WASHINGTON STATE DEPARTMENT OF HEALTH

Rule Development Committee Issue Research Report - Draft

Application of Treatment Standards 1 and 2

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Topic & Issues:

Application of Treatment Standard 1 & 2

- **Should we continue using treatment standards to manage on-site sewage systems?**
- **Is there a need to make adjustments to our existing standards?**
- **What are the important parameters and indicators of public health and environmental significance for us to consider?**
- **How do we match risk reduction strategies to the actual receiving environmental risk factors?**

Summary:

This report summarizes the literature on the topic of treatment standards for on-site sewage systems. Traditional regulations assume that a prescribed detailed system design will be adequate for those sites meeting certain minimum requirements for setbacks, distance to high water table, etc., and presume that public health will be protected if these specifications and on-site system design requirements are followed. While the prescriptive approach has generally worked well where site conditions are suitable, there are many sites in this state with less than suitable conditions.

In recent years there has been increasing discussion on the use of the performance-based regulations, which would provide more flexibility in the design and use of technologies as long as specific established treatment standards are met. Most treatment standards contain three basic elements: critical parameters of concern (e.g. FC, nitrate nitrogen NO_3-N, phosphorous), maximum allowable concentration or mass loading of the parameter(s), and the point at which the allowable concentration or loading must be met. Parameters for which treatment standards are commonly set for on-site sewage systems have included fecal coliform bacteria, total suspended solids, biochemical oxygen demand, nitrogen and phosphorus. Specific treatment standards should be defined by using risk-based analyses on a regional or site-specific level. To better match risk reduction strategies to the actual receiving environmental risk factors, multiple treatment standards should be developed. Depending on the type of specific public health risks or environmental impacts, different standards can be identified and applied to address specific resource sensitivity.

Even though it is difficult to accurately predict what level of treatment is required before the wastewater is released to the soil environment, the literature suggests treatment standards set at the point prior to the release into the soil is preferable than at some point in the receiving environment. The development of a treatment standard for nitrogen would help address the risks of pollutant delivery to sensitive water resource protection areas and would help encourage the further development of nitrogen reducing technologies.

KEYWORDS: Treatment standards, performance standards

Introduction:

Similar to most on-site sewage system regulations throughout the country, our state rules are typically based on prescriptive requirements for system location, design, and installation. Prescriptive codes identify the specific technologies that must be used under specified soil and site conditions (e.g. conventional gravity system with a three feet vertical separation distance between the trench bottom and restrictive layer). While the prescriptive approach of specifying detailed system designs for sites meeting minimum conditions generally has worked well where soils and site conditions are suitable, there are many sites in Washington State with less than suitable conditions (such as soil with high or very low permeability, high water tables or inadequate soil depth to a restrictive layer).

Many programs using prescriptive requirements are based on empirical and historical information that do not necessarily result in appropriate on-site system performance for the variety of conditions encountered in the field. Site-specific factors can also result in inadequate treatment of OSS effluent where a prescriptive approach is used. Local political pressure to approve specific types of systems for use on sites where prescriptive criteria are not met is another factor that leads to the installation of inadequate systems.

There has been a trend toward the use of performance-based codes to accomplish the same goals of public health and water quality protection as our traditional prescriptive requirements. Performance-based codes are regulations requiring that on-site systems meet specific measurable performance criteria in the form of effluent treatment standards, such as specific levels of fecal coliforms or nitrogen. The use of a performance-based approach specifies advance pretreatment requirements for sites where the prescriptive rules cannot be met. More advanced pretreatment is used at the more limited sites and in the more sensitive receiving environments.

Some members of the on-site sewage industry have expressed concerns regarding the implementation of a performance-based approach using treatment standards. In practice, it is often difficult to certify the performance of various treatment technologies under the wide range of climates, site conditions, hydraulic loads, and pollutant outputs they are subjected to in the field. Since the soil will provide significant additional treatment as the wastewater reaches the groundwater, it is also difficult to predict what level of treatment is required before the wastewater is released to a subsurface soil absorption system. The inherent difficultly of determining cumulative loadings and their impacts on a watershed, the technical difficulties of monitoring OSS to ensure system performance, the evaluation of new technologies and the potential costs, and staffing and expertise needed to implement a performance-based program can make this option more costly and difficult to implement.

The purpose of this review is to synthesize the literature available on the topic of treatment standards so that the Technical Review Committee can make appropriate recommendations about how standards regarding effluent treatment should be set and applied in Washington State. More than 40 publications, which include peer reviewed journal articles, conference proceedings, text books and government reports were collected and reviewed. Even through the majority of the publications are conference proceedings, which typically not peer reviewed, they provide useful information regarding the subject of treatment standards.

Body:

Washington State Treatment Standards (TS I & 2)

The concept of integrating performance standards with on-site sewage system management was first introduced in proposed system repair regulation during the state rule revision process in 1988. The rule revision committee at the time proposed a treatment standard of 10 mg/l BOD_5, 10 mg/l total suspended solids and 800 fecal coliform per 100 ml prior to subsurface disposal where a repaired system could not meet the required setback to wells or surface water (Woolrich, 1989). As the available horizontal separation or vertical separation decreased, the treatment standard stiffens to a 200 fecal coliforms per 100 ml limitation. The committee was cautious about including the standards in the repair regulations because of the difficulty of comparing a known and measurable performance standard with the immeasurable level of treatment provided by prescriptive system siting standards. Nevertheless, the committee decided a treatment standard was a logical choice when the effluent quality of an alternative system is known and there is virtually direct discharge of the effluent to surface water or ground water (Woolrich, 1989).

During the course of the rule revision process in 1989, the state legislature passed Engrossed Substitute House Bill 1369. The focus of this legislation was to assure that marine shoreline repair and expansion issues were specifically addressed in state on-site regulations. The legislature found that new technologies at the time had developed effective ways to treat the wastewater from these residences in order to protect against significant health hazards and water quality degradation that the existing state's on-site sewage rules did not allow. The bill provided a single treatment standard (10/10/200) to apply to all systems on sites adjacent to marine waters, required subsurface discharge and directed the State Board of Health to adopt regulations to address these sites and issues (Soltman, 1992).

In response to this legislation directive, the state Board of Health revised the on-site sewage rules in November of 1989 to facilitate the repairs of on-site sewage systems in marine shoreline areas. In doing so, it established Treatment Standards 1 and 2 for systems installed as repairs along marine shorelines (see Table 1). To address lot size and soil limitations often found at these sites, the treatment standards established the numerical parameter for on-site sewage system treatment performance needed to offset the restrictive site conditions. As sites with vertical and horizontal separation constraints exhibit diminishing capability to provide adequate sewage treatment in the soil with conventional systems, alternative systems capable of providing a known level of treatment prior to discharge to the soil for final treatment and disposal are used. The higher level of treatment (Treatment Standard 1) is required in cases where both the horizontal separation to marine water is less than 25 feet and vertical separation is less than two feet.

After completion of the on-site sewage rule revision in 1994, the state Board of Health adopted more comprehensive amendments, which included extended applicability of Treatment Standard 1 and 2 to non-shoreline repairs and to systems installed on new sites with inadequate vertical separation or sites with Type 1A soil (very gravelly coarse sands or coarser, or extremely gravelly soil) (see Table 2). The rule allowed reduced vertical separation to as little as one foot provided that wastewater is treated to Treatment Standards 2 prior to discharge to the soil. The use of systems capable of achieving Treatment Standard 2 is also required for all new installations in Type 1A soils regardless of soil depth.

TABLE 1. Treatment Standards 1 and 2

(From WSDOH. List of Approved Systems and Products. November 2001)

Standard	Treated effluent from Alternative On-site Sewage Systems Must meet (or exceed) these performance standards:		
	BOD_5 (5-day Biochemical Oxygen Demand) Maximum 30-day average (mg BOD / liter Effluent)	**TSS** (Total Suspended Solids) Maximum 30-day average (mg TSS / liter Effluent)	**Fecal Coliform** Maximum 30-day geometric mean, (Colonies/100 ml Effluent)
Treatment Standard 1:	**< 10 mg ***	**< 10 mg**	**< 200**
Treatment Standard 2:	**< 10 mg ***	**< 10 mg**	**< 800**

***** A 30 day average of less than 8.3 mg /L of carbonaceous biochemical oxygen demand (5-day $CBOD_5$) will be accepted in lieu of the BOD_5 value when data are submitted in the course of NSF Standard No. 40 testing and reporting protocols.

Table 2. Application of Treatment Standards 1 & 2

(From WSDOH. List of Approved Systems and Products. November 2001)

Permit Event	System Must Meet Treatment Standard	Applies When & Where:
Repair or Replacement	1 or 2	Horizontal separation to a water supply or surface water cannot meet the standards for new construction.[1]
New Construction or Expansion	2	• Vertical separation is less than 2 feet in Soil Types 1B, 2A &B, and 3-6.[2] • Development where Soil Type 1A exists. [3]

[1] Table VI in the SBOH rules, Chapter 246-272 WAC

[2] Table IV in the SBOH rules, Chapter 246-272 WAC

[3] Table IV in the SBOH rules and Table VII in the SBOH rules, Chapter 246-272 WAC

When selecting a treatment system, or issuing a permit, for a site requiring either treatment standard to be met, the on-site sewage system rules limit the local health officer to alternative systems for which there are alternative system guidelines and to proprietary products on the department's List of Approved Systems and Product (WAC 246-272-04001). The Department of Health develops and annually updates the Approved List, which enumerates all proprietary alternative and experimental systems approved for use in Washington State and identified systems recognized by the Department as meeting Treatment Standard 1 and 2. Systems and products meeting the treatment standards may be used at these conditional sites without further evaluation of the treatment system's performance. Appropriate design, installation and inspection, followed by proper operation by the system's owner and routine monitoring and maintenance by qualified service providers support presumption of satisfactory system performance. However, discretion concerning whether to allow installation of any specific state approved alternative or proprietary system or device is left with local health jurisdictions.

Trend Toward Performance Based Standards

On-site sewage system performance standards were first discussed in the literature by Reed (1977), who identified the shortcomings of relying on detailed compliance standards in the rapidly evolving field of on-site wastewater treatment. He recommended use of the performance standards framework, which speaks to desired outcomes as an alternative to detailed specifications of how things should be done. Reed pointed out that until the year 1974, the only statewide on-site sewage regulation in Washington state was a simple performance standard proclaiming that " No privy, urinal, cesspool, septic tank, or other receptacle for human excrement shall be constructed, maintained, or used which directly or indirectly drains or discharges over or upon the surface of the ground, or into any waters of the state either directly or indirectly; unless the content of such urinal, cesspool, septic tank, or receptacle for human excrement are subjected to some recognized sterilization treatment approved by the State Department of Health."

In more recent years, there has been increasing criticism of prescriptive on-site wastewater codes, which require certain specific site conditions, design, and technologies for installation of a system, and discussion of a possible shift to performance-based codes, which would provide flexibility in design and use of technologies as long as specific treatment standards were met. These standards would vary with the sensitivity of nearby surface or groundwater or resources and other factors.

The necessity of implementing performance standards as opposed to prescriptive standards for wastewater treatment was discussed in detail by Otis and Anderson (1994). They pointed out that prescriptive standards, which specify site requirements and codified technical specifications for system design, were principally developed for on-site systems using septic tanks followed by drainfields; the main emphasis historically was on disposal rather than treatment. System performance cannot adequately be assessed on a routine basis since the prescriptive code provide no effluent standard for the treatment systems and thus, periodic compliance monitoring is not required. Performance standards, on the other hand, specify measurable performance requirements in the form of treatment efficiencies or effluent standards that can be monitored on a routine basis to assess system performance and ensure regulatory compliance. They do not require that site characteristics or treatment methods be specified. The authors also recognized that this new approach would have a significant effect on regulating programs which would have to place “greater responsibilities on the regulating agencies, site evaluator and design professional, construction contractor, system operator and system owner”.

Smithson (1995) provided a regulator’s viewpoint on the performance-based framework and expressed concerns about the practical reality and user friendliness of performance based standards. The presumption is that giving increased responsibility to all parties will ensure that “interested, motivated, confident, well informed, well equipped and open minded regulators, designers, installers, service providers and home owners “advance” in a cooperative march to a shared objective. However, the actual responsibility will still fall on the regulator who could be “left standing alone without the protection and support of the prescriptive provisions most codes afford”. He argued that prescriptive codes, with their specified standards, provide a shelter for regulators who, in acting for a smaller local authority, lack the support or education, training and experience, and often are the lone officer involved in approvals along with a wide range of other environmental health duties. Smithson concluded that performance codes only can be acceptable if backed up by improved and standardized prescriptive requirements, which guarantee implicit performance standards by prescribing certain prerequisites for installation and use of an on-site system.

Another regulatory perspective on the use of performance standards for on-site wastewater treatment systems was presented by Crosby et al. (1998). The authors indicate that the current practice of prescriptive standards has been described as primitive and arbitrary, but they point out an equal number of difficulties with performance approaches if not addressed will lead to equal or greater failure of performance approaches than has been seen in prescriptive approaches. They suggest that the prescriptive-based approach has been recognized to work well where site and soil conditions are suitable, whereas the performance-based approach is more suited for difficult site conditions. The authors conclude that prescriptive standards will remain a useful and inexpensive management tool.

Sherman (1995) believes that performance based standards will not replace their prescriptive counterparts, but rather augment them in difficult or unusual sites. Because of the resource burden of implementing a total performance-based program, some regulatory agencies are using a performance based approached while retaining prescriptive requirements for technologies that have been proven effective under a wide range of site conditions. For example, jurisdictions might elect to use prescriptive standards in areas where it has been determined that on-site systems are not a significant contributing source of pollutants or in areas where on-site systems are not likely to cause water quality problems. Prescriptive designs might also be appropriate and practical for sites where previous experience with specified system designs has resulted in the demonstration of adequate performance (Ayres Associates, 1993).

If prescriptive designs are allowed under a performance-based program, Otis and Anderson (1994) advises these systems should be proven capable of meeting the same performance requirements as a system specifically designed for the site. Under this approach, the management entity should determine through experience (monitoring and evaluation of the prescribed systems on sites with similar site chacteristics) that the system will perform adequately to meet state performance requirements given sufficiently frequent operating inspections and maintenance. Combining prescriptive designs with performance-based programs would still require the prescriptive design for a prescribed site to have a “definite performance” which is acceptable to the regulating agency. Designers may then have the option to “engineer” a system or use a prescriptive design determined by the site and soil condition (Otis and Anderson, 1994).

Points of Treatment Standards Application

Depending upon an agency's regulatory jurisdiction, there can be different points where treatment standards might be applied. They can be applied to the effluent port of a single treatment component, the end of the treatment train (a series of treatment units connected together) or the receiving environment, which receives treated wastewater from an on-site system. When applied to a treatment train or to an individual on-site system component, the standards are a measure of the pretreatment provided by that treatment unit or series of system components prior to final treatment and dispersal in the SSAS and underlying soil. When applied to a receiving environment they are a measure of the level of treatment provided at a critical location in the receiving environment (such as at the groundwater table directly beneath the system, at the groundwater review boundary, compliance boundary or at the property lines).

EPA recommended that performance standards should be set for wastewater effluent after it has passed through the SSAS at the point of entry into groundwater or surface waters. Specific water quality standards would be imposed based on a determination of likely use of these waters, density of development, time of travel through soils, and other factors (EPA, 1999). This approach can be characterized as a fairly pure example of the concepts that standards should be based on outcomes rather than best available technology and standards are set close to the end user.

Corry (2000) pointed out that the receiving environment is not an effective point of standards measure for most on-site systems for several reasons; namely, monitoring groundwater is expensive and often ineffective because locating the plume is difficult, and travel times from the system to the point of monitoring can be long. This creates a zone where the characteristics of the effluent stream can be modified by further treatment, dilution or the addition of pollutants from other sources. He suggested two stages for applying treatment standards before pretreated wastewater is released to the environment and the outputs be measured at the end of each state. The first stage and point of measure is between the input of the first treatment device and the outfall of the last treatment device prior to introduction to soil (from a septic tank, sand filter, ATU – prior to the drainfield) measured at the outfall. The second stage is between the outfall of stage one and the end of the design treatment zone, measured at some point after introduction of the wastewater to the soil. Stage one assumes domestic strength waste; therefore, it would be necessary to pretreat wastewater from a restaurant prior to introduction to a system classified as a "domestic" treatment system.

From a practical point of view, Hoover et al. (1998) suggested it might be easier to apply treatment standards to a specific treatment unit or treatment train rather than to the soil or ground water system. This is a pertinent viewpoint, particularly if the treatment performance of operating system will be regular assessed by routine collection of sample and laboratory analyses. Hoover points out most pretreatment units can be easily modified to facilitate a sampling port that will accommodate regular sampling. On the other hand, sampling and data interpretation is much more complex when sampling the vadose zone in the soil above the water table or when sampling the ground water systems itself. Effective sampling networks within the vadose zone and/or the ground water system usually require multiple sampling points.

Nelson (2000) indicated that variable standards set at the intersection with groundwater or surface fail to meet other criteria described in the literature: specifically, they are not uniform or clear; and they are not easily measurable or enforceable. Once the soils are considered part of the treatment train, then required performance of pretreatment units would be expected to vary substantially. And, more significantly, measurement of water quality after soils treatment is highly problematic. From a monitoring perspective, it can be quite expensive to find where the wastewater plume is actually entering the groundwater and to monitor that plume periodically and groundwater levels rise and fall with rainfall and the seasons.

Other members of the on-site industry believed that on-site performance standards should be set after treatment in the soils and that these standards should vary with density of development, use of ground or surface water and other risk-related factors. This is the same approach as the "design Management Zone" concept recommended by NOWRA (1996). States, such as Minnesota and Wisconsin, have adopted this approach when developing performance-based state rules and standards (Docken and Burkes,1994; Wespetal et al. 2001).

However, Nelson (2001) pointed out that from a market development perspective, the best approach is a simplified set of treatment standards prior to release into the soils, coupled with prescriptive requirements for where these standards should be mandates and for the design of the SSAS. The process of designing standards will have additional impacts on the evolution of the market and on technology development in the decentralized wastewater field. If standards are designed properly, it may be possible to jump-start expanded use of advanced treatment technologies and management, to elevate the performance and lower the cost of such systems. The author developed a table summarizing a number of states and communities already beginning to implement such an approach (Table 3).

Table 3. Effluent Treatment Standards Prior to Discharge to Soil (Adapted after Nelson, 2000)

	BOD Mg/l	TSS mg/l	Total N mg/l	No_3 mg/l	TP mg/l	Fecals MPN/100ml	FOG Mg/l
Washington State							
TS 1	<10	<10				<200	
TS 2	<10	<10				<800	
Florida							
Secondary treatment	≤20	≤20				≤200	
Advanced secondary treatment	≤10	≤10	≤20		≤10	≤200	
AWT	≤5	≤5	≤3		≤1	≤25	
La Pine, Oregon	≤10	≤10	≤10			≤100	
Block Island, Rhode Island							
T2N	≤30	≤30	≤19				
T2C	≤10	≤10				≤1000	
Albuquerque/Bernalillo County, NM							
Conventional System (Class 1)	≤150	≤60				$\leq 10^6$	
Secondary Systems (Class 2)	≤30	≤30				$\leq 10^4$	
Tertiary Systems (Class 3)	≤30	≤30				$\leq 10^3$	
Disinfection						≤200	
Canada	15	15				50,000	
Northeast Minnesota (study targets)	25	30		10		<200	
North Carolina							
Conventional Loading Rate Systems	200	75	75				30
High Loading Rate Systems	30	30	30			10,000	10

National Numerical Treatment Standards

Nelson (2001) suggests that a single set of strict mandatory national effluent standards is unlikely, largely because Congress is unlikely to approve national standards against the resistance of state governments, who would fiercely oppose such a costly new federal set of regulations, and against the inevitable backlash of millions of homeowners. Nevertheless, industry, researchers, and regulators can collaborate in developing recommendations on basic approaches toward treatment standards, which then could be adopted by states and counties to their particular climate, soils, and other conditions. Hoover (1997) and Jantrania (1999) have both outlined how such as approach could be developed and a number of states and counties have already implemented treatment standards for difficult lots.

A series of voluntary national standards for on-site systems was first introduced by Hoover et al. (1998). Specifically, seven treatment performance standards (primary treatment, secondary treatment, tertiary treatment, nutrient reduction, disinfection, wastewater reuse, and nears drinking water) are suggested to either augment or replace existing prescriptive on-site codes. Regulatory agencies can determined which of the seven standards are most appropriate for different soil conditions (e.g. vertical separation to water table, etc.) or specific watersheds within their jurisdiction. These decisions will depend upon public health concerns and/or environmental conditions in their watershed. The most advanced pretreatment was recommended at the most limited sites and in the most sensitive receiving environments. Table 4 summarizes the standards, measurement parameters, and quantifiable limits for them.

Table 4. Proposed On-site System Treatment Standards in Various Control Zones

(From Hoover, 1998)

Standard	BOD_5 (mg/l)	TSS (mg/l)	PO_4-P (mg/L)	NH_4-N (mg/L)	NO_3-N (mg/L)	Total N (% removed) [a]	Fecal coliform (CFU/100 ml)
TS1- primary treatment							
TS1u – unfiltered	300	300	15	80	NA	NA	10,000,000
TS1f- filtered	200	80	15	80	NA	NA	10,000,000
TS2-secondary treatment	30	30	15	10	NA	NA	50,000
TS3 – tertiary treatment	10	10	15	10	NA	NA	10,000
TS4 – nutrient reduction							
TS4n nitrogen reduction	10	10	15	5	NA	50%	10,000
TS4p phosphorus reduction	10	10	2	10	NA	25%	10,000
TS4np- N & P reduction	10	10	2	5	NA	50%	10,000
TS5 – bodily contact disinfection	10	10	15	10	NA	25%	200
TS6- wastewater reuse	5	5	15	5	NA	50%	14
TS7- near drinking water	5	5	1	5	10	75%	<1[b]

a. Minimum % reduction of total nitrogen (as nitrate-nitrogen plus ammonium-nitrogen) concentration in the raw treated wastewater
b. Total coliform colony densities <50/100 ml

Hoover (1998) presents these treatment standards under the assumption that they will be applied as a measure of the level of pretreatment that occurs prior to the wastewater being applied to the soil. For example, treatment standard number one (TS1) in Table 4 is the minimal treatment level expected within the septic tank itself, and thus, represents septic tank effluent. This standard defines the minimum level of pretreatment that must be obtained prior to treatment in the soil. The soil will provide additional treatment beyond this primary level. However, the amount of soil treatment that occurs will depend upon the soil conditions at a given site.

How these multiple treatment performance standards based on risk could be used was illustrated by Hoover et al. (1998). The authors explained the reasons for multiple standards as opposed to a single treatment standard are as follows. "There are multiple local health and natural environments that have varied tolerance for wastewater effluent constituents. For example, scattered agricultural homesteads dense subdivisions and lakeside cottages pose different health and environmental risks. Because solutions to reduce risk are expensive for homeowners it is important to match risk reduction strategies to the actual localized factors. One size fits all regulation of a single performance standard either results in needless cost to homeowner or increased risk to the human or natural environment."

NOWRA is currently underway in developing a model performance code for the on-site industry that is based on performance rather than prescriptive regulations (Corry, 2000). The code is proposing a performance matrix that relates effluent quality to water quality or treatment standards and quality assurances. The quality assurance standards are a set of management requirements to attain the effluent quality with the technologies chosen in a particular design. The series of treatment standards would recognize that the health and environmental risks of specific treatment designs vary with site conditions and proposed uses of the treated wastewater. Consequently, successively more stringent wastewater constituent treatment standards and related quality assurance measurements will be arrayed in matrices, with treatment standards on the vertical axis, or variance control, standards on the horizontal axis. Treatment system designs and components will then be able to evaluated against the matrix.

Kreissl et al. (2002) raised questions regarding whether a model code, such as NOWRA's, being developed on the basis of incomplete and conflicting existing data would be universally accepted by regulatory agencies. The adoption of such a code requires significant changes in any regulatory program taking years to accomplish and cannot be implemented unless management of more advanced technologies can be assured. The authors suggested that such national standards always would be incomplete by definition because it will fail to account for all local site conditions and may stifle the adoption of new ideas.

Wastewater Parameters of Concern

Domestic wastewater contains microbial and chemical constituents that poses significant risk to public health and the environment if not treated effectively before being released to the receiving environment. Some of the traditional parameters for which treatment performance standards are commonly set for on-site wastewater treatment systems include suspended solids, biochemical oxygen demand, fecal coliform, while other parameters used to a lesser extent include nitrogen, phosphorus, and oil and grease.

BOD

BOD, biochemical oxygen demand, is an analytical measure of how much oxygen is consumed in biological processes that degrade organic mater in wastewater. BOD is widely used as an indicator of treatment efficiency, while it has only indirect significance to human and environmental toxicity. BOD can be used to determine the amount of organic pollution in surface water and also is used to determine the strength of wastewater by measuring how much dissolved oxygen is used by microorganisms during biochemical oxidation of any organic matter present in wastewater. High wastewater strength (high BOD values) could aggravate the condition of soil with poor aeration by further depleting available oxygen and produce reducing conditions in the soil.

Sewage sources can contribute organics that can lead to high levels of dissolved oxygen in the water body. Low dissolved oxygen is one of the leading causes of water quality impairment for rivers, lakes, and estuaries. High BOD effluent discharging to surface water can result in the depletion of dissolved oxygen in the aquatic environment, which can lead to a die-off of aquatic organisms and anaerobic conditions. The BOD of raw sewage is about 300 mg/L (Bitton, 1999) and drops to 10-30 mg/L in treated wastewater (Asano, 1998).

TSS

TSS, total suspended solids, is a measure of the amount of suspended solids found in wastewater effluent. Large quantities of suspended solids in wastewater can affect wastewater treatment process in several ways. Suspended solids can interfere with the flow of water in transport pipes, distribution components, and soil pores. Plugging of the orifices by these sediments reduces distribution efficiency. Plugging of the soil pores with particulate solids accelerates soil clogging. Suspended solids in groundwater and surface water can cause anoxic conditions. The average concentration of TSS in untreated wastewater in the U.S. is 210 mg/L (Crites and Tchobanoglous, 1998) and it ranges from <1 to 30 mg/L in treated wastewater (Asano, 1998).

Fecal Coliform

Fecal coliform bacteria specifically originate from the intestinal tract of warm-blooded animals. These organisms are used as an indicator of the presence of pathogenic microbes or level of disinfection because they occur naturally in the feces of warm-blooded animals in higher concentrations than pathogens and are easily detectable. They exhibit a positive correlation with bacterial pathogens and respond similarly to environmental conditions and treatment processes. Fecal coliform determinations by themselves do not as precisely predict the presence or concentration of pathogenic viruses or protozoa as they do bacteria. However, because of the general reliance on fecal coliform as the universal pathogen indictor, system performance criteria have not been set for viruses or protozoa. A number of sources report the level of fecal coliform in septic tank effluent at 10^6-10^8 MPN/100 ml (Siegrist, 2001).

Nitrogen

Nitrogen is an aquatic plant nutrient that can contribute to eutrophication and dissolved oxygen loss is surface waters especially in nitrogen-limited lakes, estuaries, and coastal embayments. Algae and aquatic weeds can contribute trihalomethane (THM) precursors to the water column that might generate carcinogenic THMs in chlorinated drinking water. Excessive nitrate-nitrogen in drinking water can cause methemoglobinemia in infants and pregnancy complications.

Phosphorus

Phosphorus is essential to the growth of algae and other biological organisms and is most often the limiting freshwater nutrient for algae and aquatic weeds. Lake studies have shown that when total phosphorus concentrations exceed 0.03 mg/L lakes tend to be highly productive or eutrophic (Schindler, 1977). Excessive algal growth lowers water quality, and its eventual decay at the lake bottom can release stored phosphorus, perpetuating a cycle of recurring algae blooms.

Oil and Grease

If present in excessive amount, oil and grease will interfere with aerobic biological process and lead to decreased wastewater treatment efficiency. Grease, which is insoluble in and less dense than water, may harden in tanks and can accumulate and completely clog soil pores.

Determining Effluent Allowance Concentration

Treatment standards are the minimum numerical values, based on performance criteria that can be used to define the acceptable public health risks and environmental impacts of on-site sewage systems in order to meet performance goals. The standards may be based on the type of water body that is ultimately receiving the treated wastewater effluent (groundwater or surface water) and the present or projected uses of the water body (e.g. for drinking water, shell fishing, recreation). For example, a treatment standard for fecal coliform might be established in a shellfish growing area where bacterial pollution is a problem.

Treatment standards have been advocated (e.g. Otis and Anderson, 1994; Hoover et al., 1998a), but there appears to be no agreement as to the performance criteria, pollutants of concern, the performance to be achieved within a prescribed space-time domain, or the methods to be used to measure and assess compliance. Many factors need to be considered such as system type, size, and the sensitivity of the primary receiving environments. There appears to be general agreement that the standards should be clear and quantifiable to allow credible verification of system performance through compliance monitoring. From a realistic point of view, the standards that are selected also should be simple and direct using cost-effective, long-standing standard analyses that are routinely analyzed at most wastewater laboratories.

Crosby et al. (1998) advises performance standards that are unrealistic may cause alternative technologies to fail to meet high expectations. Specific standards should recognize the dynamics of the system performance, including the use of annual averages (or the mean of monthly means) instead of strict numerical limits. They also suggest performance-based standards be tied to specific environmental concerns of an area. For example, if a nitrogen sensitive saltwater environment or a drinking water well is located near a treatment system, a nitrogen standard may be appropriate for the treatment system.

Although the concepts of risk assessment and risk management have not generally been applied to on-site technologies, recent explicit risk-based decision-making has been advocated (Otis and Anderson, 1994; Hoover et al. 1998 a,b; Loomis et al., 1999). Risks associated with potential threats to public health and environmental quality must be maintained within acceptable limits over the range of permitted applications. As the risk of systems not meeting their performance requirements increases (e.g. increasing environmental sensitivity, treatment system complexity, daily wastewater flows, or wastewater strength), management control must increase proportionately to ensure the risk to public health and the environmental quality remain with in acceptable limits (Eliasson et al., 2001). Treatment performance requirements must be appropriate to protect public health and sustain environmental quality. Performance requirements may vary with environmental sensitivity, population density, and treatment technologies used.

In a document for the Massachusetts-based ad hoc Task Force for Decentralized Wastewater Management, Hoover (1997) provides a risk-management framework, which could be adopted by any community anywhere in the country. This document includes a logical process for qualitatively assessing the risks from on-site systems on a watershed basis and then goes on to provide a detailed management scheme for controlling risks. The crux of the risk management approach is a groundwater and surface water protection matrix that classifies each subwatershed area into five control zones (called R5, R4, R4, R3, R2, or R1). For each control zone (R5 through R1) the document identifies appropriate treatment performance standards that must be achieved by the on-site system and specifies when and where these systems can be used. These zones reflect the sensitivity and importance of drinking water sources, estuaries, and other natural resources, and treatment standards vary for nitrogen or phosphorous removal, disinfection, etc.

Hoover (1997) illustrates how such treatment standards can be targeted to specific watershed areas to manage the potential risks from on-site systems in a community. One potential application of these standards could be to specify additional wastewater treatment in areas that need additional ground water and /or surface water protection. Another potential application could be to augment the existing prescriptive code criteria to allow reduced vertical separation distances to the water table, bedrock and unsuitable soil horizons using pretreatment to provide public health and environmental protection. Research by Duncan et al. (1994) and Converse and Tyler (1998) supports this approach of substituting soil depth with pretreatment.

While Hoover et al. (1998) have developed risk-based approaches for managing on-site systems, their approach is qualitative. Formal risk-based models that are quantitative have rarely been applied to the on-site sewage systems. Although there are currently some proposals to apply these quantitative models to on-site systems, it will take some time before this effort becomes fully developed for application (Siegrist, 2001).

Cost-benefit Information:

When treatment performance standards are defined and imposed, the least costly option to meet that standard can be chosen. For sites that are more vulnerable to risks to public health and the environment, then the technology options to manage those risks will change, likely increasing the cost and need for management oversight. Cost of site evaluation and design would be substantially higher than for a prescriptive code. A standard for the pretreated effluent could be overly conservative, unnecessarily increasing the cost of the on-site sewage system.

In contrast, prescriptive type approaches could be overly conservative in an attempt to address the worst-case scenario in rules, thereby increasing cost of an on-site system unnecessarily. On the other hand, prescriptive approaches can limit options and flexibility for alternative systems design thereby resulting in increase potential for inadequate performance of permitted systems on poorly suited sites or denials of appropriate alternative technologies.

Conclusions:

A comprehensive review of the literature to address identified key issues on the subject of treatment standards for on-site sewage systems was conducted. The following conclusions can be drawn from the information available in the literature:

1. A performance-based approach that specifies advanced pretreatment requirements (treatment standards) can replace or augment existing prescriptive codes and facilitate progressive siting and design strategies.

2. Most treatment standards contain three basic elements: critical parameters of concern (e.g. FC, nitrate nitrogen NO_3-N, phosphorous), maximum allowable concentration or mass loading of the parameter(s), and the point at which the allowable concentration or loading must be met.

3. Parameters for which treatment standards are commonly set for on-site sewage systems have included fecal coliform bacteria, total suspended solids, biochemical oxygen demand, nitrogen and phosphorus.

4. The literature suggests the best approach to set treatment standards is at the point prior to release into the soil. From a market development perspective, standards set at the point of release into the SSAS are far preferable than at some point in the receiving environment.

5. The treatment standards should take into account the treatment due to physical (filtration), biological, and chemical processes in the soil. Research has shown that pretreatment can be substituted for soil depth to obtain similar levels of wastewater treatment. However, it is difficult to accurately predict what level of treatment is required before the wastewater is released to the soil environment.

6. Systems designed to meet specific treatment standards using a risk-based analyses on a regional or site-specific level are needed. To better match risk reduction strategies to the actual receiving environmental risk factors, multiple treatment standards should be developed. Depending on the type of specific public health risks or environmental impacts, different standards can be identified to address specific environmental sensitivity.

7. Developing a treatment standard for Total Nitrogen would be beneficial in addressing the risks of pollutant delivery to sensitive water resource protection areas in the state and would help encourage the further development of nitrogen reducing technologies.

8. Formal quantitative risk-based models have rarely been applied to the on-site wastewater field. Although there are currently some proposals to apply these quantitative models to on-site systems, it will take some time before this effort becomes fully developed for use.

- **Should we continue using treatment standards to manage on-site sewage systems?** Yes.
    - **If yes, should we continue to set the treatment standards at the point prior to release into the soil?** Yes.
    - **If yes, should we set standards at some point in the receiving environment?** No.
- **Is there a need to make adjustments to our existing standards?** Yes.
- **If yes, what adjustments should be made?**
    - **Additional parameters?** Yes.
    - **Additional levels?** Yes.
    - **Different maximum allowable concentrations?** Yes.
    - **Add mass loading of the parameter(s)???**

- **What are the important parameters and indicators of public health and environmental significance for us to consider?** Fecal coliform bacteria, total suspended solids, biochemical oxygen demand, nitrogen and phosphorus.
- **How do we match risk reduction strategies to the actual receiving environmental risk factors?** Develop site vulnerability and treatment standard matrixes, which identify the level of wastewater treatment needed to protect ground water and surface water quality and match site vulnerability and relative risks to the required treatment standards. This question should be further addressed under the topic area of Table IV issues.

References:

Asano, T. (1998). Wastewater Reclamation, Recycling, and Reuse: Water Quality Management Library Volume 10, Takashi Asano, (ed), Technomic Publishing, Lancaster, Pennsylvania, pp. 40.

Ayres Associates. 1993. Onsite Sewage Disposal System Research in Florida, An Evaluation of Current Practices in Florida. Rep. to the Dept. of Health and Rehab. Services, Tallahassee, FL. p. 5-1 through 5-3.

This manual covers a wide array of topics on on-site wastewater systems including: design, management, failure modes and wastewater characteristics. The scope of this manual, similar to the EPA Onsite Wastewater Treatment & Disposal System Manual, is limited to what is applicable in the state of Florida. Sludge disposal, however, is not covered. Many tables include hard to find data on special wastewater characteristics, concentrations of metals in septic tanks, and septic tank effluent monitoring.

Bitton, G. 1999. Wastewater Microbiology. 2nd Edition. Wiley-Liss, NY, pp 592.

Bruuresema, Tom. 1998. Onsite Product Performance Standards: A Time of Change. In: NOWRA 1998 Conference Proceedings of Onsite Treatment: First Choice For Protecting the Environment, Ft. Mitchell. KY. p. 12-14.

Focus on new initiatives underway and recent completed revisions to the NSF standards for onsite wastewater treatment technologies, with discussion of an accreditation program for individuals providing home inspections of onsite well and septic systems.

Converse, J.C. and E.J. Tyler. 1998. Soil Treatment of Aerobically Treated Domestic Wastewater with Emphasis on Modified Mounds. In On-Site Wastewater Treatment: Proceedings of the Eighth National Symposium On Individual and Small Community Sewage Systems. ASAE, St. Joseph, MI. p. 306-319.

Wastewater treatment by soil beneath 35 modified mounds and 4 at-grade soil absorption units receiving aerobically treated wastewater was determined. The soil texture ranged from sand to clay loam and estimated seasonal saturation was just below ground surface in many cases. Thirty-six of the dispersal units received wastewater from aerobic units and two from single pass sand filters. Effluent was distributed via pressure distribution to all systems. On approximately 50% of the soil absorption units, effluent was delivered to only half of the unit which increased the effluent loading to the other half of the unit. To evaluate the treatment effectiveness, soil cores were taken from beneath and adjacent to the system at 15 cm (6 in.) increments to a depth of 105 cm (42 in.). Fecal coliforms, nitrogen compounds and chlorides were evaluated. Median (50% above and 50% below) fecal coliform in the aerated wastewater was 10^3 counts/100mL. Wastewater fecal coliform counts ranges from <1 (not detectable) to >10^5 counts/100 mL. Median fecal coliform counts were below detection limits at 30 cm (1 ft) beneath the infiltrative surface. At 105 cm (42 in.) below the infiltrative surface <10% of the samples contained fecal coliform >1 MPN/g dry soil. When wastewater with <10^3 counts/100 mL was added, median soil fecal coliform counts were <1 MPN/g dry soil within 15 cm (6 in.) of the infiltrative surface and at 60 cm (2 ft) below the infiltrative surface

<10% of the samples contained fecal coliform > 1 MPN/g dry soil. Separation from the wastewater infiltrative surface might be based on the odds of meeting a treatment goal for the soil. For example, based on median values fro all samples collected being below detection limits, it may be reasonable to set the separation distance at 30 com (1 ft). Based on only 10% of the values exceeding the detection limits, a separation limit of 60 cm (2 ft) may be selected. Similar separation distance could be assigned based of the ability of the treatment unit reducing fecal coliforms. Median total nitrogen concentration of the aerobically treated wastewater was 32 N/L. Median soil nitrated concentrations was 26 N/L at 105 cm (42 in.) and similar to amounts found beneath mounds and at-grade systems receiving septic tank effluent.

Corry, Mike. 2000. NOWRA Onsite Performance Model Code Proposed Development Process. In NOWRA 2000 Conference Proceedings of Onsite: The Future of Water Quality, Grand Rapids, MI. National Onsite Wastewater Recycling Association, Laurel, MD. p 193-203.

Corry, Michael. 2001. NOWRA Model Performance Code Committee Report To NOWRA Membership. National Onsite Wastewater Recycling Association, Laurel, MD. pp. 17.

Crites, R, and Tchobanoglous, G. 1998, Small and Decentralized Wastewater Management Systems. McGraw-Hill Series in Water Resources and Environmental Engineering, pp.1084.

Crosby, Jeff, McCarthy, B., Craig, Gilbertson, and Richard Axler. 1998. A Regulatory Perspective on Impediments and Solutions to the Use of Performance Standards for Onsite Wastewater treatment. In On-Site Wastewater Treatment: Proceedings of the Eighth International Symposium On Individual and Small Community Sewage Systems. ASAE. St. Joseph, MI. p. 259-267.

The current interest in using performance standards to define wastewater treatment is necessary but problematic. An example presented on how to overcome problems is of interest to regulators, design engineers, and researchers. Regulatory perspectives on performance-based standards are critical to the success or failure of difficult projects using alterative technologies. Introducing experimental/alternative technologies and new innovations are a challenge to public perceptions of right and wrong. Reaction may result in an unrealistic expectation of solving all problems or in establishing unrealistic standards (i.e., drinking water). Standards which are unrealistic may cause alternative technologies to fail (high expectations). Solutions utilized recently in northern Minnesota have the potential to solve problems. These include a pro-active regulatory approach using experimental/alternative technologies toward solving existing problems. Prescriptive standards will remain a useful and inexpensive management tool. A goal is to keep prescriptive standards for prescriptive situations and performance standards for performance situations. Strategies that include annual performance averaging and establishment of reasonable standards are critical to encouraging change, solving problems, and protecting public health and financial resources. A community lakeshore constructed wetland treatment system is described as a model for problem for problem resolution.

Docken, L. and B.D. Burkes. 1994. Wisconsin’s On-Site Code: A Status Report. In On-Site Wastewater Treatment: Proceedings of the Seventh International Symposium On Individual and Small Community Sewage Systems. ASAE. St. Joseph, MI. p. 16-21.

The State of Wisconsin is in the process of drafting and introducing a revised on-site waste code that incorporates performance standards for the on-site industry. Included in the code development process is re-engineering the management of on-site systems in Wisconsin and developing education for many licensed individuals.

Duncan, C.S., R.B. Reneau, and C. Hagedorn. 1994. Impact of Effluent Quality and Soil Depth on Renovation of Domestic Wastewater. In On-Site Wastewater treatment: Proceedings of the Seventh National Symposium On Individual and Small Community Sewage Systems. ASAE, St. Joseph, MI. p. 219-228.

Many soils are marginally suited for installation of on-site wastewater disposal systems. With soil limitations, additional wastewater treatment prior to soil application may allow for a reduction in soil depth. Undisturbed 20-cm-diameter soil columns (fine loamy, mix, mesic Typic Hapludult), in a factorial arrangement between depth of soil (15, 30, and 45 cm) and type of effluent (septic tank, constructed wetlands, and recirculating sand filter), were used in this study. Effluent (670 cm3/d) was applied 6 times daily. Additional treatment of septic tank effluent by a constructed wetland and a recirculating sand filter resulted in 30 and 70% higher average soil infiltration rates, 92 and 96% reduction in fecal coliforms, 34 and 44% reduction in total nitrogen, and a 60 and 94% reduction in BOD5, respectively. Fecal coliforms were present only in soil leachate from the 15 and 30 cm soil depths receiving septic tank effluent and the 15 cm depth that received constructed wetland effluent. Average soil leachate NO3- -N concentrations were 19, 10 and 14 mg/L from soil columns receiving septic tank, constructed wetland, and recirculating sand filter effluents, respectively. Soil leachate contained <5 mg/L TKN and 1.8 mg/L NH4+-N. Total nitrogen losses were 55,73, and 66 for the septic tank, constructed wetland, and recirculating sand filter treatments, respectively. BOD5 averaged less than 4 mg/L in the soil column leachate, despite a 10 fold difference among influent types. In comparing the 1993 and 1994 growing seasons, average plant tissue dry weight, percent N, and percent P were greater during the 1994 growing season. The results from this study indicate that additional treatment of septic tank effluent can be substituted for soil depth.

Eliasson, J.M., D.A. Lenning, and S.C. Wecker. Critical Point Monitoring – A New Framework For Monitoring On-Site Wastewater Systems. In On-Site Wastewater Treatment: Proceedings of the Ninth International Symposium On Individual and Small Community Sewage Systems. ASAE. St. Joseph, MI. p. 461-469.

Continuous oversight of on-site wastewater system performance is important in order to avoid public health and water quality problems, high system repair costs, and impaired consumer confidence. The Critical Point Monitoring (CPM) process is being developed to help meet a statewide monitoring mandate for local health agencies in Washington State to develop and implement plans to initiate periodic monitoring of all on-site wastewater systems. The principles of the Hazard Analysis and Critical Control Point (HACCP) system were integrated into the monitoring process to provide more rigorous control and oversight of operation, monitoring and maintenance activities to ensure systems are consistently meeting their performance requirements. The CPM process provides a systematic preventive-based approach for monitoring on-site wastewater systems. By concentrating on the wastewater flow points in a system that are most critical to monitor and control, CPM catches problems in the early stages before they become serious and expensive to correct. While CPM is a process standard, in practice its application requires choosing performance standards for the identified critical monitoring points. The seven steps in the CPM process include a system hazard analysis, critical monitoring point identification, establishing critical limits, monitoring procedures, corrective actions, record keeping, and verification procedures.

EPA. 1986. Septic Systems and Ground-Water Protection. An Executive Guide. EPA, Office of Ground-Water Protection, Washington, D.C. pp. 13.

EPA. 1997. Response to Congress on the Use of Decentralized Wastewater Treatment Systems (832-R-97-001b). EPA, Office of Water. Washington, D.C. pp. 35.

Haffner, Richard. 2000. Small Wastewater Treatment Systems Consensus Standards. Presented at the Small Drinking Water and Wastewater Systems Conference. Phoenix, AZ. pp. 8.

The American National Standards Institute has accredited NFS International to develop American National Standards in the area of small wastewater treatment systems. ANSI/NSF Standards in this area include ANSI/NSF 40, Residential Wastewater treatment Systems, ANSI/NSF 41, Non-liquid Saturated Treatment Systems, and ANSI/NSF 46, Evaluation of Components and Devices Used in Wastewater Treatment Systems. Each of these standards establishes minimum materials, design, and construction, product literature, and performance requirements for the products meetings their scopes. ANSI/NSF 40 also requires certain service-related obligation of the product manufacturers. Technical Committees of the International Organization for Standardization develop international standards. To date, no international standards for small wastewater treatment systems have been developed. However, several member bodies of the International Organization of Standardization, in addition to ANSI through NFS International, have developed national wastewater treatment standards for use within their county.

Heber, J. 1997. Performance Based Standards for Onsite Sewage Treatment and Disposal Systems in Florida. In: NOWRA 1997 Conference Proceedings of Onsite Performance: form, function & final results. College Station, Texas. p. 5-9.

Florida is the fourth most populous state in the nation and is heavily dependent on onsite systems for the treatment and disposal of residential and commercial wastewater. Onsite sewage treatment and disposal system (OSTDS) standards were first introduced in Florida in 1921. Changes in these standards evolved slowly until the 1970's, however, beginning in 1972 major progress in the siting, design, construction and use of OSTDS has occurred. This paper chronicles some of the significant changes in Florida's OSTDS laws, standards and program, including the recent development of performance-based standards.

Hoover, M.T. 1997. A Framework for Site Evaluation, Design, and Engineering of On-Site Technologies Within a Management Context. Marine Studies Consortium, Waquoit Bay National Estuarine Research Reserve, and *ad hoc* Task Force for Decentralized Wastewater Management. Marine Studies Consortium, 400 Heath St., Chestnut Hill, MA 02167. pp. 81.

Hoover illustrates a risk-management framework, which is intended to apply to specific watershed areas to manage the potential risks from on-site systems in a community. The document provides a logical process fro qualitatively assessing the risks form on-site systems on a watershed basis and then goes on to provide detailed management scheme for controlling risks. The soul of the risk management approach is a groundwater and surface water protection matrix that classifies each subwatershed area into on of five control zones (called R5, R4, R4, R3, R2, or R1). For each control zone (R5 through R1) the document identifies appropriate treatment performance standards that must be achieved by the on-site system and specifies when and where these systems can be used. It suggests that zones should be established around sensitive resources or drinking water supplies, and that there should be even sets of effluent treatment standards roughly equivalent to primary, secondary, and tertiary treatment, additional nutrient reduction, disinfection, wastewater reuse, and near drinking water, which apply based on a simple analysis of soil depths and types.

Hoover, M.T., A. Arenovski, D. Daly, and D, Lindbo. 1998. A Risk-Based Approach to On-Site System Siting, Design and Management. In: On-site Wastewater Treatment. Proceedings of the Eighth National Symposium on Individual and Small Community Sewage Systems, ASAE, St. Joseph, MI. p. 66-78.

On-site system siting and design has traditionally been based upon the specific conditions on the lot in question with little regard to the surrounding environment or the cumulative effect of all on-site systems in the watershed. A newly developed risk-based approach to on-site technologies provides a logical process for qualitatively assessing the risks form on-site systems on a watershed basis utilizing a siting, design and management approach to control these risks. Risk assessment and management begins by ranking the value and vulnerability to pollution of surface water and ground water receiving environments in the watershed. The next step is to develop a two-way table called a ground water and surface water protection

matrix. This protection matrix determines the control measures to be used within each receiving environment depending upon the value of the receiving environment to the community and it's vulnerability to pollution. Control measures include siting criteria, treatment performance standards, system inspection requirements, operation and maintenance activities, and resource impact assessments of the cumulative impacts of on-site systems in the watershed. Periodic system inspection, operation and maintenance and ecological resource assessments are the responsibility of a local or regional management entity. This risk-based approach affords substantial flexibility of a local or regional management entity. This risk-based approach affords substantial flexibility to the site evaluation and design process; particularly when compared to the prescriptive approaches that are currently used in most state and local codes. This flexibility is possible because of the long-term system monitoring, assurance of maintenance and control of environmental impacts form on-site systems. In essence, the management entity assures that both public health and environmental are protected. Communities can then reliably depend upon both conventional and advanced on-site technologies to meet their long-term wastewater treatment needs. This option fits between the two traditional community wastewater infrastructure extremes of poorly maintained conventional septic systems and highly maintained centralized wastewater treatment plants.

Hoover, M. T., D. Siever, and D Gustafson. 1998. Performance Standards for On-Site Wastewater Treatment Systems. In On-Site Wastewater Treatment: Proceedings of the Eighth International Symposium On Individual and Small Community Sewage Systems. ASAE. St. Joseph, MI. p. 346-355.

A series of voluntary national standards for on-site technologies are proposed. Specially, seven treatment performance standards are suggested to either augment or replace existing prescriptive on-site codes. Once national treatment performance standards are developed, state county and town regulatory agencies can determine which of the seven standards are most appropriate for different soil conditions with their jurisdictions. These decisions will depend upon public health concerns and/or environmental conditions in their watersheds. From a manufacturers point of view, this approach would reduce the hundreds of local standards they have to meet to a more manageable few standards. The seven wastewater treatment performance standards for on-site technologies that are proposed are: 1) primary treatment, 2) secondary treatment, 3) tertiary treatment, 4) nutrient reduction, 5) disinfection, 6) wastewater reuse and 7) near drinking water. The primary wastewater treatment standard includes two levels: unfiltered and filtered. The nutrient reduction standard includes three levels: nitrogen reduction, phosphorus reduction, and nitrogen/ phosphorus reduction. These performance standards can be applied to pretreatment units themselves, or alternatively to the receiving environment.

Jantrania, Anish. R. 1998. Are We Ready For the 21st Century? In: NOWRA 1998 Conference Proceedings of Onsite Treatment: First Choice For Protecting the Environment, Ft. Mitchell. KY. p. 2-8.

Overview of the current state of the onsite wastewater industry, with suggestions for establishing goals and objectives that will enable the industry to continue moving forward from various perspectives such as regulations, technology, O&M and customer service.

Jantrania, Anish. R. 2000. Building a Foundation for Performance Based Regulations. In: NOWRA 2000 Conference Proceedings of Onsite: The Future of Water Quality, Grand Rapids, MI. p. 185-192.

Joubert, Lorrine, Brenda, Dillman, George, Loomis, David, Dow, and James Lucht. 1999. Case Study: Using On-site Wastewater Treatment Standards to Achieve Community Water Quality Goals in Block Island, RI. . In: NOWRA 1999 Conference Proceedings of NOWRA: New Ideas For A New Millennium!, Jekyll Island, GA. p. 7-13.

Everybody's talking about the watershed or risk-based approach to managing onsite systems, but how does this translate to small communities with limited staff? A report on a practical, watershed-specific strategy for managing pollution risks of onsite wastewater treatment systems adopted by the Town of New Shoreham,

an island community located 10 miles off the coast of Rhode Island, on Block Island. The process of developing the wastewater management program, elements of the adopted ordinances, and helpful hints for others considering this approach.

Kreissl, James F. and Paul Chase. 2002. Proposed National Onsite Standards: A Broad Assessment of Their Relative Benefits to Industry. Small Flows Quarterly, National Small Flows Clearinghouse, University of West Virginia, Winter 2002. Vol. 3, No. 1. p. 28-33.

In most states, onsite wastewater treatment system manufacturers and suppliers are restricted by regulatory systems that are dominated by prescriptive codes. When a site does not meet prescriptive code requirements, states often do not allow many alternative onsite system designs, even if their performance has been proven elsewhere on similar sites. Local code administrators usually have no incentive to try new systems that are not already approved by the state. In this article, the authors examine the impact of the current state regulatory environment on the onsite wastewater industry as well as various ideas being proposed for its reform. Potential benefits of these reforms to the onsite industry are assessed.

Loomis, George, Lorraine Joubert, Brenda Dillmann, David Dow, James Lucht, and Arthur Gold. 1999. A Watershed Risk-Based Approach to Onsite Wastewater – A Block Island Case Study. In Proceedings Tenth Northwest On-Site Wastewater Treatment Short Course, College of Engineering, University of Washington, Seattle, WA. p. 249-262.

This paper reports on a practical, risk-based wastewater management program adopted by the Town of New Shoreham, a community located 10 miles off the coast of Rhode Island, on Block Island. Joubert et al. (1999) summarizes this program's septic system inspection ordinance, wastewater treatment levels for new construction and repairs, retrofitting of existing systems, and public education and technology transfer. This paper will focus primarily on elements of the adopted ordinances, and helpful hints for others developing community wastewater management programs.

Nelson, V.I. 2000. Market Growth Strategies: Lessons From the Literature. In: NOWRA 2000 Conference Proceedings of Onsite: The Future of Water Quality, Grand Rapids, MI. p. 75-82.

Nelson, V.I. 2001. A Market Analysis of the Need for Standards In the Decentralized Wastewater Industry. In On-Site Wastewater Treatment: Proceedings of the Ninth International Symposium On Individual and Small Community Sewage Systems. ASAE. St. Joseph, MI. p. 516-523.

The economics literature suggests that national agreement on standards is one of the most important needs to stimulate market growth in an emerging industry. High national effluent standards for on-site or cluster wastewater systems for all lots requiring advanced treatment would stimulate product innovation and investment in low-cost production and distribution facilities, particularly if no existing technologies could meet those standards at this time. Some industry professionals have proposed that on-site performance standards be set after treatment in the soils and that these standards should vary with density of development, use of ground or surface water, and other risk-related factors. However, from a market development perspective, the best approach is a simplified set of effluent standards prior to release into the soils, coupled with prescriptive requirements for where these standards should be mandated and for the design of soil-absorption systems. Agreement on these and related management standards should be facilitated by regulatory-industry-academic partnerships and should be informed by increased research into fate and transport and relative risks from nutrient and pathogen releases into the environment.

NOWRA, 1996. Recommended Onsite Wastewater Treatment Performance Criteria. National Onsite Wastewater Recycling Association. Northbrook, IL. pp. 4.

Oakley, Stewart M. 1995. Developing Protocols for Onsite Wastewater Treatment Standards: A Preliminary Report from Butte County, California. In Proceedings Eighth Northwest On-site Wastewater Treatment Short Course, College of Engineering, University of Washington, Seattle, WA p. 303-318.

High groundwater nitrate levels are a common problem in rural water quality. Septic tanks and agricultural runoff are the primary culprits in most instances. This article discusses such a contamination problem in the Chico, CA area. Nitrates from the area's 12,000 septic systems were contaminating groundwater to levels exceeding 10 mg/l. To combat this problem, Butte County, CA implemented a Nitrate Compliance Program. Recommendations of the plan included sewering areas where densities exceeded 3-20 EDU (equivalent dwelling units) per acre, implementing groundwater sampling protocols, establishing an on-site wastewater management district and furthering public education.

Otis, Richard J. 1995. The Elusive Alternative. In Proceedings Eighth Northwest On-Site Wastewater Treatment Short Course, College of Engineering, University of Washington, Seattle, WA. p. 1-8.

Otis, R.J. 2001. Boundary Design: A Strategy for Subsurface Wastewater Infiltration System Design and Rehabilitation. In On-Site Wastewater Treatment: Proceedings of the Ninth International Symposium On Individual and Small Community Sewage Systems. ASAE. St. Joseph, MI. p. 245-260.

Design of onsite wastewater treatment systems primarily focuses on the placement and size of the infiltration surface in the soil. Emphasis in design is on the hydraulic capacity of this surface. Where soils are less permeable, alternative designs have been employed in an effort to maximize the hydraulic capacity of the system. Many alternative designs have been developed and promoted to enhance wastewater infiltration. Unfortunately, hydraulic and treatment failures still occur in unacceptably high numbers. Rehabilitation of failing systems also is often less than satisfactory. This suggests that inappropriate application of traditional and alternative designs is occurring because of insufficient attention to other factors that can impact system performance. This paper presents a rational strategy for system design and diagnosing system failures.

Otis, R.J., and D.L. Anderson. 1994. Meeting Public Health and Environmental Goals: Performance Standards for On-Site Wastewater Treatment Systems. In On-Site Wastewater Treatment: Proceedings of the Seventh International Symposium On Individual and Small Community Sewage Systems. American Society of Agricultural Engineers (ASAE). St. Joseph, MI. p. 1-10.

Design of onsite wastewater treatment systems primarily focuses on the placement and size of the infiltration surface in the soil. Emphasis in design is on the hydraulic capacity of this surface. Where soils are less permeable, alternative designs have been employed in an effort to maximize the hydraulic capacity of the system. Many alternative designs have been developed and promoted to enhance wastewater infiltration. Unfortunately, hydraulic and treatment failures still occur in unacceptably high numbers. Rehabilitation of failing systems also is often less than satisfactory. This suggests that inappropriate application of traditional and alternative designs is occurring because of insufficient attention to other factors that can impact system performance. This paper presents a rational strategy for system design and diagnosing system failures.

Reed, S.I. 1977. State Programs and Perspectives. Individual Onsite Wastewater Systems. In Proceedings of the Fourth National Conference; National Sanitation Foundation, Ann Arbor, MI. p. 27-34.

Identifies the shortcomings of relying on detailed compliance standards in the rapidly evolving field of on-site wastewater treatment. Recommends the increased use of performance standards as an alternative. The major role of federal, state and local environmental health organizations should be to provide leadership for public involvement and for the cooperation of all concerned parties in determining priorities and goals.

Schindler, D.W. 1977. Evolution of Phosphorus Limitation in Lakes. Science. 195(4275):260-262.

Sherman, Kevin M. 1995. A Prescription for Performance-Based Codes: Another Perceptive. Small Flows, National Small Flows Clearinghouse, Fall 1995. Vol. 9, No. 4. pp. 13.

Sherman, Kevin M. 1997. The Future of Onsite Wastewater Systems. In Proceedings Ninth Northwest On-Site Wastewater Treatment Short Course, College of Engineering, University of Washington, Seattle, WA p. 1-7.

Siegrist, Robert R. 2001. Advancing the Science and Engineering of Onsite Wastewater Systems. In On-Site Wastewater Treatment: Proceedings of the Ninth International Symposium On Individual and Small Community Sewage Systems. ASAE. St. Joseph, MI. p. 1-10.

Onsite wastewater systems represent a necessary and appropriate component of the wastewater systems infrastructure in the U.S. In contrast to disposal oriented systems of the past, current and future systems are focused on advanced treatment that is protective of public health and environmental quality. System designs can now be assembled from an expanding array of options from which choices can be made regarding a given application. There is a considerable knowledge base regarding onsite system design, implementation, and performance that enables most commonly used systems to be effectively deployed in most settings. However, the current state-of-knowledge and standard-of-practice does have gaps and shortcomings that can preclude rational system design to predictably and reliably achieve specific performance goals. While choices today are often constrained by prescriptive regulatory codes, they also can be hampered by the absence of a sound science and engineering knowledge base. This paper discusses the basis and need for advancing the science and engineering of onsite wastewater systems to secure their necessary and appropriate status as a component of a sustainable wastewater infrastructure in the U.S.

Smithson, A.B. 1995. A Prescription for Performance Based Codes. Small Flows, National Small Flows Clearinghouse, University of Web Virginia, Summer 1995. Vol. 9, No. 3. p. 9-10.

Soltman, J. M. 1992. Repair of Systems Along Marine Shorelines - Application of Treatment Standards 1 and 2. In Proceedings Seventh Northwest On-site Wastewater Treatment Short Course, College of Engineering, University of Washington, Seattle, WA p. 249-263.

Puget Sound, a large inland sea, located in Western Washington, is enjoyed for its scenic beauty, recreational opportunities, and its aquatic resources. The shorelines of its bays and islands are dotted with housing structures with a wide variety in size, age, shape, occupancy, and pattern of use. These structures rely primarily on on-site sewage systems for sewage treatment and disposal. A factor in the significance of these on-site systems is the distribution of and increase in population during the past two or three decades. Existing and proposed building sites are commonly characterized by shallow, high-permeable or very-slow permeable soils, steep slopes or cliffs, small size, questionable water supplies, and a high potential for precipitation. To specifically address existing systems, the State Board of Health established rules for the repair and replacement of individual on-site sewage treatment and disposal systems. This paper describes the development of

Washington's marine treatment standard approach, introduce guidelines for alternative system applications, and present examples of this approach.

Wespetal, M.S., and L.L.C. Frekot. 2001. Development and Implementation of Performance Standards Assessing Performance Designs. In On-Site Wastewater Treatment: Proceedings of the Ninth International Symposium On Individual and Small Community Sewage Systems. American Society of Agricultural Engineers (ASAE) . St. Joseph, MI. p. 488-497.

In October 1999, the Minnesota Pollution Control Agency amended its state rule for individual sewage treatment standards to include performance standards. The standards were developed after assessing the outcomes achieved by conventional systems and applying those outcomes to performance standards. The standards are broad in nature to allow maximum design flexibility. The standards are based on protection of public health, safety, the environment, and include provisions for consumer awareness. A design assessment model for performance systems is based on giving treatment “credit” for known treatment components such as loading rates, soil separation, soil texture and dosing frequency. In this manner, the designer can adjust the various design parameters to conceptually meet performance expectations. This paper describes the process used to develop performance standards, justification for the selected standards, and a method to assess a system design.

Woolrich, Robert and David Lenning, 1989. New Washington State On-Site Sewage Regulations. In Proceedings Sixth Northwest On-site Wastewater Treatment Short Course, College of Engineering, University of Washington, Seattle, WA p. 1-14.

Washington State Department of Health. 1994. On-Site Sewage Systems: Rules and Regulations of the State Board of Health. Chapter 246-272 Washington Administrative Code.

Washington State Department of Health. 1997. Barriers Assessment Study and Action Plan for Alternative On-Site Sewage Systems. Prepared by Adolfson Associates, Inc. for WA State Dept. of Health. pp 72.

Washington State Department of Health. 2001. List of Approved Systems and Products. November 2001. Wastewater Management Program.

Zachritz, Walter H., Clara Cates, and Frank Huang. 1998. Development of Technology-Based Standards for On-Site Systems for Groundwater Protection in Albuquerque, New Mexico. In On-Site Wastewater Treatment: Proceedings of the Eighth International Symposium On Individual and Small Community Sewage Systems. ASAE. St. Joseph, MI. p. 254-258.

According to the 1990 US Census, about 17,800 conventional septic tank/drainfield systems are operating in Bernalillo County, New Mexico. Although the extent of groundwater contamination caused by these systems is not clear, recent studies indicate that groundwater contamination caused by the septic drainfield systems may be widespread. Based upon the ”Albuquerque/Bernalillo County Ground-Water Protection Policy and Action Plan” a two-year field study is currently underway to demonstrate the ability of selected alternative on-site systems to remove conventional wastewater pollutants, particularly nitrogen species organic-N, NH_4^+, and No_3-N). Six alternative systems and a conventional septic tank/drainfield system are being evaluated for their ability to remove nitrogen species, organics, suspended solids, fecal coliform, and other constituents while in place at various homesites throughout Bernalillo County. Performance standards of the alternative on-site systems developed in this study will be used to modify City and County on-site liquid waste ordinances.