# PERFORMANCE-BASED REGULATION FOR ONSITE/DECENTRALIZED WASTEWATER FACILITIES: GENERAL CONCEPTS AND THE STATE OF ARIZONA FRAMEWORK

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## INTRODUCTION

Performance-based standards have been adopted for many regulated activities. Onsite systems regulation has a legacy of prescriptive standards which are typically difficult to administer when applying new technology or addressing unusual site conditions. Prescriptive onsite system standards have generally met public expectations until the 1970s when septic tank system siting emerged as an environmental issue, and was superimposed on historic public health concerns. These and other problems stimulated response in the areas of scientific research, regulatory options, new products and multi-state product marketing programs. Until the advent of large scale product marketing, the onsite industry was essentially a cottage industry of locally supplied components and local regulation. Cluster/decentralized wastewater systems have emerged, in part, due to economic and management problems related to the application of technology to manage wastewater discharge. Prescriptive regulation without apparent scientific basis has lost support in critical sectors. These circumstances have contributed to the current interest in alternative regulatory approaches for the design, installation and operation of both onsite and decentralized wastewater facilities. Many state and local government officials are contemplating adoption of performance-based technical standards for onsite systems, but there is no common vision about what these standards should be.

Several authors have contributed to the national dialog about the topic (Otis and Anderson, 1994), (Hoover et al., 1998), (Jantrania, 1999), (Corry, 2000), (Bowers, 2001) and (Nelson, 2001). The application of performance-based design and management concepts are discussed in the EPA draft management guidelines (EPA, 2000). This paper identifies issues related to the general topic of performance-based technical standards and describes the recently adopted Arizona rule. Key issues discussed include the point of compliance, appropriate parameters/statistical boundaries, design adjustments for improved wastewater treatment, and the algorithms that provide the linkages to the underlying science.

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## BACKGROUND

The 1972 Amendments to the Federal Water Pollution Control Act provided a standardized national framework and substantial grants to designated state water pollution control agencies for planning and program activities for surface water quality restoration and protection. No similar national program has been established to guide state efforts regarding administrative processes and technical standards for onsite wastewater systems. Regulators are being pressured to either update existing, prescriptive regulations, or allow others to change the agenda through the political process. Without some guiding framework to standardize the application of science in new technical standards, state and local updating efforts are likely to magnify the problems of the existing regulatory patchwork.

The U.S. Environmental Protection Agency (EPA) has proposed draft guidelines for an onsite/decentralized management framework (EPA, 2000) which consists of 13 key elements. The first five program elements - planning, performance requirements, site evaluation, design, and construction - pertain to an "Installation Authorization" (IA) that leads to a construction approval for a specific project. The EPA document also provides substantial information related to eight "Management/Institutional" (M/I) program elements: operation and maintenance, residuals management, certification/licensing, education/training, inspections/monitoring, corrective actions, record keeping/reporting, and financial assistance. Subsequent referrals in this paper to onsite systems are intended to generally include decentralized systems.

The IA elements focus on information about site characteristics, wastewater characterization, wastewater treatment (unit processes and soil) and wastewater dispersal risk (health and environmental). State and local programs have evolved from varying enabling laws and practices, historically propelled by public health concerns with some recent accommodations for environmental concerns. In the past, the development of onsite systems standards has not been adequately accompanied by an examination of questions about (a) what scientific information is necessary to integrate environmental and health criteria for onsite facilities planning and regulation, and (b) how much of this information is readily available for program updating? The answers to these questions are essential to adopting a performance-based regulatory program. This examination entails the determination of pollutants pertinent to onsite systems (nitrogen, phosphorus, pathogens and indicator organisms), equations and models governing the fate of constituents throughout treatment and dispersal processes, and appropriate statistical terms for risk assessment. While this task may seem overwhelming, there are several program models that can be considered. One suggestion is to pattern the onsite regulatory framework to resemble a scaled down version of the NPDES and RCRA models, and that treatment and dispersal technologies should be tested and assessed under a protocol that produces data to address these questions (Bowers, 2001).

In Arizona, new onsite system rules were recently adopted and became effective on January 1, 2001. The rulemaking effort benefitted from extensive consultations with a diverse stakeholders group to help determine the principle elements of a performance-based rule. The following points emerged out of this process:

- Technical standards must focus on outcomes and be expressed in narrative or numeric terms,

- Technical standards should be based on identified assumptions and scientific data that allow the application of rule in a generalized manner,

- Technical standards must relate the characteristics of raw wastewater, treated wastewater and dispersal, including flows and loading rates,

- Technical standards must pertain to measurable wastewater characteristics and should apply at specific points of compliance, and

- Technical standards for treatment and dispersal performance must address the relationships among requirements for site assessment, design, installation, and operation.

This paper explores how performance-based technical standards for onsite system design can be structured to ensure that discharges comply with relevant environmental and health standards. The wastewater treatment parameters of concern identified during the Arizona rulemaking include five-day biochemical oxygen demand ($BOD_5$) and total suspended solids (TSS) concentrations to determine dispersal rates in native soil, total coliform counts to ensure final soil treatment for potential pathogens and total nitrogen concentration to limit pollutant loading of the aquifer. A model was later developed for implementing the training program that illustrates the linkages among wastewater characterization, treatment and environmental receptors with the pollutant parameters and algorithms.

DISCUSSION

Stakeholders that helped develop the new Arizona rule for onsite systems expressed a preference for performance-based technical standards which specified outcomes in narrative or numeric terms. They were very familiar with the use of numeric standards for specifying effluent limitations and other discharge controls, equipment sizes, slopes, setbacks and other commonly measured features. Considerable effort was directed to developing narrative performance standards. While appearing less definable, narrative standards were recognized as equally important as numeric standards. Narrative performance standards were in some instances adapted from prescriptive standards. An example is the replacement of a prescriptive requirement for an observation port by criteria providing for the visible observation of wastewater levels in the system. The hotly debated topic of designer qualifications was settled by a narrative description of acceptable design, rather than by a list of "credentialed" occupational categories. While the outcomes are essentially the same, the technique is different.

Determination of appropriate performance parameters and associated statistical measures of confidence should consider concerns related to technical, legal, economic and social factors. The following four wastewater performance parameters were chosen for the Arizona rule to characterize performance for more than 20 onsite treatment train and/or disposal technologies:

1. $BOD_5$ and TSS, 30-day arithmetic average values [the rule includes an algorithm that relates reductions of $BOD_5$ and TSS to Soil Absorption Rate (SAR) increases, thus allowing designers to use smaller disposal fields].

2. Total Coliform, 95th percentile value (to meet Arizona aquifer water quality standard; credits are provided for better treatment performance by algorithms in the rule, thus allowing a smaller interval of acceptable soil to provide final removal of potential pathogens in a zone of unsaturated flow).

3. Total Coliform, 99th percentile value for surface discharge (to meet Arizona reclaimed water quality standards and to meet treatment requirements for onsite system technologies designed for surface dispersal of treated wastewater in conjunction with "a fail-safe mechanism" to prevent inadequately treated wastewater from being discharged), and

4. Total Nitrogen, 5-month arithmetic mean (to ensure compliance with Arizona aquifer water quality standards).

The point at which performance-based standards apply is also an issue for discussion. Should standards apply at the septic tank outlet, at the bottom of the disposal feature, at the bottom of the active soil treatment zone, or in groundwater? The answer varies. Even though a wastewater discharge receives a final treatment in native soil, a performance requirement applied at the end of the installed treatment train may be the most effective. Constructed observation features, such as a sampling port at the end of the treatment train, is often available and can be linked to performance test data. However, an algorithm is necessary for determining soil treatment capabilities for the different characteristics of dispersed wastewater. Such an algorithm must be based on scientific research that is appropriate to the soil, climate, discharge characteristics and loading rates, wastewater parameters and needed statistical certainty. The algorithm should provide the basis for adjusting dispersal system design when improved treatment train performance is provided. Arizona's new onsite system rule includes algorithms to determine design credits when the treatment train improves discharged wastewater quality to better than septic tank effluent for $BOD_5$, TSS and Total Coliform. These algorithms, specified in Arizona Administrative Code R18-9-A312 (Arizona Secretary of State, 2001), allow designers to overcome site limitations by consistent methods based on improved treatment train performance. This approach forces consideration of treatment train performance to justify all dispersal system design credits.

Arizona's new rule also establishes default performance levels for each treatment train technology for the parameters described above. These are summarized in Table 1. Design requirements to achieve these levels for each technology are specified in rule at Arizona Administrative Code R18-9-E302 through R18-9-E322 (Arizona Secretary of State, 2001). A technology is assumed to meet its default performance level if the onsite system is designed, installed and operated in accordance with the rule. A compliance determination (without wastewater sample collection) can be made whenever the onsite facility is inspected for site conditions, required operational records and evidence of unapproved conditions. Numeric performance level adjustment for treatment equipment is authorized by rule for a specific product that performs better than its default level. Appropriate third-party performance data must be submitted to corroborate the claimed performance improvement.

Table 1. Default treatment train performance values specified in Arizona rules for onsite treatment technologies.

| Arizona General Permit Number | Onsite Technology | $BOD_5$ (mg/l) (Note 1) | TSS (mg/l) (Note 1) | $Log_{10}$ Total Coliform (cfu / 100 ml) (Note 2) | Total Nitrogen (mg/l) (Note 3) | Comments |
|---|---|---|---|---|---|---|
| 4.02 | Septic tank w/disposal by trench, bed, chamber, or seepage pit | 150 | 75 | 8 | 53 | Standard for comparison to other technologies. Based on the requirement for an effluent filter. |
| 4.03 | Composting toilet | 0 | 0 | 0 | 0 | No discharge of black water to native soil is allowed. |
| 4.04 | Pressure distribution system | N/A | N/A | N/A | N/A | Does not materially change wastewater quality. |
| 4.05 | Gravelless trench | 150 | 75 | 8 | 53 | |
| 4.06 | Natural seal evapotranspiration bed | N/A | N/A | Note 4 | Note 4 | TC and nitrogen performance value is dependent on specific design. |
| 4.07 | Lined evapotranspiration bed | N/A | N/A | 0 | 0 | No discharge of wastewater to native soil is allowed. |
| 4.08 | Wisconsin mound | 30 | 30 | 5.5 | 53 | |
| 4.09 | Engineered pad system | 50 | 50 | 6 | 53 | |
| 4.10 | Intermittent sand filter | | | | | |
| | a. With underdrain system | 10 | 10 | 3 | 40 | |
| | b. With bottomless filter design | 20 | 20 | 5 | 53 | |
| 4.11 | Peat filter | 15 | 15 | 5 | 53 | |
| 4.12 | Textile filter | 15 | 15 | 5 | 30 | Assumed performance for standard design. |
| | | 15 | 15 | 5 | 15 | With submittal of corroborating performance data. |
| 4.13 | RUCK® system | 30 | 30 | 6 | 30 | Assumed performance for standard design. |
| | | 30 | 30 | 6 | 15 | With submittal of corroborating performance data. |

Table 1, Continued

| | | | | | | |
|---|---|---|---|---|---|---|
| 4.14 | Sewage vault | 0 | 0 | 0 | 0 | No discharge of wastewater to native soil is allowed. |
| 4.15 | Aerobic system w/subsurface disposal | 30 | 30 | 5.5 | 53 | Assumed performance for standard design. |
| | | 30 | 30 | 5.5 | 15 | With submittal of corroborating performance data. |
| 4.16 | Aerobic system w/surface disposal | 30 | 30 | 0 | 53 | Requires disinfection by a system covered under General Permit 4.20. |
| 4.17 | Cap system | 150 | 75 | 8 | 53 | |
| 4.18 | Constructed wetland | 20 | 20 | 5 | 45 | |
| 4.19 | Sand lined trench | 20 | 20 | 5 | 53 | |
| 4.20 | Disinfection device | N/A | N/A | 0 | N/A | Required for surface disposal. Can be designed for reduced performance if full disinfection is not needed. |
| 4.21 | Sequencing batch reactor | 30 | 30 | 5.5 | 53 | Assumed performance for standard design. |
| | | 30 | 30 | 5.5 | 15 | With submittal of corroborating performance data. |
| 4.22 | Subsurface drip irrigation | N/A | N/A | N/A | N/A | High quality wastewater source is required. |

**Raw Wastewater** - Defined in AAC R18-9-101(30) as $BOD_5$ = 380 mg/l and TSS = 430 mg/l (Arizona Secretary of State, 2001)
**Default Performance Values** - Apply at the location where treated wastewater is applied to the native soil. A technology is presumed to comply if the design, installation and operation is per Title 18, Chapter 9, Article 3 (Arizona Secretary of State, 2001).
**N/A** - Not Applicable
**Note 1** - 30-day arithmetic mean.
**Note 2** - 95$^{th}$ percentile, except 99$^{th}$ percentile for General Permits 4.16 and 4.20.
**Note 3** - five-month arithmetic mean.
**Note 4** - See **Comments** column.

Performance-based technical standards for onsite wastewater facilities should allow for decisions that consider the efficacy of a range of possible solutions which address site conditions, design, installation and operation to ensure compliance with environmental and health protection criteria. A prescriptive code, on the other hand, is easier to apply but constrains both regulators and applicants to more narrowly defined choices. Administration of performance-based standards is more complex but excels over prescriptive standards in better matching treatment and dispersal decisions to site conditions. A system of performance-based standards also requires a higher level of knowledge and skills for both regulators and service providers (such as site evaluator, designer, contractor, operating specialist) (Otis and Anderson, 1994).

As Arizona's draft rule evolved, it became apparent that the performance-based approach is comprised of several components, linkages and algorithms that constitute a simple model; acknowledgment of these components drove further refinement of the rule. No doubt this is a topic for a chicken/egg discussion, but suffice to say that this model led to an improved understanding of the design process for overcoming site limitations by performance-based technical standards. Figure 1 illustrates the simple, three-component logical model that forms the basis of Arizona's performance-based approach.

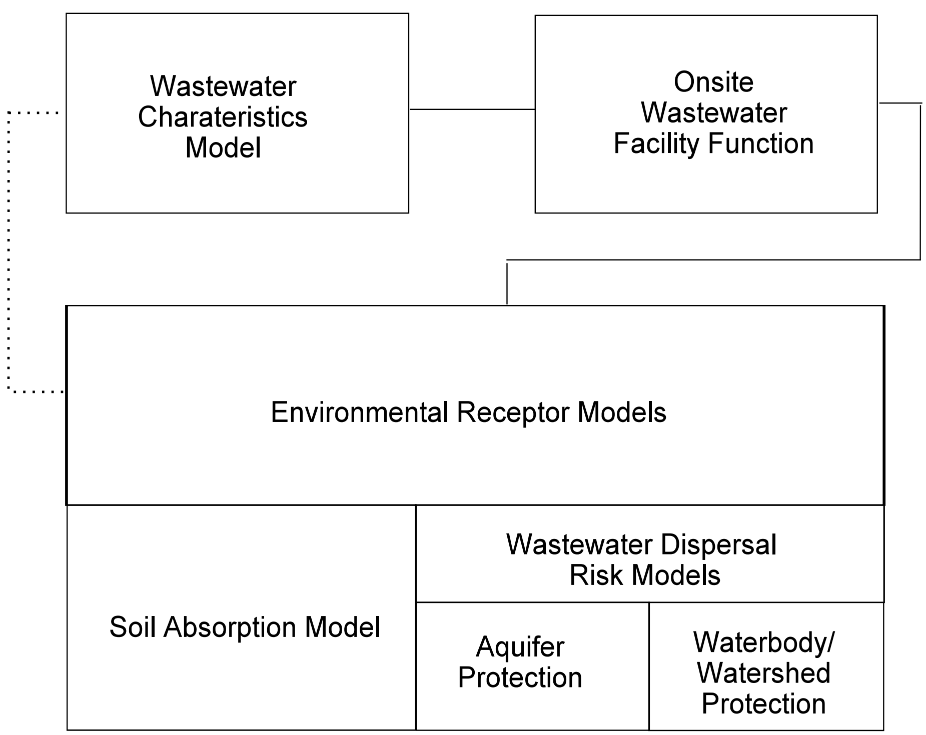


**Figure 1**. Model for Performance-based Regulation of Onsite Wastewater Facilities.

This logical model consists of three functional components - wastewater characterization, facility hydraulic and unit process functions, and environmental receptor models. All functional components are linked to the overall rule framework which includes site evaluation, system selection and facility design standards. Each functional component is defined by one or more algorithms and/or parameters, which specify internal relationships and links to the other components.

The environmental receptor model is the most complex of the functional components. This complexity is due, in part, to a multitude of regional and site-specific factors such as (a) physical, chemical and biological transformation processes, (b) climatic and soil conditions, ( c) consideration of acceptable risk and (d) consideration of social-economic-political-legal issues. This contrasts with approaches which rely on prescriptive regulations. Agencies relying on prescriptive onsite regulations are typically expert with soil absorption design, but may not be addressing environmental risk considerations (Otis and Anderson, 1994). Often onsite facilities and environmental regulation is the jurisdiction of multiple regulatory agencies, thereby separating soil onsite system permits from environmental regulation.

The logical model is most pertinent to the IA elements of the EPA draft management guidelines described earlier. The transition from prescriptive to performance-based regulation must be accompanied by improved data about wastewater treatment and dispersal performance by equipment, soils and management practices. Product testing should provide more comprehensive data about treatment train performance, including pollutant reductions for parameters relevant to raw wastewater characteristics, receiving water quality and environmental health. Data are needed about the efficacy of soil treatment for various soil conditions and physical, chemical and biological characteristics of the wastewater. Other research is needed on innovative methods of source minimization, wastewater treatment and system management. Expanded data collection and assessment efforts must be targeted to serve the needs of the public by addressing the health and environmental concerns of regulatory programs. Regulators need to agree on a more common framework for performance-based testing and regulation of onsite systems. Manufacturers need to help facilitate this effort. Data needs will become better defined when greater standardization (based on identified performance criteria) is achieved. New data can then be collected under enhanced protocols by more cost-effective methods. For example, the current NSF/ANSI Standard 40 protocol for influent and effluent data is useful, but it is short of what regulators and manufacturers need to assess acceptability within a framework of performance-based regulation. It may be appropriate to evaluate specific virus and other pathogenic agents in addition to indicator organisms. If the Federal Safe Drinking Water Act requires testing for new constituents for source water quality, then it should be considered for an enhanced protocol. An expanded testing and assessment protocol is under consideration by several states ( Bowers, 2001).

A key link between the model and the M/I elements of the EPA draft management guidelines described earlier is the need for collecting compliance data. Some have argued that operational data are needed for confirming onsite wastewater facility performance at each installation site. However, monitoring so many small onsite systems in a manner similar to larger wastewater facilities is not feasible due to cost, accessability and other factors. The new Arizona rule has yet to address regulatory surveillance activities, however, compliance evaluation by field observations (that exclude wastewater sample collection and laboratory analysis) is anticipated to be sufficient for initial program implementation. The new rule assigns responsibility to the system owner to follow the operation and maintenance provisions of the operating permit, including an operation and maintenance plan for other than conventional septic systems. If performance-based technical standards are to be an effective tool for onsite system regulation, success (defined as achieving planning and permitting objectives) hinges not only the scientific defensability of the IA element but also the effectiveness of the M/I component. The regulatory framework for onsite management functions is explored in depth in several publications(Otis and Anderson, 1994), (Jantrania, 1999), (EPA, 2000).

A proposal (Hoover et al., 1998) has been widely presented to categorize performance-based technical standards for onsite wastewater treatment systems into seven treatment categories with seven physical, chemical and biological parameters. These categories are envisioned as voluntary national criteria that should be considered to help replace existing, prescriptive onsite codes and to reduce the number of local standards to a more manageable few. This approach could greatly simplify the myriad of different codes across the country and eliminate the many different prescriptive standards that have no apparent documented scientific basis. However, it has been argued that these treatment categories do not satisfactorily address regional environmental/health standards and that the categorization proposal could retreat into simple technology labeling rather than encouraging incremental performance improvements with accompanying design credits.

The National Onsite Wastewater Recycling Association (NOWRA) has approved a proposal to develop a process for a model onsite system code (Corry, 2000). A committee is working on the tasks including a matrix for performance criteria built on risk-based effluent quality and operational quality assurance.

## SUMMARY

Performance-based technical standards for onsite wastewater system design should be considered as a way of facilitating the first five program elements of the EPA draft management guidelines relating to installation authorization. A simple, three-component model embodies the principal relationships pertaining to the performance-based technical standards that were adopted by the State of Arizona. A key link between model and the M/I component of the draft EPA management guidelines is the need for collecting appropriate data to confirm compliance with the performance-based technical standards and to validate the fundamental algorithms used.

Performance-based technical standards for design, installation and operation of onsite wastewater facilities may have advantages over prescriptive standards because they:

1. more completely address public health and environmental concerns in a more standardized manner based on environmental receptor models,

2. encourage targeted research to demonstrate performance,

3. standardize methods for specifying treatment technologies,

4. benefit from more comprehensive testing and assessment protocols for treatment and dispersal technologies using statistical testing techniques,

5. improve the level of knowledge and skills for regulators and service providers,

6. encourage the development and introduction of treatment and dispersal technologies based on scientifically determined performance, and

7. create a more standardized protocol for performing compliance surveillance of operating onsite systems.

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