, Arnold. 2000. "Life cycle assessment as a tool in environmental impact assessment." *Environmental Impact Assessment Review*. 20(4): 435-456.

Vos, Robert and Joe Devinny, Ian Penn, and Stephanie Pincetl. April 2005. Phase 2, Integrated Resources Plan for the Wastewater Program Draft Sustainability Analysis. Prepared for the City of Los Angeles, Department of Public Works and Department of Water and Power.

Vos, Rovert and Joe Devinny, Adel Hagekhalil, Hyginus Mmeje, Heather Boyle, and Kathleen Bullard. 2005. "Sustainability Indicators for the City of Los Angles Department of Public Works Integrated Resources Plan." *Technology 2005 Conference Proceedings*.

World Commission on Environment and Development (WCED). 1987. The Brundtland Report (Our Common Future).