

# **DECENTRALIZED TREATMENT OFFERS COST EFFECTIVE REUSE FOR A SUSTAINABLE NEW COMMUNITY<sup>1</sup>**

*Barbara R. Bradley<sup>2</sup> Nolte Associates, Inc. San Diego, CA  
Dave Richard, Nolte Associates, Inc. Sacramento, CA  
Blake Tresan Nolte Associates, Inc. Sacramento, CA  
Christina Brown Nolte Associates, Inc. Sacramento, CA*

## **Introduction**

The University of California (UC) and the County of Merced (County) have embarked on a challenging and visionary planning effort to build a new campus in Merced County, referred to as the University Community Planning Area (UCPA). The plan acknowledges the profound influence of the UC campuses on the social and environmental fabric of life, an influence spanning decades and even centuries. Given the enduring influence of its campuses, UC committed to building the new UC Merced in accordance with environmental stewardship principles. The County has taken this commitment and expanded it to encompass sustainable development. The intent is to create a model of development, serving as an example for other communities and providing lessons for future students.

Nolte Associates, Inc. was asked to prepare conceptual plans for water-related infrastructure for both the campus and community. The plan would integrate water systems for maximum reuse potential, and to enhance a sense of stewardship by future residents. The Conceptual Plan for Integrated Water-Related Infrastructure (Conceptual Water Plan) suggests a bold departure from conventional infrastructure solutions, but not a departure from human health and environmental protection. This plan and the ensuing infrastructure policies in the Community Plan are the first steps toward a system of integrated water resources where decentralized onsite wastewater treatment and reuse plays a major role.

## **Conceptual Water Plan Goals and Objectives**

The following goals and objectives of the Conceptual Water Plan were developed with frequent input from UC and other stakeholders.

1. Emphasize the most efficient use of water.
2. Emphasize actions to avoid or minimize impacts to remaining vernal pools and wildlife habitat.
3. Work with gravity, not megawatts (Take advantage of natural forces.).
4. Use natural low-energy systems when practical, as opposed to mechanical systems.
5. Design systems that are affordable to construct, implement, and operate.
6. Use a system's output or waste for beneficial use.

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<sup>2</sup> Corresponding author, 15090 Avenue of science, Suite 101, San Diego, CA 92128, 858-385-2105 barbara.bradley@nolte.com

7. Provide flexibility to allow a change in technology, funding, and/or management to be implemented easily at a future date.
8. Construct systems in phases so that they can be installed on an as-needed basis.
9. Provide an integrated approach for implementation.
10. Design systems that will protect on-site and off-site groundwater and surface water resources quality and quantity.

The extensive amount of information prepared previously for the Campus and the compressed time frame for the development of the Conceptual Water Plan influenced the approach to the work. The project team performed much of the work during facilitated brainstorming sessions and workshops with the UC, regulators, and stakeholders. These sessions promoted multi-disciplinary approaches that shaped the role of water for the new campus. The overall methodology used multiple working sessions to compile and process information and concepts quickly with senior personnel.

## **Technologies and Strategies for Water-Related Infrastructure**

Several strategies and technologies were developed and evaluated during formulation of an integrated plan for water, wastewater, and stormwater infrastructure to the Campus and UCPA.

### ***Water Supply***

All water supply strategies targeted ground water extraction with an onsite or offsite well field. Most of the infrastructure scenarios developed include use of recycled water. Groundwater is a shared resource critical to the economic base of the county, agriculture. Thus it only made sense for economic reasons to find ways to recycle water within the new urban community.

### ***Wastewater Collection and Treatment***

Several wastewater treatment systems were examined:

- Onsite decentralized collection and treatment
- Natural low-energy systems.
- Onsite and offsite mechanically intensive treatment systems

Decentralized Systems for Wastewater Collection and Treatment: The suitability of these systems to treatment and *onsite* reuse became particularly important. The collection options for decentralized treatment consisted of treating wastewater from individual homes, clusters of homes, and commercial buildings. For homes, offices, or industrial sites, wastewater could be collected from sewer pipes as they exit the buildings, or special plumbing could separate specific waste streams suited for reclamation. The conveyance option evaluated for decentralized treatment was a small-diameter variable-slope collection system. Of particular interest was the STEP/STEG system (septic tank effluent gravity/septic tank effluent pump system). This system uses septic tanks prior to collection to reduce costs in numerous ways. Settled and filtered septic tank effluent can be conveyed in small-diameter sealed pipes. Infiltration is sharply reduced, as is clogging. Effluent received at the downstream treatment plant requires less treatment.

Intermittent sand filters, recirculating granular media filters, and biotextile filters were the onsite wastewater treatment technologies evaluated.

Natural and Low-Energy Systems for Wastewater Treatment: The following natural and low-energy treatment processes were considered for this project:

- Pond systems
- Overland flow
- Constructed wetlands
- Rapid infiltration (groundwater recharge).

These systems were considered too large to fit the site constraints although they offered several benefits for sustainable development.

Mechanically Intensive Treatment Systems: These systems were defined as systems that concentrate the treatment process in a relatively small area and use high-energy mechanical equipment and concrete tankage to accelerate and optimize the natural physical and biological processes that treat wastewater. Two mechanical treatment processes were considered for the Campus and UCPA:

- Oxidation ditch followed by filtration and disinfection
- Membrane bioreactor.

***Water Recycling and Reuse***

It was recognized that reuse of treated wastewater for non-potable purposes would conserve valuable fresh water and beneficially use what is otherwise considered a waste product. California regulations (Title 22) permit a variety of uses for recycled water, many of which were applicable to the Campus and the UCPA. End uses for recycled water would depend on the level of treatment. Table 1 compares reuse strategies identified by treatment technology and level of treatment.

**Table 1.** Reuse Strategies Compared by Treatment Technology and Level of Treatment

| <b>Treatment Technology</b>    | <b>Treatment Level</b>                                   | <b>Recycled Water Quality Designation Per California Regulations Title 22</b> |
|--------------------------------|--|---|
| Decentralized Onsite Systems   | Settling and oxidation; with or without disinfection     | Undisinfected secondary<br>Disinfected secondary                              |
| Natural Low Energy Systems     | Secondary with disinfection                              | Disinfected secondary – 23  |
| Mechanically Intensive Systems | Secondary with coagulation, filtration, and disinfection | Disinfected tertiary  |

***Storm Water Management***

Objectives for the stormwater system were to use best management practices (BMPs) that mimicked the natural hydrologic regime. Based on an evaluation of hydrologic controls and site

constraints, the following BMPs were the recommended practices to meet the project's goals and objectives.

- Bioretention (rain gardens)
- Floodplain (vegetated) Buffers
- Filter Strips
- Grassed Swales
- Fossil Filters
- Monitoring

Storm water was only partially integrated with the wastewater systems. Recycled effluent was considered for augmenting water supplies to the bioretention basins during dry weather.

### **Criteria for Evaluating Technologies and Integrated Strategies**

Twelve technical criteria and six implementation criteria were developed to evaluate potential infrastructure scenarios and institutional alternatives. These criteria are defined below.

#### ***Technical Criteria for Infrastructure Concepts***

1. **Capital Cost.** The initial cost for infrastructure construction.
2. **Permitting Time and Risk.** Time to obtain permits from the regulatory agencies and the likely level of regulatory complexity.
3. **Ability to Meet Campus Opening Schedule.** The degree of certainty that the initial phase of infrastructure could be installed and operational for a campus opening in Fall 2004.
4. **Regional Environmental Stewardship.** The degree of impact to off-site surface water and groundwater quality and quantity.
5. **Local Environmental Stewardship.** The degree of impact to on-site vernal pools, wildlife habitat, and ground/surface water.
6. **On-Site Wastewater Reuse.** The degree to which treated wastewater is reused in a closed loop system within the Campus and UCPA.
7. **Maintenance of Natural Drainage Courses.** The degree natural drainages are maintained in their natural status.
8. **Life Cycle Costs.** The combined cost of infrastructure construction, operation and maintenance costs for the useable life of the infrastructure.
9. **Phaseability.** The ability to install water-related infrastructure systems in phases.
10. **Flexibility.** The degree to which the management or infrastructure technologies implemented initially could be changed in the future.
11. **Reliability.** A measure of how reliable the water-related infrastructure systems would be in achieving their goals of water conservation and minimal effects on downgradient groundwater resources.

12. **Land Use Constraints.** The degree to which the Campus land use plan would be affected/constrained by the water-related infrastructure systems chosen for implementation.

### *Institutional Criteria for Operations and Maintenance Scenarios*

1. **Short Term Implementation.** The ability to implement the organizational structure in the short term to have the organizational structure in place and operating effectively by the opening of the Campus.
2. **Long Term Implementation.** The ability to implement the organizational structure in the long term without significant organizational issues.
3. **General Management.** The ability of the organizational structure to function with the existing agencies in the region and deliver the required services without significant administrative problems.
4. **Fiscal – On-going Operating Costs.** The ability to cost-effectively deliver the integrated water-related services.
5. **Capital Funding.** The ability to provide capital funding through debt markets or private capital, to minimize the up front development costs of the infrastructure systems to the State, City, County, or developers.
6. **Adaptability.** The ability to modify the organizational structure as the Campus and UCPA mature over time and changes are made to the delivery of water-related infrastructure systems as a result of new technologies or new engineering practices.

## **Development of Integrated Strategies**

An initial group of five water-related infrastructure scenarios were developed, all using ground water as the source of potable water. Some scenarios contain recycled water as a source for nonpotable water uses. The *scale* of the infrastructure varied considerably.

### ***Scenario No. 1 – Baseline Concept***

In this scenario, potable water would be used for both potable and non-potable demands. A conventional wastewater collection system would be constructed to transport wastewater to a centralized on-site treatment facility. Tertiary treated recycled water would be used for existing golf course irrigation with all excess recycled water then directed to on-site and/or off-site wetlands for maintenance purposes. Stormwater management was not integrated with other water-related infrastructure systems. Stormwater collected in culverts would drain to surface water or into detention basins.

### ***Scenario No. 2 – City of Merced Connection***

In this scenario, potable water would be used for both potable and non-potable demands. A conventional collection system would transport wastewater to the existing Merced Wastewater Treatment Facility (WWTF), approximately 10 miles to the southwest. Treated effluent discharges to surface water and is used to maintain duck ponds and wetlands with a small amount used for agricultural irrigation. Stormwater management was not integrated with other water-related infrastructure systems. BMPs would maintain pre-development runoff water

quality. Stormwater collected in culverts would drain through wetlands existing along local drainage courses to surface water.

### ***Scenario No. 3 – Decentralized, Multi-Scalar, Local Environmental Stewardship***

Decentralized on-site infrastructure in multiple closed-loop systems was emphasized. Groundwater would provide water for potable demands only. Wastewater treated in community-sized on-site systems would produce effluent suitable for subsurface irrigation and other non-potable water uses, including maintenance of wetlands used to treat stormwater runoff. Stormwater management was integrated with the other water-related infrastructure systems. BMPs would maintain pre-development runoff water quality. Stormwater collected via swales, vegetated strips, and natural flow patterns would be conveyed to ponds, wetlands, and detention basins for treatment and use for non-potable water uses (i.e., to augment landscape irrigation) or for ground water recharge either on-site or off-site.

### ***Scenario No. 4 – Centralized, Local Environmental Stewardship***

Scenario No. 4 maximized on-site reuse through an extensive dual distribution system. Water supplied by a well field would provide water for potable uses. Wastewater collected by a conventional wastewater collection system would be treated in a centralized tertiary treatment plant. Reclaimed water conveyed in a non-potable water distribution system would maintain wetlands used to treat stormwater runoff. Reclaimed water would be used for landscape irrigation, toilet flushing, and cooling towers. Any excess reclaimed water would be used for groundwater recharge or discharged to surface water. Stormwater management was integrated with the other water-related infrastructure systems with BMPs used to maintain pre-development runoff water quality. Stormwater collected in swales, vegetated strips, and natural flow patterns and conveyed to ponds, wetlands, and detention basins would recharge groundwater.

### ***Scenario No. 5 – Centralized, Regional Environmental Stewardship***

Scenario No.5 maximized off-site reuse opportunities. Water supplied by a well field would be used for potable and some non-potable uses. A conventional wastewater collection system would transport wastewater to a centralized secondary or tertiary treatment plant located on-site or in the North Merced community area. Secondary effluent could be used for irrigation of large nearby agricultural fields and/or provide water to the Merced Irrigation District for other agricultural uses. Tertiary treated water would be used for golf course irrigation, irrigation of large landscape areas on campus, or off-site groundwater recharge. Stormwater management was not integrated although BMPs would be used.

### ***Assessment Process and Stakeholders' Role***

County, state, federal regulatory agencies and the UC provided guidance and comments that helped refine the details of each of the scenarios through a series of facilitated meetings and workshops. The scenarios were presented to a panel of experts to ensure that no viable alternatives were overlooked. Based on the experts comments, scenarios were further refined. During a one-day collaborative workshop, the stakeholders ranked the five infrastructure scenarios using the twelve technical criteria listed above. In addition, they ranked potential institutional arrangements. The overall preferred infrastructure scenario was Scenario No. 3 – the Decentralized, Multi-Scalar, Local Environmental Stewardship. Scenario No. 2 (City of Merced Connection), received considerable support for certain infrastructure system options.

## **Conceptual Plan for Integrated Water Infrastructure**

For land planning purposes, scale became the critical issue for the integrated water system and optimizing onsite reuse. Figure 1 is a decision tree used to make the final selection, that reflects the scale and site conditions.

As a result of the collaborative process between the project team, UC, and key stakeholders, the Conceptual Plan for integrated, water-related infrastructure systems was developed as shown in Figure 2. The Conceptual Plan reflects individual components of the candidate strategies, emphasizes on-site environmental stewardship, and maximizes onsite reuse opportunities for landscape irrigation, cooling towers, and toilet flushing within institutional buildings.

Ultimately, the onsite collection and treatment system comprised a STEP/STEG collection system, a recirculating gravel filter, a biotextile filter, ultraviolet disinfection, and subsurface drip irrigation systems for disposal and irrigation. An interim pipeline conveying wastewater to the City of Merced WWTF was included. The recommended institutional arrangement for the County of Merced to manage the integrated water related systems for both the UC and County, possibly with support from the City of Merced.

The wastewater collection, treatment, and recycling systems would occur independently in forty 55-acre wastewater management zones over the 2,200-acre site. Despite this apparent fractionization of the system, currently available computer-based remote telemetry monitoring and control technologies would allow the entire system to be managed by a central wastewater authority. An advantage of this approach is the ability to develop the wastewater infrastructure as needed, as opposed to having to capitalize in a large centralized facility long before its design capacity has been met. Additionally, the decentralized approach would reduce the size and magnitude of how collection and recycled water distribution system. The cost for the decentralized treatment and reuse system is about \$27,200,000 for phase I (0.84 MGD) and \$ 89,200,000 full build out (3.29 MGD). The cost was virtually the same as the cost of exporting the wastewater to the City of Merced's WWTF with no reuse opportunities in the new campus community. About 50 percent reduction in potable water demand within the new community can be achieved. Even greater reductions could be achieved were there land available for water storage during wet weather.

The Conceptual Plan is the first step toward an integrated water system that institutionalizes a new high level of environmental stewardship.

### **References**

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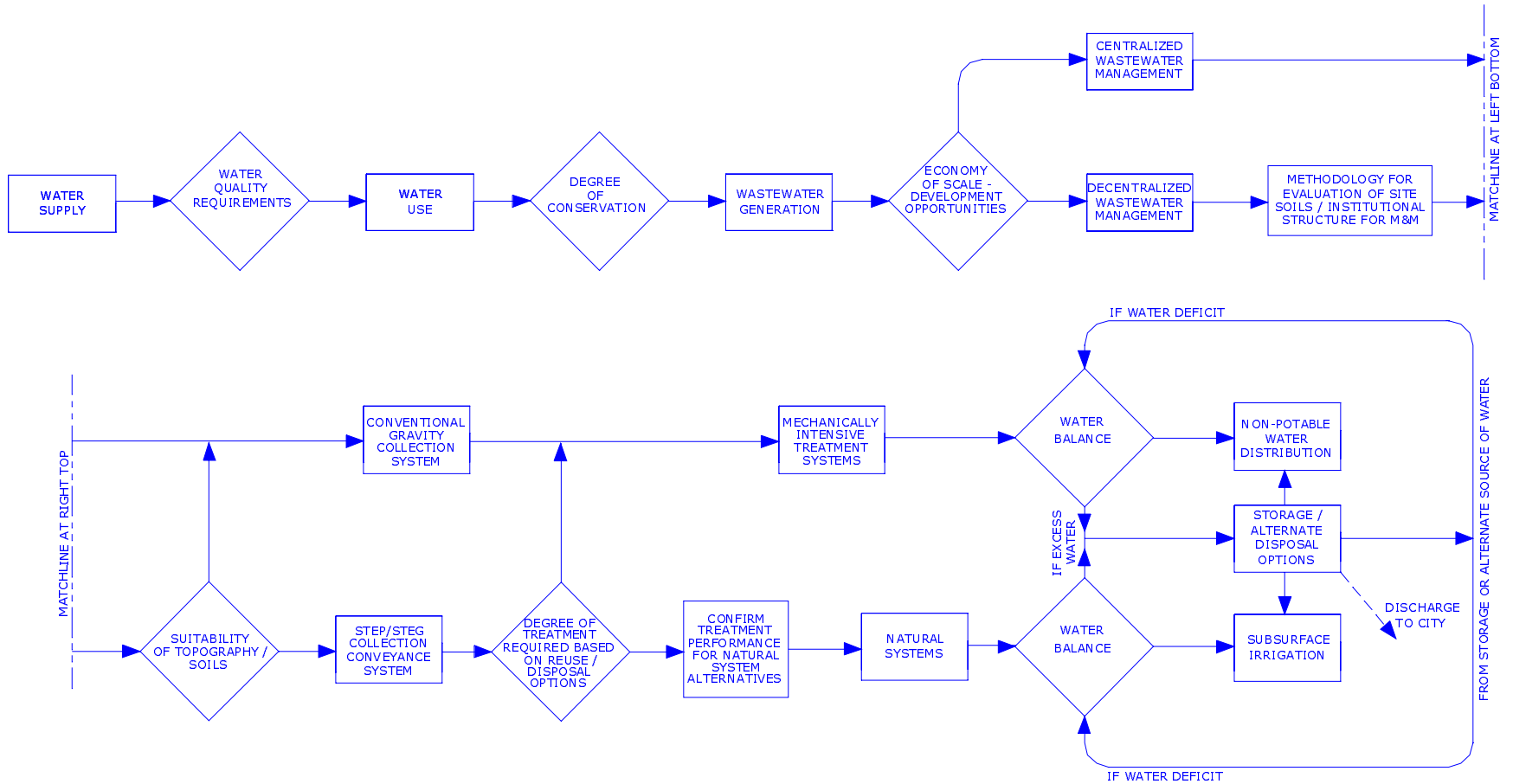


FIGURE 1

DECISION TREE FOR INTEGRATED WATER RELATED MANAGEMENT STRATEGIES

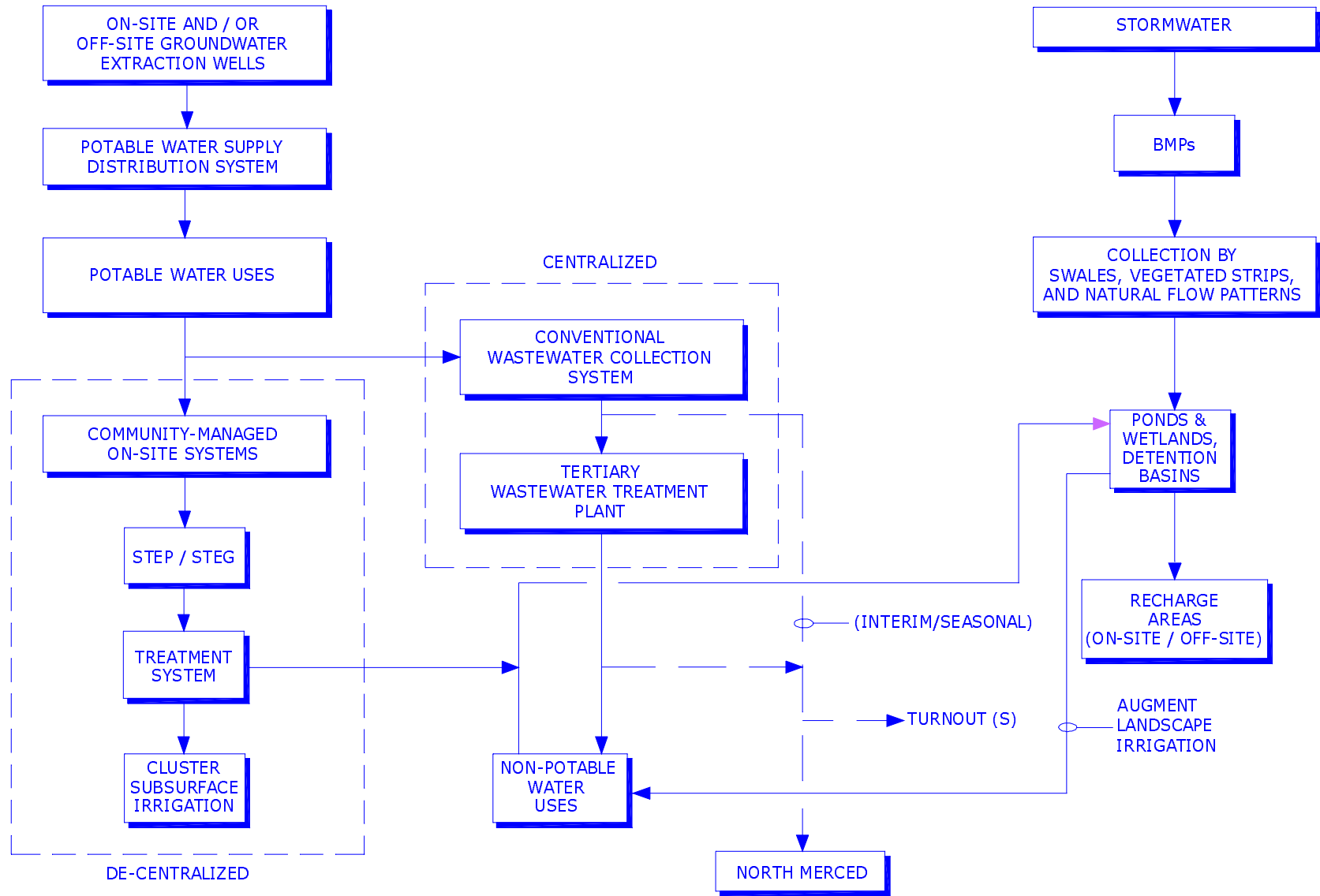


FIGURE 2  
 PREFERRED SCENARIOS FOR WATER-RELATED INFRASTRUCTURE SYSTEMS

