INTEGRATIVE WATER MANAGEMENT AND CONSERVATION DEVELOPMENT:

ALTERNATIVES FOR THE CENTRAL TEXAS HILL COUNTRY

Kent S. Butler

Andrew Karvonen

With

Urvi Desai, Research Assistant
Sarah Price, Research Assistant
Jonathan Ogren, Research Assistant

And several other graduate students in the

Community and Regional Planning Program
School of Architecture
The University of Texas at Austin

December, 2004

This project was made possible by a research contract with the Lower Colorado River Authority and an unrestricted gift from Ms. Rebecca Hudson, an owner of the Rocky Creek Ranch

TABLE OF CONTENTS

Preface and Acknowledgements …… iii
Abbreviations …… iv
Executive Summary …… v
Introduction …… 1
Home in the Hill Country: Site Inventory and Design Factors …… 4
  Rocky Creek Ranch Case Study …… 4
  Marketing Considerations …… 6
  Water Infrastructure …… 7
    Water Supply …… 8
    Water Reclamation and Reuse …… 10
    Storm Water Runoff Management …… 12
  Site Layout and Development …… 14
    Impervious Cover …… 14
    Clustering …… 15
    Low-Impact Development …… 16
  Economic Considerations …… 16
  Development Initiative and Process …… 17
    Regulations and Permitting …… 18
    Infrastructure Systems Management …… 19
Alternative Development Scenarios …… 20
  Rocky Creek Ranch Subdivision Plan …… 20
  Three Alternative Development Scenarios …… 21
    Conventional Scenario …… 21
    Light Blue Scenario …… 23
    Deep Blue Scenario …… 25
  Comparative Discussion of the Alternative Scenarios …… 31
    Impervious Cover and Open Space …… 31
    Roadways and Trails …… 32
    Housing Sizes and Types …… 32
    Water Supply and Demand …… 33
    Storm Runoff-Water Quality Impacts …… 39
  Economic Assessment …… 45
Conclusions and Recommendations …… 50
References …… 53
Appendices …… 55
  Feasibility of Rainwater Harvesting Systems …… 55
  Feasibility of Using Reclaimed Effluent to Meet Irrigation Demand …… 57
  Methodology for Determining Water Quality Impacts …… 59

PREFACE AND ACKNOWLEDGEMENTS

This study was conducted by faculty and students in the School of Architecture, Community and Regional Planning Program at the University of Texas at Austin. It was supported by a contract with the Lower Colorado River Authority and a gift to The University from Ms. Rebecca Hudson, representing the Rocky Creek Ranch in western Travis County. There were many important contributors to this study, all of whose assistance cannot be fully acknowledged. The principal contributors to the background research that informed this study were the following graduate students who enrolled in either of two research studios in 2003 and 2004, titled, CRP 383, "Urban Environmental Analysis" and "Applied Techniques in Environmental Analysis," both supervised by CRP Professor Kent Butler:

Catherine Craig	Kathleen Ligon
Urvi Desai	Meeta Morrison
Lawrence Diamond	Jonathan Ogren
Eric Geppelt	Sarah Price
Sylvia Leon Guerrero	Steven Rossiter
Andrew Karvonen	Devashree Saha
Katherine Kier	James Vaughan
Jin-Oh Kim	Julie Warr
Dalbyul Lee	Emily Young

Special acknowledgement must be given Urvi Desai, Andrew Karvonen, Jonathan Ogren, and Sarah Price, who contributed supplemental research and graphical support following the completion of the studios. Urvi Desai produced many of the graphics in this report; and Andrew Karvonen provided considerable additional research and documentation; and Jonathan Ogren refined the economic cost spreadsheets; and Sarah Price completed many specific research tasks initiated by others.

Other public officials and private consultants who were invaluable contributors to the research and feasibility analyses of this project include the following:

<u>City of Austin:</u>
Patrick Hartigan, William Hoffman, Seyed Miri, Richard Peterson, Les Tull, George Zapalac

<u>Lower Colorado River Authority (LCRA):</u>
Burt Carter, Glenda Champagne, Kevin Crittendon, Angie Flores, Thomas Hegemeir, Sheri Kuhl, William Leisering, Ken Manning, Nora Mullarkey, Mary Ann Neely, Janet Stevenson

<u>Texas Commission on Environmental Quality (TCEQ):</u>
Ren Berra, Jim Highberg, Michael Lannen, James McCain, Heidi Wittenborn

<u>Travis County Transportation and Natural Resources</u>
Don Griggsby, Robert Morris

<u>The University of Texas at Austin</u>
Michael Barrett, P.E., Christene Moore

Private Consultants, Contractors, and other Professionals:

David Armbrust, Attorney, Armbrust and Brown, LLP
Beryl Armstrong, Plateau Land and Wildlife Management
Jim Blair, Bee Cave Drilling, Inc.
Rob Bookheim, APEC Engineering and Construction
Charles Bush, City of St. Petersburg, FL, Reclaimed Water Division
Richard Heinichen, Tank Town, Inc.
Rebecca Hudson, Landowner and Developer
Jeffrey Kingsbury, McStain Neighborhoods
Clif Ladd, Loomis Austin, Inc.
Mike McIlveen, M.D., Tank Town, Inc.
Carlotta McLean, Real Estate Agent
Tyler Molatore, Orenco Systems
John Noell, P.E., Urban Design Group
Mike Ridley, Ridley Development Management
Julio Sattler, Wastewater Solutions
Paul Smith, Richardson Verdoorn, Inc.
Jeff Snowden, Onsite Systems, Inc.
Ron Tyne, Rocket Properties
David Venhuizen, P.E., Engineering Consultant
Paul Vetter, Barley & Pfeiffer, Architects
Gail Vittori, Center for Maximum Potential Building Solutions
Don Walden, Land Development Consultant
Edward Wendler, Jr., Land Development Consultant
Steven Wilkie, Cerrozona Construction Services, Inc.
Steven Windhager, LBJ Wildflower Research Center
David Zorn, APEC Engineering and Construction

ABBREVIATIONS USED IN THIS REPORT:

BMP….… Best Management Practices
CRP…..… Community and Regional Planning Program, Univ. of Texas at Austin
gpd……… gallons Per Day
gpcd…..… gallons Per Capita-Da*y*
LBJ……… Lyndon Baines Johnson
LCRA….… Lower Colorado River Authority
LID……… Low-Impact Development
MUD….… Municipal Utility District
SOS…...… Save Our Springs
TCEQ…… Texas Commission on Environmental Quality
USFWS…. U. S. Fish and Wildlife Service

EXECUTIVE SUMMARY

In the Central Texas Hill Country, citizens and local governmental entities are at a crossroads—new development proposals are prompting public action on long-term issues concerning regional water supplies, water reclamation and reuse, and storm runoff pollution control. Each land use/water supply decision that is made in the region has the potential to result in significant consequences in terms of future water supplies, economic cost, and ecological impact. The planning and design of new residential developments and water management strategies for the Hill Country will shape the future of the region in terms of water use, cost of living, water quality, and landscape/environmental stress. Various new approaches, such as "low-impact development," "conservation development" and "integrated water management" have recently been pursued, but have not been sufficiently documented or critically evaluated.

In this study we will examine the Rocky Creek Ranch, a 468-acre tract located on Hamilton Pool Road in western Travis County. We will propose, model, and then critically analyze three alternative residential development scenarios, all prepared for this same tract. Each scenario is critically analyzed in terms of water supply and demand, water reclamation, impacts on downstream water quality, and economic cost. Our study makes a critical and quantitative assessment of the ways in which households and communities use water for domestic purposes. We find exciting opportunities to manage water much more efficiently in residential developments by integrating what are normally independent and unconnected water service functions of local utility operations. We will pose challenges for those who will bear the economic costs and environmental consequences of living in the Hill Country landscape.

The Study Site

The study site is bisected by Rocky Creek, which flows to the southeast into Little Barton Creek and then into the main stem of Barton Creek. Ultimately runoff from the site recharges the Edwards Aquifer and discharges from Barton Springs or associated springs, or into the Colorado River in central Austin. The landscape is representative of the Hill Country as found in western Travis and Hays counties. The soils are thin, with Glen Rose limestone outcroppings on the surface in some locations. Most of the land has previously been cleared for livestock grazing. The vistas across the Rocky Creek valley are beautiful and captivating; and the landscape is highly attractive as a potential site for a residential community. There is no municipal water supply or water reclamation utilities currently serving the area, but various options are being actively considered and plans are underway for new water services to be provided to the site.

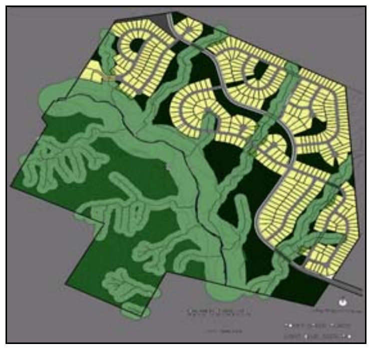
Rocky Creek Ranch


View along Rocky Creek to the Northwest

Alternative Development Scenarios

Several alternative development site plans were prepared for Rocky Creek Ranch as part of a graduate studio project at the Community and Regional Planning Program of the School of Architecture, University of Texas at Austin. Three of the site plans were redesigned in greater detail so as to be representative of fundamentally different, but viable options for residential development in the Hill Country. The three development scenarios presented in this study specify the lotting pattern, transportation and drainage network, water and water reclamation services (including demands and production levels), storm water runoff management strategies, detailed landscaping assumptions, and other amenity features.

Conventional Scenario



Light Blue Scenario

Deep Blue Scenario

Conventional Scenario: The Conventional scenario is typical in many ways of low-density suburban subdivisions in the Hill Country that were developed over the last 25 years. This plan consists of 230 single-family lots and houses, distributed relatively uniformly over the 468-acre tract, with open spaces provided in floodplains and streamside buffer zones (see figure above). Lot sizes range from a minimum of 1.0 to approximately 1.5 acres, each containing a home site and septic tank-drain field area that is approvable under county and state health regulations. The percent impervious cover for the entire 468-acre tract is approximately 11%; and in the 304 acres of net developed site area it is approximately 17%.

The proposed water supply is municipal surface water, provided to the development by the LCRA through a transmission line and storage tank on Hamilton Pool Road and feeding into distribution lines along the internal streets of the development. Water reclamation and disposal is achieved with onsite septic tank-soil absorption systems. Storm water quality management strategies consist of an array of sedimentation/filtration basins, vegetative buffer strips, and wet ponds within small tributaries.

Light Blue Scenario: The Light Blue scenario, named as such because it incorporates a considerable level of water- and land-conserving, or "blue" management practices, consists of 430 single-family lots and houses (see figure above). The development is clustered on the northeast half of the tract (northeast of Rocky Creek). Floodplain and streamside buffer zones, open space trail corridors, and a significant amount of undisturbed open space on the southwest side of the creek are provided by dedicating the land on the southwest side of the creek as a conservation easement, under separate ownership. The lot sizes on the northeast portion of the property range from 8,400 to 11,200 sq. ft. Impervious cover over the entire 468-acre tract is approximately 12%, and the percent cover on the 128 acres of net developed site area in the northeast portion is approximately 45%.

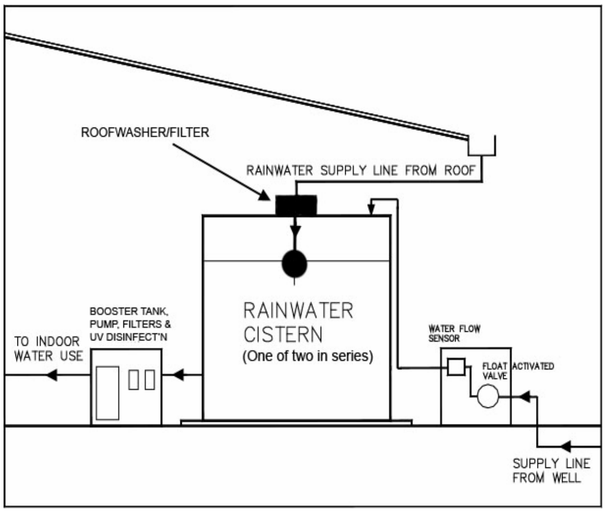
The water supply is municipal surface water, provided by the LCRA, with a transmission line and storage facility on Hamilton Pool Road and distribution lines along the internal streets of the development (similar to the Conventional scenario). Water reclamation and disposal is achieved with a centralized advanced secondary treatment plant in the southeast corner of the tract and a subsurface drip irrigation system installed on virtually all of the remaining open spaces on the northeast half of the creek. Storm water quality management strategies consist of an extensive array of sedimentation/filtration basins, vegetative buffer strips, wet ponds, underground storm sewers, and overland flow within small tributaries.

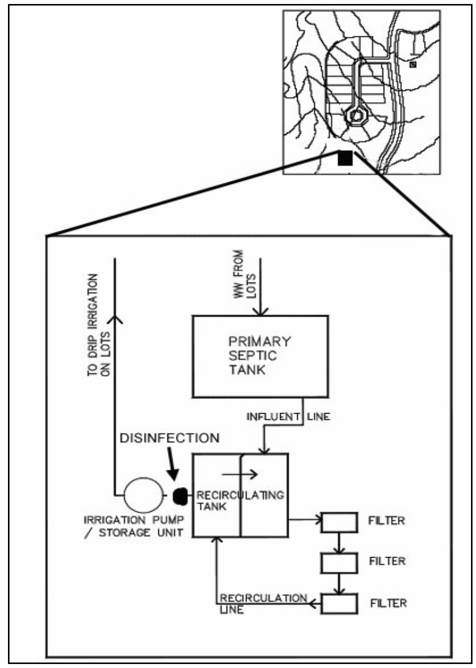
Deep Blue Scenario: The Deep Blue scenario integrates conservation design and low-impact development strategies to achieve very low water demand and environmental impact. It consists of 230 single-family lots and houses, developed in clusters of 14 to 36 units each, all on the northeast portion of the tract (see figure above). Open spaces include floodplains, streamside buffer zones, and a significant amount of undisturbed open space on the southwest two-thirds of the tract dedicated as a conservation easement, under separate ownership. Lot sizes are 10,500-13,500 sq. ft. Impervious cover over the entire tract is approximately 7%; and the 68 acres of net developed area within the residential clusters is approximately 26%. However, since rainwater catchment systems are used to intercept rooftop runoff as a water supply, roof areas contribute almost no storm water runoff or pollutant loadings downstream. Accordingly, the effective impervious cover within the net developed site area is reduced to only 17%; and over the entire tract it is effectively only 4% after subtracting rooftop catchment areas.

The water supply is a combination of rainwater catchment system on each house, coupled with supplemental water from three municipal wells on the site (see figure below). The rainwater systems are the primary water supply for all indoor water demands. Approximately 13,500 gallons of cistern storage is specified, although size may vary with household preference and size. Total roof area (including oversized garages/rain barns) on each lot is in the range of 3,200-3,900 sq.ft. The water supply should meet all indoor water demands, even in dry periods, unless there is an extreme drought or excessive water use. In anticipation of such cases, each rainwater system is supplemented by a connection to the municipal well supply, whereby the household cistern can be filled from one of the wellhead storage tanks and pumping stations. The connection of the municipal well system to the household cistern is separated by an air gap to avoid any risk of crossover of water supplies.

The prototype rainwater harvesting system is conceptually planned based on collaborations with manufacturers, installers, and designers of systems operating in western Hays and Travis counties for the past 10 to 20 years. Similarly, the municipal well system is sized and determined to be feasible after holding consultations with engineering and well drilling professionals with experience in the Hamilton Pool Road area. The wells would be designed to provide at least 0.6 gallons per minute of firm water supply to each household at all times, even though in actuality it would be used only for supplementation during peak demand periods or significant droughts. The storage tanks would be sized to provide more than the minimum required by the State for a groundwater-based municipal water utility.

Outdoor irrigation water demands are met by a water reclamation and reuse system using several small clustered package treatment plants that utilize a recirculating filter process acceptable to State permitting entities (see figure below). The reclamation process is operated by a licensed utility operator and master irrigator. Disinfected reclaimed water is distributed to pressure drip irrigation fields on each residential lot. Such practices are becoming widespread in other parts of the US, particularly in Florida and California.





Prototype Rainwater Harvesting System

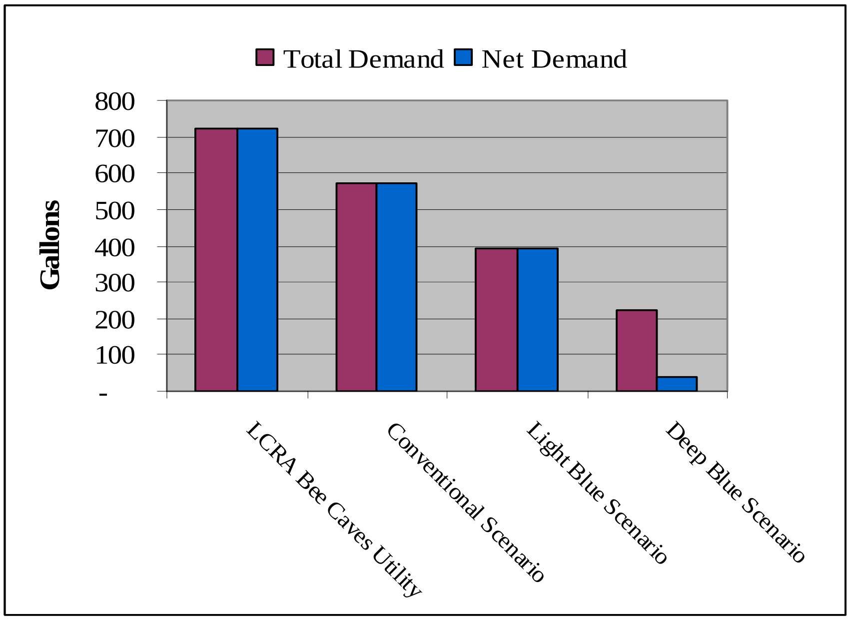
Water Reclamation/Reuse System

Implications for Water Demand

The variations in water use and environmental impact among the alternative scenarios are considerable. The Conventional scenario includes relatively large lots with relatively large irrigated lawn areas, while the smaller lots in the Light Blue scenario require less outdoor irrigation. The Deep Blue scenario applies reclaimed, reusable effluent onto residential lawns and landscapes from the clustered package plants through underground drip irrigation systems. Homeowners may optionally demand supplemental water for outdoor irrigation based on personal household preference from their rainwater system or from the municipal well system.

Indoor water demand is assumed to vary considerably as well, ranging from 90 gallons per capita-day in the Conventional scenario to only 45 gallons per capita-day in the Deep Blue scenario. This aggressive conservation assumption is justifiable based on national surveys of communities that make full utilization of water conserving technologies and practices, with no noticeable changes in lifestyle.

Our study shows that in a single-family household in each of the three scenarios, the amount of "net water demand" – water that would need to be supplied from sources away from the development -- varies by a factor of 15-to-1 among the scenarios. The following figure summarizes the "total demand" of water, in gallons per day (gpd), that would be required in each scenario, as well as the "net demand" that would need to be supplied to a single-family house from offsite sources. They vary from 571 gpd in net demand for the Conventional scenario to only 37 gpd in the Deep Blue scenario. This analysis demonstrates the potential for significant water savings when we critically examine how we can integrate the various water services provided to households.



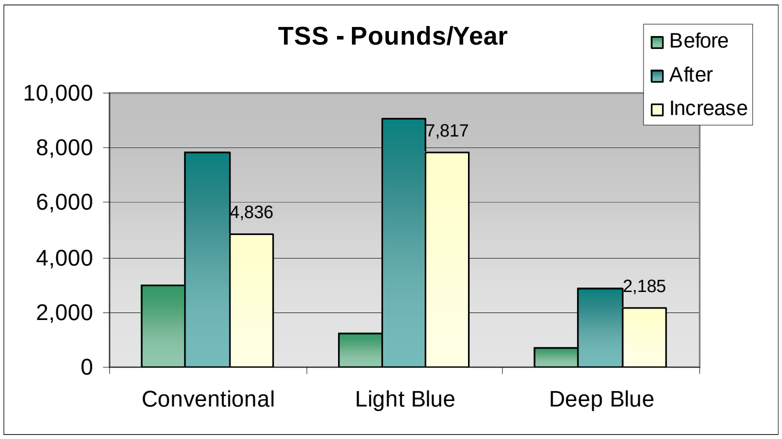
Average Daily Water Demand per Household (in gpd)
"Net Demand" is the Amount Supplied from Offsite Sources

Implications for Water Quality

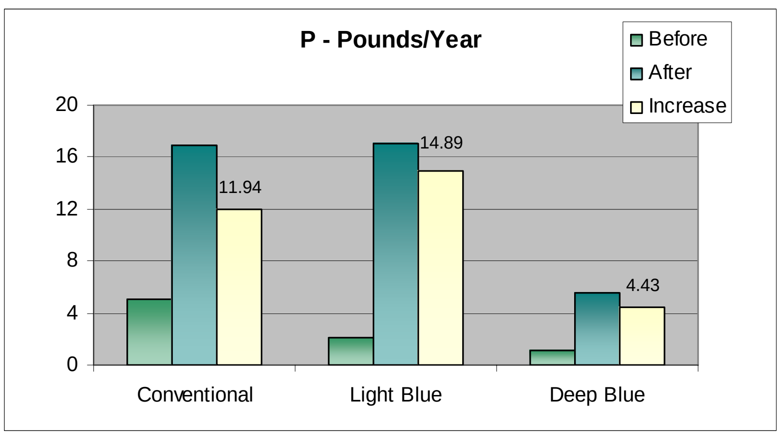
Each scenario was further planned and designed to include "best management practices" (BMPs) to reduce storm water runoff pollution. We used the water quality protection recommendations of the US Fish and Wildlife Service (USFWS) for the Barton Springs watersheds as a general guide, but development of a detailed BMP design that would achieve strict adherence to the nondegradation provisions of the USFWS guidelines was not possible, given the time and resource constraints of this study. Instead, a panel of experts and a simplistic pollutant loading model was used to approximate the BMP strategy best suited for each scenario. The following assessment summarizes the expected performance of the BMP strategy developed for each scenario by the expert panel.

The Conventional scenario does not require much control of runoff volume as a result of the low overall impervious cover, but still needs a limited number of structural as well as nonstructural BMPs, including sedimentation-filtration basins, vegetative buffers, and wet ponds. The Light Blue scenario, with its intensive impervious cover in the northeast half of the site, requires considerably more use of structural, higher-maintenance BMPs to capture and detain storm runoff volumes and pollutant loads. This plan calls for several sedimentation-filtration basins, vegetative buffers, and wet ponds. The Deep Blue scenario, unlike the other two, is able to make full use of non-structural BMP strategies on account of its low impervious cover and considerable amount of open space situated to receive overland flow from developed areas. The runoff pollution is retained in bio-retention areas and filtered by vegetative buffer strips. It is clearly able to comply with USFWS guidelines.

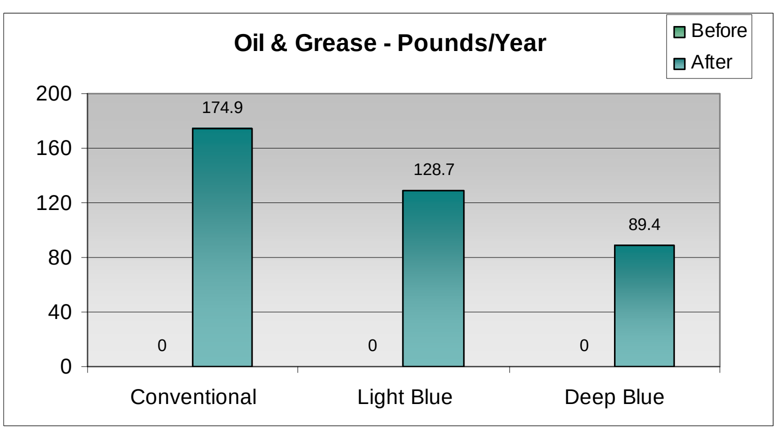
The relative magnitudes of impact of the scenarios, in terms of pollutant loadings into receiving waters, are presented in the following figures. While the Conventional and Deep Blue scenarios have approximately the same number of lots, the Conventional scenario yields 2.2 times the amount of total suspended solids, 2.7 times the amount of phosphorus, and 2.0 times the amount of oil and grease, as compared to the Deep Blue scenario.



Total Suspended Solids (TSS) Pollutant Loadings for the Three Scenarios



Total Phosphorus (P) Pollutant Loadings for the Three Scenarios



Oil and Grease Pollutant Loadings for the Three Scenarios

Economic Assessment

We made a detailed estimation of the cost of constructing and maintaining the subdivision in each scenario as well as the ongoing costs to the home owner for all water services and associated landscape amenities. Cost estimations were developed in consultation with numerous engineering professionals, using typical construction prices of infrastructure built in the region in recent years, updated to winter 2003-04 prices. Altogether, some 80 cost factors were inventoried and estimated, ranging from water lines of certain diameters to water quality BMPs, to monthly user charges for water reclamation services, to developer interest charges for financing the development. The following tables summarize the costs of each scenario.

Per Lot Construction Costs for Each Scenario

	Conventional	Light Blue	Deep Blue
Water Supply	$16,406	$14,009	$16,739
Water Reclamation	$10,000	$11,348	$11,151
Landscape Irrigation	$5,200	$4,160	$68
Storm Water Quantity and Quality	$4,623	$6,107	$3,279
Utility District	$6,249	$9,692	$4,739
Open Space	$528	$607	$376
Transp. & Other Infrastructure	$18,799	$12,916	$13,331
Financing and Land Acquisition	$25,297	$14,418	$24,838
TOTAL	**$87,102**	**$73,258**	**$74,521**

Ongoing Monthly Costs per Living Unit for Each Scenario

	Conventional	**Light Blue**	**Deep Blue**
Life-cycle Costs	$266	$194	$199
Administrative/Operational/ Maintenance Costs	$113	$134	$73
Total Ongoing Costs	$379	$328	$272

The most important contribution of this cost estimation procedure, aside from identifying the relative costs of different development scenarios, is the presentation of the various types of costs from different development designs in a common frame for comparison. It is now possible, for example, to compare the costs of water services provided by a central utility (e.g., LCRA) with those constructed by a developer (e.g., a private water utility), with those constructed by a house builder (e.g., rainwater catchment systems). Similarly, the varying means of funding and financing construction costs as well as ongoing services costs in the different scenarios can be compared side-by-side.

Many specific findings and observations are made from this analysis of construction costs in the main report. For example, while the Light Blue scenario contains 200 more lots than the Conventional or Deep Blue scenarios, the construction costs on a per lot basis are still comparable to those in the Deep Blue scenario. Another finding is that irrigation costs for the Deep Blue scenario are considerably lower than for the Light Blue scenario, since in the Deep Blue scenario, the residential irrigation systems are operated as a part of the water reclamation/reuse system, thereby achieving considerable savings in irrigation costs by not using potable surface water for outdoor irrigation.

Many findings are also evident in evaluating the ongoing costs to the home owner. Ongoing costs for the Light Blue scenario are considerably lower than those for Conventional; and correspondingly, the costs for the Deep Blue scenario are considerably lower than for the Light Blue scenario, for several reasons. The life-cycle costs (the ongoing costs required to cover repair and replacement) in the Conventional scenario are much higher, largely as a result of the shorter life-expectancy of the septic tank-soil absorption systems. And the administrative/ operation/maintenance costs of the Deep Blue scenario are considerably lower than both of the other scenarios, as a result of the nonstructural BMP strategies used, the rainwater harvesting systems, and other factors. In the coming years, these ongoing costs will become increasingly important, especially those costs that are subject to energy- and labor increases over time.

What are the revenue potentials of each scenario? While it is not possible to research and formulate reliable estimates of the marketability and lot sales velocity for each scenario, we can make an approximation of the lot sales price required to generate specified target net revenues (say, $4 million) to the developer. Using the gross construction costs for all lots in each scenario, plus real estate transaction costs, we determine that the following lot prices would be required to achieve a $4 million net revenue target: Conventional--$107,977; Light Blue--$85,490; Deep Blue--$94,892.

Findings and Conclusions

In this study we consider and evaluate various scenarios for Hill Country development and recommend some approaches in the end that balance the demands of the economic stakeholders with the demands of the environmental stakeholders. The scenarios and evaluations presented in this report suggest possible paths toward responsible development and they demonstrate that such paths are quite feasible. The overarching conclusion of this study is that responsible development in this region must fully consider the cumulative impacts of new development on area water and environmental resources. Only with thoroughly integrative approaches to the provision of water services to new developments will we begin to move towards a future that is sustainable in terms of water use and water quality impacts. The exciting promise of this study is that we can make choices and can see more clearly the consequences of those choices, for the developers and home builders, as well as the public entities responsible for serving and regulating the housing industry.

Individual home owners are typically not able to directly influence the direction of new developments or housing products—to move them towards more sustainable futures in terms of water use and environmental impact. But the perceived need and demand for significant change of this sort appears to be at hand. This study provides a base for further assessment of the steps that can be taken, both now and in the future, towards a more sustainable design of development in the Hill Country.