Spokane County Shoreline Management Plan (SMP): Proposed Elements of a Phosphorus Management Standard

Spokane County, Washington

for
Perkins Coie

April 9, 2014

GeoEngineers
Earth Science + Technology

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1.0 BACKGROUND

At present, septic tank regulations in the current Spokane county Shoreline Master Program (SMP) relating to the management of phosphorus (P) releases in shoreline areas are considered inadequate to protect shoreline areas under Spokane County jurisdiction. The SMP Guidelines rule, WAC 173-026-241(3)(j), Residential Development, states:

> "Master programs shall include policies and regulations that assure **no net loss** of shoreline ecological functions will result from residential development. Such provisions should include specific regulations for setbacks and buffer areas, density, shoreline armoring, vegetation conservation requirements, and, where applicable, on-site sewage system standards for all residential development and uses and applicable to divisions of land in shoreline jurisdiction."

Given documented releases of anthropogenic phosphorus in the county, the Washington Growth Management Hearings Board has found that "increased phosphorus inputs to shoreline ecosystems result in **net loss** of ecological functions".

As a result, Spokane county is responsible for developing a revised SMP to "assure that **no net loss** of shoreline ecological functions will result from residential development" as a result of phosphorus releases.

The "no net loss" standard is designed to eliminate impacts (above baseline conditions) to shoreline ecological functions resulting from new development. In principle, this standard is based on the premise that "new adverse impacts to the shoreline environment that result from planned development should be avoided, when possible". When new adverse impacts cannot be avoided then their impacts must be mitigated. Because mitigation strategies can never prevent all cumulative adverse impacts to ecological function, restoration is a necessary component of the "no let loss" standard.

2.0 OBJECTIVES

Spokane River

This report documents GeoEngineers, Inc.'s (GeoEngineers') efforts to identify current Best Management Practices (BMPs) relating to P management for on-site wastewater treatment systems (OWTS) within the shoreline environment. In addition, this report (along with the associated appendices) serves as a compilation of current topical information regarding the management of phosphorus in OWTSs with emphasis on the shoreline ecosystem. Finally, this document provides recommended elements of a new phosphorus management strategy, based on the assessment of best available technologies and practices to assist Spokane County in developing a revised SMP that complies with SMP requirements to best control phosphorus releases from OWTSs. The six specific objectives set for this work are:

- Document information gathering activities;
- Warehouse topical technical information/reports;
- Recommend P management elements for a revised SMP;
- Provide Technical Data to guide design;
- Summarize Technical Data; and
- Provide Contact Information for identified experts.

3.0 METHODOLOGY

The identification of current BMPs relating to phosphorus management for on-site wastewater treatment systems in the shoreline zone consisted of literature searches in combination with contacting national wastewater organizations, academic researchers and private industry consultants. In addition, the results of recent information collection activities relating to phosphorus management by officials from Spokane County and the Washington State Department of Ecology (Ecology) were obtained. A special emphasis was placed on identification of experts in academia and nationally recognized wastewater organizations whose information and opinions were considered to be less "biased" than those in private industry. Physical documentation of phosphorus management system information was obtained either directly from journals or web-based sources or in some cases received directly from individuals following requests to provide information about specific management strategies or systems. Every data element and document generated as part of information collection activities is not included in this report. Professional judgment was used to select a subset of documents and information considered relevant to the understanding of phosphorus management and the achievement of the "no net loss" standard for shorelines in Spokane County.

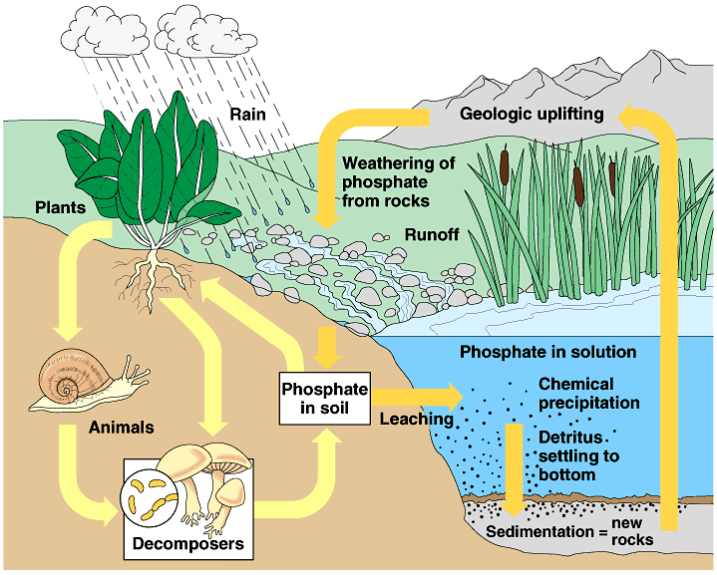
Although initial information gathering was focused on more traditional septic wastewater management strategies (e.g., minimum setback distances and vertical separation), as the information gathering process progressed, increasing focus was given to advanced treatment systems (ATS) which pre-treat from the septic tanks before discharge to the leach field that would be applicable to shoreline areas. The change in focus from traditional OTWS to ATS was facilitated by concerns about the ability of traditional systems to effectively remove Phosphorus from OWTS effluent within a designated shoreline zone.

4.0 TRADITIONAL STRATEGIES FOR PHOSPHORUS MANAGEMENT

Nutrient enrichment is a leading cause of water quality impairment in the waters of the United States, and wastewater inputs from OWTS near aquatic habitats are a significant source of phosphorus pollution in aquatic ecosystems. A growing body of research suggests that conventional onsite systems relying on septic tanks and soil absorption systems for phosphorus removal do not always prevent impairment of surface waters. Past practices have largely focused on nitrogen removal from OWTS, assuming that if nitrogen is effectively managed than other nutrients, including phosphorus will be sufficiently controlled. For example, in a recent U.S. Environmental Protection Agency (EPA) report (2013), the following is noted:

> "While phosphorus reductions are also identified in the TMDL, the focus of this document is on technologies and practices for reducing nitrogen discharges from onsite systems because phosphorus does not move as readily as nitrogen in subsurface soils" (U.S. EPA 2013).

Phosphorus, like other nutrients (e.g., nitrogen) has a natural cycle in the environment. In general, the availability of phosphorus in the environment is restricted by the rate of weathering of host minerals (e.g., apatite) making the phosphorus cycle one of the slowest biogeochemical cycles in nature (Crichton 2012). Once available, phosphorus can move quickly through the environment and become incorporated into biological systems (e.g., plants and animals). However, such biological up-take is temporary as plants and animals cycle phosphorus back in the environmental through death and decomposition. Phosphorus in soil that is not taken up by biological systems will eventually be transported to and by streams and rivers in dissolved form or part of suspended solids to the world's oceans. Over many millions of years ocean sediments are consolidated into phosphorus bearing rocks formations that can become subject to subsequent geologic uplift and weathering to complete the cycle (NESC 2013). As a result of phosphorus reliance on geologic process to both fix and release it into the environment, its cycle is much slower than either the carbon or nitrogen cycles.



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Phosphorus has few avenues to escape from the subsurface in a gaseous state. Once in the terrestrial system it is only a matter of time until it migrates to a local surface water body (NESC 2013).

In the case of nitrogen natural mechanisms exist (i.e., denitrification) to convert nitrogen containing chemicals (i.e., nitrates) back into nitrogen gas and effectively remove them from the terrestrial system. Such mechanisms do not exist for phosphorus. As a consequence, a phosphorus containing chemical will remain within terrestrial systems, available for groundwater and surface water transport (and eutrophication), until fixed by geological processes in the earth's oceans. The net result relevant to OTWS is that once phosphorus has been released into the near surface environment it is only a matter of time until that portion which is not fixed by biological systems is transported through groundwater, surface water or erosional processes to a surface water body. This subtle but important difference seems to have been largely neglected in previous OTWS management strategies which are largely based on nitrogen cycling.

Generally, statements regarding the effectiveness of conventional systems in phosphorus management do not account for these important mechanisms. For example, Reneau et al. (1989) reports that "effective phosphorus removal is typically achieved in all but coarse sandy soils."

Another author reports that "…one of the major strengths of septic systems in general is the ability to treat phosphorus. Phosphorus in wastewater effluent tends to attach itself, or sorb to soil particles in the unsaturated zone below septic drainfields. It is common for this process to remove 85 percent to 95 percent of phosphorus, and complete removal typically occurs long before effluent reaches surface water." (TSWQC 2005). Although such statements are undoubtedly true for short-term, and possibly mid-term phosphorus sequestration, they effectively discount the long-term limitations of natural soils and wetland environments to retain non-biologically fixed phosphorus. This is an important point when considering P management in shoreline environments.

Such limitations on long-term phosphorus fixation seem to have been largely ignored in past phosphorus management strategies related to OWTSs. Given the increasing incidents of surface water impairments related to Phosphorus loading, the reality of the limitations of long-term phosphorus fixation from simple soil treatment has become more widely recognized and new treatment technologies are emerging.

Kelly et al. (2007) reported the efficacy of a variety of vegetative conditions (crop, grasses and cottonwood) to remove P from associated agricultural practices. After 4 years of study, these researchers found that the amount of P uptake in the plants was linked to the biomass produced annually. Although plants did take up some P (with cottonwood as the most effective), soil P concentrations changed little of the study. The authors postulated that plants only uptake the bioavailable fraction of P and cannot utilize soluble P. The authors also noted that vegetation harvest was not done over the study timeframe and that leaf and other litter from the sample vegetation stands was recycling P back into the soil. Despite the fact that vegetative buffers work well for several functions, removal of P was not effective from these results without a concerted management effort and intense monitoring.

Sawhney & Hill (1975) note "the varying sorption capacities of different soils and also that, because sorption capacity is finite, the geometry of the disposal system impacts on the length of time required to 'saturate' the soil to any given depth." Nagpal (1981) notes similarly that "a continuously or frequently loaded drainfield will exhaust its apparent nutrient (phosphorus) retention capacity rather quickly". Campillo (1999) indicates "phosphorus (P) in the form of (ortho)phosphate reacts readily with soil components, but the capacity of soil to bind P is limited…and if this nutrient is systematically applied in excess of plant needs then substantial amounts of P can be leached to deeper soils and to the groundwater." More recent work regarding the finite capacity of terrestrial materials to sequester phosphorus in the long-term is more pointed and less qualified. Dunne and Reddy (2005) state, "sorption [onto soils] as well as storage [of phosphorus] in biomass are saturable processes, meaning they have a finite capacity and therefore cannot contribute to long-term sustainable removal" (Dunne and Reddy, 2005).

Why previous phosphorus management strategies have largely avoided known limitations on long-term phosphorus fixation is unclear. At least part of this avoidance has likely resulted from the relative complexity of sequestration mechanisms and the general lack of the current science to demonstrate or characterize them in terms of phosphorus retention capacity. Some researchers (Dunne et al., 2005) have suggested that "to retain [phosphorus] on a long-term basis using soils or wetland systems, phosphorus mass inputs rates should be limited to long-term storage

capacities". Such theoretical approaches that embrace the reality of phosphorus retention limitations are ideal, but appear to be far from implementable given the current state of the science to adequately characterize phosphorus retention capacities in complex systems. Such complexities have been enumerated by a number of authors. Reneau et al. (1989) indicated that "the mechanisms for removing phosphorus from effluent water in the soil system to include plant uptake, biological immobilization, and adsorption or precipitation processes. The latter includes physical adsorption, chemisorption, anion exchange, surface precipitation, and precipitation as separate solid phases". Pant et al., (2001) notes "the mechanisms, processes and interactions controlling long-term phosphorus retention include a vast array of complex interconnected parameters including deposition rates of incoming phosphorus containing particulate matter, hydraulic residence times, the kinetics and thermodynamics of chemical phosphorus precipitation, accretion and partial decomposition of organic and detrital material".

Although it may be theoretically possible to ensure long-term P fixation at a given site, the ongoing evidence of shoreline eutrophication indicate that the performance of conventional systems for phosphorus removal is variable or inconsistent (Reed and Brown, 1995). These inconsistencies can be attributed to the complexity of phosphorus removal mechanisms, and the lack of consideration of these complexities in design (Kadlec and Knight, 1996).

In a recent evaluation of promising phosphorus management approaches (Stone Environmental 2005), "research and demonstration" needs were identified to highlight those areas where additional research and field testing would assist in better phosphorus management. This report identified the need to "develop a vulnerability index for phosphorus breakthrough" as its highest priority. In this context, the vulnerability index is intended to be a comprehensive site assessment tool that:

> "…can be used to discover the need for any sort of phosphorus-removal method beyond the native capacity in the soil. Quantifying the relationship between soil properties phosphorus absorption capacity through soil chemistry tests (e.g., metals content, anion exchange capacity, and others) and morphometric tests could both help site soil absorption systems to maximize phosphorus removal in soil and save money by identifying places where no measures other than SAS siting are needed because the soil at the site has adequate phosphorus-fixation potential to provide long-term removal."

The fact that this research need was identified as the highest ranking need relating to phosphorus management, underscores the reality that the science is currently lacking to adequately characterize sites for their potential for long-term phosphorus fixation. As a result, generalized nutrient management approaches such as the establishment of minimum setback distances and vertical separations are considered indefensible as they pertain to phosphorus management.

As noted previously, phosphorus has few avenues to escape from the subsurface in a gaseous state and once in the terrestrial system it is only a matter of time until it non-biologically fixed phosphorus migrates to a local surface water body. Due to this, and because natural systems are complex and the capacity for long-term phosphorus fixation cannot be currently quantified, there is the need for engineered treatments solutions (i.e., ATS) to deal with the immediate threat of phosphorus releases and the associated impairment of shoreline ecological function.

5.0 PHOSPHORUS POLLUTION FROM SHORELINE ZONE SEPTIC SYSTEMS

Various researchers have linked phosphorus contamination of surface waters to wastes derived from septic systems (Corbett et al, 2002; Meyer and Barak, 2005; Dudley and May, 2007; Withers and Jarvie, 2008; Neal et al., 2010; Macintosh et al, 2011; Withers et al., 2012). This is not surprising given that septic tank effluent has an average total phosphorus concentration of 10 mg/L ([milligrams per liter] Lowe et al, 2009). Phosphorus concentrations of just 0.01 to 0.02 mg L^{-1} are sufficient to induce eutrophication and harmful algae blooms (HABs) in running surface waters (Heathwaite and Dils, 2000). A single household discharges 450 gallons per day wastewater, resulting in 0.6 ounces (17 g [grams]) phosphorus per day, or 13.7 pounds (lbs) per year. Just 0.35 ounce (10 g) of phosphorus (PO4-P) in waterways promotes the growth of up to 2.2 lbs (1 kg [kilograms]) of algae.

Phosphorus retention by soils is a finite process, e.g. soils cannot adsorb phosphorus indefinitely (Brady and Weil, 1996; Richardson, 1985; Faulkner and Richardson, 1989; Richardson and Craft, 1993). Meyer and Barak (2005) investigated phosphorus movement under a decommissioned septic system in Southern Wisconsin. They found that concentrations of phosphorus below the septic system chamber were much higher compared to the surrounding soil. Corbett et al. (2002) investigated the spatial variability of nitrogen and phosphorus in a sand aquifer influenced by onsite sewage treatment and disposal systems in the Florida Keys. They reported P concentrations as high as 5.9 mg/L in septic tank effluents. This P concentration decreased linearly with distance from the drain field, with values falling to 0.5 mg/L about 57 meters from the drain field.

However decreased, this P concentration is 25-50 times greater than P concentrations that can induce HABs (Heathwaite and Dils, 2000). The authors pointed out that even after passing through and well beyond the drain field, P concentrations remained higher than the natural background concentrations. Zanini et al. (1998) and Robertson (2008) found field evidence that long-term P attenuation (or movement of P into the fixed pool) was limited to micro-sites (small sites in soil) in the unsaturated soil zones where changing redox (anaerobic and aerobic) conditions promoted rapid precipitation of insoluble P minerals. In a 16-year study of P dynamics in a calcareous sand, Robertson et al. (1998) and Robertson and Harman (1999) found that P fixation could not be relied upon to attenuate P movement to groundwater and surface water.

Dodley and May (2007) conducted comprehensive study on phosphorus loading to water bodies from septic tanks. They stated that the extent of P removal in septic systems is dependent upon many inter-related factors which include: soil grain size and chemical composition, proximity to the water table, proximity to surface water, capacity of the system in relation to the number of people using it, chemical composition of the sewage that is received by the system, and the frequency at which the tank is emptied of sludge. Also, the effective functioning of the tank itself is dependent upon several interconnected components that are responsible for capturing solids and breaking down organic materials. Failure of any one of these components will reduce the extent to which P is retained by the system.

To date, most estimates of the contribution of P from shoreline zone located septic tanks to water bodies have used a simple export coefficient approach applied at the catchment, regional or national scale. This is a very general method that takes no account of local variation in P removal due to the influence of factors such as soil type, hydrology, and the location, age and level of

maintenance of the system itself, all of which may have a significant impact on P transfer from septic tanks to waterbodies. It also tends to assume that all tanks are properly maintained and functioning correctly, which is often not the case. In order to assess the contribution of septic tank systems to P loads to water more accurately, more information is needed on these factors and their impact on P mobility.

6.0 OPTIONS IDENTIFIED AND EVALUATED

Although ATSs are likely necessary to achieve the shoreline "no net loss" standard in the long-term, conventional system components are considered useful and necessary. This is because ATSs although greatly beneficial, have only finite efficiencies (e.g., 90 percent P removal) and therefore will allow some phosphorus discharge within the shoreline zone in the long-term. Therefore, those conventional system components or approaches that can be adopted (in conjunction with ATSs) will assist in ultimately achieving the "no net loss" standard. As a result, conventional system components and approaches are outlined in this section within the following categories:

- Administrative Controls
- OSWT/SAS Design
- Source Reduction
- Source Diversion

6.1. Administrative Controls

Administrative controls are designed to eliminate or to mitigate phosphorus discharges to local waters by providing regulatory limitations to the placement of OWTS systems in shorelines zones and mandating system design/configuration, Operation & Maintenance requirements, and inspections. OWTS system are often primary sources of nutrient loading, however, other factors common to land development (e.g. construction sediments, road runoff, fertilizers, industrial projects) also typically increase phosphorus loading to surface waters. Prohibitions/limitation on phosphate fertilizers may also be needed in the shoreline zone. Table 1 presents a summary of the administrative control strategies associated with P management related to OWTSs.

TABLE 1. POTENTIAL ADMINISTRATIVE CONTROL STRATEGIES FOR PHOSPHORUS MANAGEMENT IN THE SHORELINE ZONE

Item	Concept
1	Prohibitions to new OWTS Installations with the 200 ft. buffer zone.
2	County to require OWTS system upgrades for systems within the 200 foot buffer zone in association with any property use changes or existing OWTS failures.
3	County to approve/inspect any replacement of failed OWTS to ensure new standards are achieved.
4	Allowance for case-by-case variances if the applicant can show "no net increase" in phosphorus loading from changed/increased OWTS flows.
5	Requiring regular OWTS inspections to ensure proper system operation.
6	Allowances for case-by-case variances if the applicant can show the presence of a groundwater/watershed boundary within the 200 foot buffer zone that would prevent effluent within the buffer from reaching the nearby water body (immediately).
7	Requirements for periodic Septic Tank "pump-outs" to reduce the build-up of solid-phase phosphorus concentrations and subsequent aqueous phase effluent concentrations.
8	Establishment of phosphorus treatment standards (e.g., 90% or greater phosphorus reduction) and/or phosphorous discharge concentration limits (e.g., 1 mg/l P or less) OTWS effluent.

6.2. OWTS System Design Improvements

Whether for a newly installed system or for a failed existing system, OWTS systems should be designed to ensure no degradation to associated waterways. Design features discovered through this investigation are presented in Table 2.

TABLE 2. POTENTIAL DESIGN ENHANCEMENT STRATEGIES FOR PHOSPHORUS MANAGEMENT IN THE SHORELINE ZONE

Item	Concept
1	Siting the OWTS on the most topographically upgradient property boundary perpendicular to groundwater flow to allow for the maximum possible adsorption of phosphorus.
2	Establishing minimum horizontal separation distance (e.g., 150 feet) to freshwater bodies in order to maximize phosphorus adsorption.
3	Requiring the use of leaching trenches or drip irrigation versus leachfields.
4	Establishing a minimum vertical separation distance (e.g., 10 feet) to maximum site groundwater elevation to maximize phosphorus adsorption.
5	Requirements for periodic pressure dosing to homogenize and optimize phosphorus adsorption.
6	Requiring minimum cross-sectional surface area for OWTS systems to maximize phosphorus adsorption.
7	Requirements for specific Soil Absorption System (SAS) design options and configurations (e.g., in line filters, long/narrow trenches, and shallow systems) to fit site conditions.

6.3. Source Reduction

Source reduction prevents phosphorus from entering wastewater streams by reducing or eliminating its use in domestic products and by reducing the amount of kitchen waste in wastewater. Source reduction results in wastewater that contains little more phosphorus than that from urine and feces (NDWRCDP, 2005). Table 3 summarizes the potential source reduction strategies for P management associated with OWTSs.

TABLE 3. POTENTIAL SOURCE REDUCTION STRATEGIES FOR PHOSPHORUS MANAGEMENT IN THE SHORELINE ZONE

Item	Concept
1	Use of only Phosphorus-free laundry detergent.
2	Use of only Phosphorus-free dishwasher detergent.
3	Prohibitions/limitation on phosphate fertilizers in the shoreline zone.
4	Eliminate garbage disposal.

6.4. Source Diversion

Two-thirds or more of the phosphorus in domestic wastewater is contained in the blackwater, and about two-thirds of the phosphorus in the blackwater is in the urine (NDWRCDP, 2005). Therefore, roughly 50% of the phosphorus generated in the home is in the urine. Collecting urine and/or feces separately, with no water or very small amounts of flush water, makes it possible to transport them cost-effectively for treatment in a less-sensitive environment or to recycle them to agriculture (NDWRCDP, 2005). Table 4 lists the source diversion strategies for P management.

TABLE 4. POTENTIAL SOURCE DIVERSION STRATEGIES FOR PHOSPHORUS MANAGEMENT IN THE SHORELINE ZONE

Item	Strategy
1	Blackwater holding tanks and separate graywater treatment (with microflush toilets).
2	Composting of feces and separate graywater treatment.
3	“No-mix” toilets which separate urine from feces.
4	Properly designed and operated composting toilets.

7.0 TREATMENT

Allowing or mandating the use of innovative/alternative treatment systems in the shoreline zone is another way to reduce phosphorus in septic system effluent. Several emerging technologies have been advanced and implements across the United States and in foreign countries recently. Table 5 identifies the potential treatment strategies for P management.

- Vegetative Barriers
- Septic Tank Precipitation
- PhosRID (phosphate filter/precipitation system)

- RUCK CFT (nitrogen removal but effective for phosphorus)
- Reactive media filters (Fe, Al, Ca)
  - Natural
  - Manufactured (Filtralite® and Utelite®)
  - Industrial by-products

TABLE 5. POTENTIAL TREATMENT STRATEGIES FOR PHOSPHORUS MANAGEMENT IN THE SHORELINE ZONE

Item	Concept
1	Enhanced SAS medium (e.g., Limestone, tire chips)
2	Reactive media barriers/filters (e.g., Fe, Al, Ca)
3	Vegetative barriers (limited use in winter months)
4	Requirements for Post-Septic Tank/Pre-SAS Advanced Treatment System (ATS) (e.g., PhosRID, RUCK CFT, PhosphoReduc)
5	Establishment of ATS standards for phosphorus (e.g., 90% or greater phosphorus reduction) and/or phosphorous discharge concentration limits (e.g., 1 mg/l P or less) OTWS effluent.
6	Requirements for the period replacement and off-site disposal of ATS media.
7	Requirements for initial and ongoing testing of ATS systems (e.g., periodic total phosphorus and pH testing) to ensure performance requirements are being met.
8	Requirements for the installation of groundwater piezometers to enable periodic testing of SAS phosphorus concentrations.
9	Approval of off-site disposal areas for spent treatment media
10	Develop requirements for spent treatment media re-use as phosphorus rich soil amendment.

8.0 RECOMMEDATIONS ELEMENTS OF A PHOSPHORUS MANAGEMENT STANDARD

The recommended overall strategy of phosphorus management in the shoreline zone in Spokane County is a hierarchical approach based upon the following four basic management principles:

1. Prohibitions to OSWT systems in the shoreline zone will be required wherever possible.
2. Where OSWT systems are unavoidable in the shoreline zone, an engineered ATS will be required in order to achieve the “not net loss” standard.
3. Where feasible, conventional OSWT management approaches will be utilized in conjunction with ATSs to further reduce residual phosphorus discharges beyond the levels achieved through advanced treatment.
4. Previously existing OWTS systems will be upgraded within the 200 foot buffer zone as a consequence of property use changes or existing OWTS failures in order to achieve the necessary “restoration” component of the “no net loss” standard.

Table 6 incorporates these management principles as associated with the recommended elements of a comprehensive P management strategy for Spokane County.

All of the previously identified potential management strategies were evaluated to determine which of those should be included in an overall management strategy for Spokane County attempting to qualitatively balance the needs of:

- Environmental Protection/Ecological Function
- Private Landowner Rights/Cost of Implementation
- Burden of County Inspection/Monitoring/Enforcement

The result is the following recommended list (Table 6) of phosphorus management elements that should be considered in crafting future standards.

TABLE 6. RECOMMENDED ELEMENTS OF A COMPREHENSIVE PHOSPHORUS MANAGEMENT STRATEGY IN THE SHORELINE ZONE

ELEMENT	ASSOCIATED MANAGEMENT PRINCIPLE	DESCRIPTION
1	1	Prohibitions to new OWTS Installations with the 200 ft. buffer zone where feasible.
2	2	Requirements for Post-Septic Tank/Pre-SAS ATS.
3	2	Establishment of ATS standards for phosphorus (e.g., 90% or greater phosphorus reduction) and/or phosphorous discharge concentration limits (e.g., 1 mg/l P or less) OTWS effluent.
4	2	Requirements for the period replacement and off-site disposal of ATS media.
5	2	Requirements for initial and ongoing testing of ATS systems (e.g., periodic total phosphorus and pH testing) to ensure performance requirements are being met.
6	2	Requirements for the installation of groundwater piezometers to enable periodic testing of SAS phosphorus concentrations.
7	2	Approval of off-site disposal and off-site re-use areas (e.g., acid mine drainages, forestry applications horticulture) for spent treatment media.
8	3	Requiring regular OWTS inspections to ensure proper system operation.
9	3	Requirements for periodic Septic Tank “pump-outs” to reduce the build-up of solid-phase phosphorus concentrations and subsequent aqueous phase effluent concentrations.
10	3	Siting the OWTS on the most topographically upgradient property boundary perpendicular to groundwater flow to allow for the maximum possible adsorption of phosphorus.
11	3	Establishing minimum horizontal separation distance (e.g., 150 feet) to freshwater bodies in order to maximize phosphorus adsorption.
12	3	Establishing a minimum vertical separation distance (e.g., 10 feet) to maximum site groundwater elevation to maximize phosphorus adsorption.
13	3	Requirements for specific SAS design configurations (e.g., long/narrow trenches).
14	3	Requirements for shallow SAS designs.
15	3	Phosphorus-free laundry detergent.
16	3	Phosphorus-free dishwasher detergent.

ELEMENT	ASSOCIATED MANAGEMENT PRINCIPLE	DESCRIPTION
17	3	Prohibitions/limitation on phosphate fertilizers in the shoreline zone.
18	3	Enhanced SAS medium (e.g., Limestone, tire chips).
19	4	Requirements for monitoring of existing systems within the 200 foot buffer zone to determine total phosphorus discharge concentrations.
20	4	Requirements for OWTS system upgrades for systems within the 200 foot buffer zone in association with any property use changes or existing OWTS failures to achieve the necessary "restoration" component of the "no net loss" standard.

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APPENDICES

GeoEngineers