TNRCC Regulatory Guidance

Remediation Division

RG-366/TRRP-28 April 2001

SUBJECT: **Application of Remedy Standards A and B**

Objectives: This guidance document provides an overview of Remedy Standards A and B.

Audience: Regulated Community and Environmental Professionals

References: The regulatory citation for Texas Risk Reduction Program (TRRP) rule for notification is 30 TAC §350.31-33, §350.35.

The TRRP Rule and Preamble is on-line at http://www.tnrcc.state.tx.us/oprd/rules/indxpdf5.html.

The TRRP rule, together with conforming changes to related rules, is contained in 30 Texas Administrative Code Chapter 350, and was published in the September 17, 1999 Texas Register (24 TexReg 7413-7944). Download Tier 1 PCL Tables, toxicity factors and other TRRP information at http://www.tnrcc.state.tx.us/permitting/trrp.htm.

Contact: Technical Support Section at 512/239-0310; Corrective Action Section 512/239-2343; Site Assessment & Management Section 512/239-2509; Superfund Cleanup Section 512/239-2425; Voluntary Cleanup Program Section 512/239-5891

For mailing addresses, please see TNRCC's web page at www.tnrcc.state.tx.us .

Introduction to the Texas Risk Reduction Program Remedy Standards

This guidance document introduces and explains Remedy Standards A and B as established under TRRP. The goal is to give a basic understanding of the requirements of each remedy standard, an understanding of flexibility provided by the different remedy standards, and to make the reader aware of factors that are important in deciding which remedy standard may be appropriate for the affected property.

Where do remedy standards fit in the TRRP process?

Figure 1 is a simplified overview of the TRRP process. Following the reporting of a release of chemicals of concern (COCs) to the TNRCC, the person must determine the applicability of TRRP to the release. If TRRP is applicable, then an affected property assessment must be completed. As part of the completion of the affected property assessment, cleanup levels, referred to as protective concentration levels (PCLs), are established for the COCs as appropriate for the specific conditions at the affected property, including the land use and groundwater classification. Once the affected property assessment is completed and PCLs are established, the extent of each environmental media (for example, soil and groundwater) that contains COCs at concentrations greater than the critical PCLs, or the lowest PCLs, are identified and designated as PCL exceedence (PCLE) zones (Figure 1).

At any particular affected property there can be PCLE zones in the surface soil, subsurface soil, groundwater, surface water and/or sediment. Figure 2 depicts an affected property with soil and groundwater PCLE zones. Simply put, a PCLE zone is that volume of waste and environmental media that needs to be addressed with a response action. Under TRRP, response actions must conform to one of two different remedy standards, Remedy Standard A or B (Figure 1). It is the remedy standards that are the focus of this guidance document.

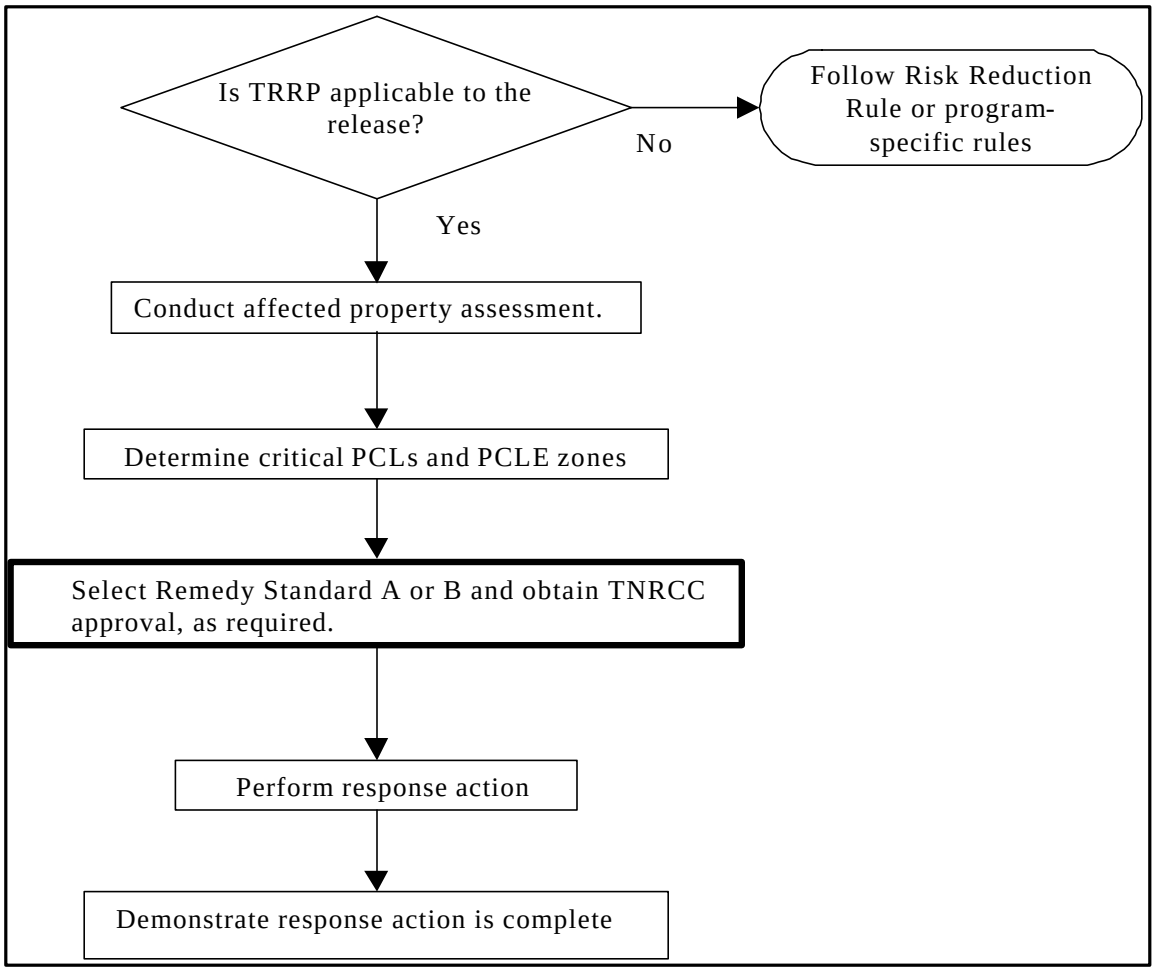

Figure 1. The TRRP process with Remedy Standards A and B process step highlighted.

All Response Actions Must Meet the Requirements of Remedy Standard A or B.

Once the affected property is subject to TRRP and the person is thereby required by a TNRCC program area to address identified PCLE zones, it is the person's responsibility to select the appropriate remedy under either Remedy Standard A or Remedy Standard B. The remedy standards are performance-based requirements that are to be used to demonstrate that the concentration of COCs at an affected property are protective of human health and the environment and that the active and productive use of the affected property is preserved. The remediation of all PCLE zones must conform to the requirements of either Remedy Standard A or B, unless another approach is required by another TNRCC regulation, permit or order; or unless a facility operations area (FOA) is approved in accordance with §§350.131-135. However, the person who is conducting the response action has the choice of applying either Remedy Standard A or B. The selected remedy must address both human health and ecological exposure concerns.

Interim measures are not precluded from being taken before or during the application of a remedy standard when they are needed to mitigate an emergency, abate an on-going release, or to stabilize or abate the spread of COCs (§350.1 and §350.33(d)).

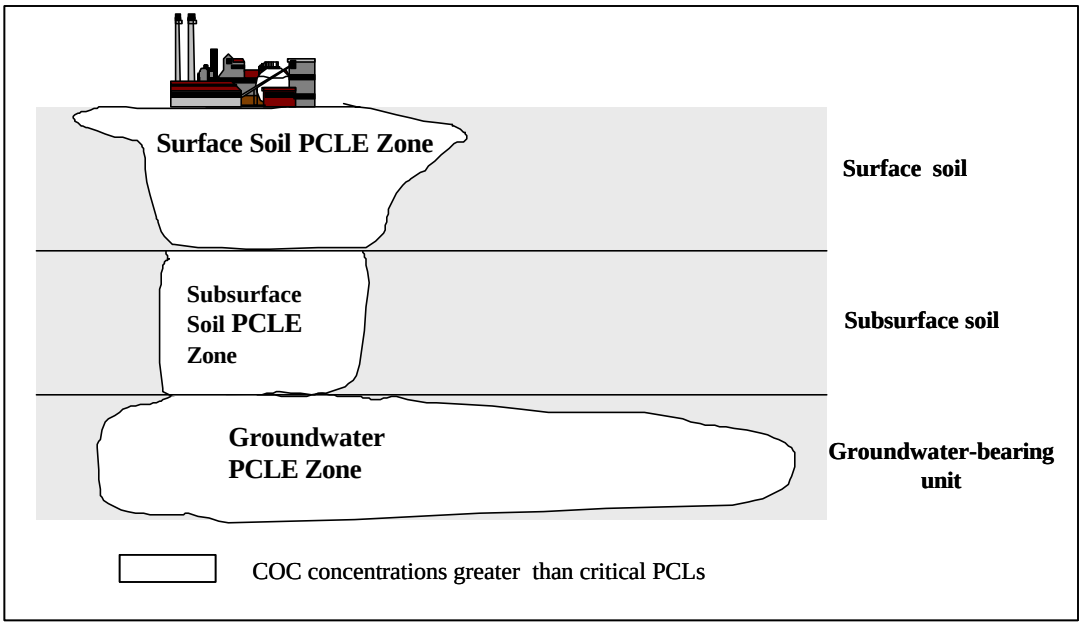

Figure 2. Cross-section view of an affected property illustrating soil and groundwater PCLE zones.

Remedy Standard A is a "pollution cleanup" remedy that requires the affected media to be removed and/or decontaminated. Remedy Standard B is an "exposure prevention" remedy and allows removal, decontamination, and control remedies or control remedies alone. The terms remove, decontaminate, and control as used in TRRP are defined in Table 1. Table 1 also provides examples of remedial technologies that qualify for removal, decontamination and control.

A selected remedy standard applies to all media at an affected property. An affected property is the extent of environmental media with a COC in excess of a residential assessment level. There may be more than one affected property within a tract of land or a facility. For further explanation of an affected property, see TNRCC guidance document *Land Use Classification* (RG-366/TRRP-9). TRRP does not allow the person to mix and match Remedy Standards A and B with different media within a single affected property. For example, you cannot use Remedy Standard B for soil and Remedy Standard A for groundwater for the same affected property. If the soil PCLE zone in Figure 2 is to be capped, but the associated groundwater PCLE zone is to be decontaminated, then the remedy standard applied to the affected property (soil and groundwater) is Remedy Standard B. Likewise, if a control measure is used to address the on-site portion of a PCLE zone at an affected property, but removal is used to address an off-site portion of the same PCLE zone, then Remedy Standard B is what has been applied to the affected property even though the off-site portion is remediated to a Remedy Standard A equivalent. If there are two or more distinct affected properties resulting from different sources within a single piece of property (e.g., different SWMUs within an operating facility), you can use Remedy Standard A for one affected property and Remedy Standard B for the other.

The relationship between PCLs and remedy standards are illustrated in Figure 3. In short, PCLs determined under Tiers 1, 2, and/or 3 can be used with Remedy Standard A or B (Figure 3 and Table 2). However, if the Remedy Standard B plume management zone option is used, then lateral groundwater transport considerations must be made under Tier 2 or 3. Therefore, it is wise to anticipate and keep in mind preferences for the remedy from the outset. (Note that ecological PCLs are only established under Tier 2 or 3 of the ecological PCL development process.).

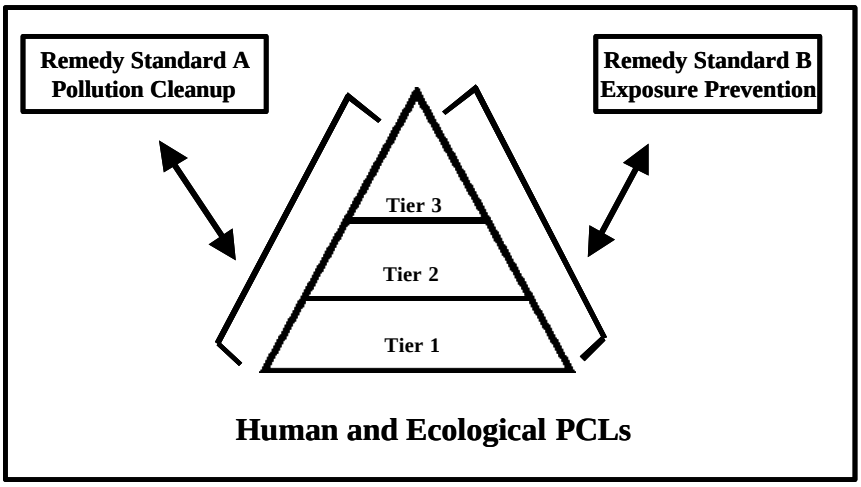

Figure 3. The relationship between PCL development and remedy standards.

Table 1. Remedy Options for Remedy Standard A and B.

Remedy Standard	Response Objectives	Typical Remedial Technologies
A & B[1]	**Remove –** a removal remedy is the direct removal of concentrations of COCs that exceed the critical PCLs. Waste or environmental media are removed from the affected property to another location for storage, processing, or disposal in accordance with all applicable requirements.	Excavation
		Pump and disposal
A & B[1]	**Decontaminate** – a decontamination remedy means a permanent and irreversible treatment process that results in the elimination of concentrations of COCs that exceed their respective critical PCLs. In order for a treatment process to achieve decontamination, it must be demonstrated that it "permanently and irreversibly destroys or extracts COCs in a waste or environmental medium" to levels below the critical PCL and that "any remaining residue after treatment will not pose a threat of future release of COCs" at levels greater than the critical PCLs.	Air sparging
		Biological degradation
		Carbon adsorption
		Chemical Fixation[2] (including metals precipitation)
		Chemical oxidation
		Incineration/thermal desorption
		Monitored natural attenuation
		Pump and treat
		Reactive treatment
		Soil vapor extraction
		Solidification[2]
		Solvent extraction
		Stabilization[2]
		Steam injection
		Surfactant flushing
		UV treatment of water
B only	**Control** – a control remedy uses physical and/or institutional controls in combination with appropriate maintenance, monitoring, and any necessary further response action to prevent the exposure of human or ecological receptors to concentrations of COCs that exceed their respective PCLs.	Chemical Fixation[2] (including metal precipitation)
		Engineered caps/lateral barriers
		Hydraulic Barriers / Containment
		Impermeable barrier
		Interceptor trenches
		Liners
		Monitored natural attenuation
		Reactive permeable wall
		Solidification[2]
		Stabilization[2]

1. Removal and decontamination are in combination with controls in Remedy Standard B.
2. Stabilization, solidification, and fixation are initially presumed to be a control measure until a demonstration is made that the process can achieve the decontamination performance requirements. (§350.31(b))

Table 2 provides a comparison between Remedy Standards A and B.

Table 2. Comparison of Remedy Standards A and B.

Attribute	Remedy Standard	
	A	**B**
Self-implementation allowed	Yes	No
Land Use and Property Limits		
• Residential	Yes	Yes
• Commercial/industrial	Yes	Yes
• On-site	Yes	Yes
• Off-site	Yes	Yes
Applicable groundwater class		
• Class 1	Yes	Yes
• Class 2	Yes	Yes[1]
• Class 3	Yes	Yes[1]
Tiered PCL development		
• Tier 1 PCLs	Yes	Yes
• Tier 2 PCLs	Yes[2]	Yes[2]
• Tier 3 PCLs	Yes[2]	Yes[2]
Response objective		
• Remove	Yes	Yes
• Decontaminate	Yes	Yes
• Control	No	Yes
Physical Controls	No	Yes
Institutional Controls	Sometimes[3]	Always
Ecological Services Analysis	No	Yes
Post-Response Action Care (PRAC)	No	Yes
Financial Assurance	No	For physical controls
No Further Action letter	Yes	Yes[4]

[1]A plume management zone is not applicable to class 1 groundwater unless restoration is technically impracticable.

[2]Ecological PCLs are only established under Tiers 2 and 3.

[3]See Table 3

[4]A conditional No Further Action letter is issued after completion of the remedy and a final No Further Action letter is issued at the completion of PRAC.

Remedy Standard A Requirements

Remedy Standard A is a self-implementing remedy that requires the following response objectives to be achieved:

- Remove and/or decontaminate PCLE zones:
  - Remove any listed hazardous waste which is contained within a waste management facility component or which is separable from environmental media using simple mechanical removal processes (*See FAQ No. 4*);
  - Remove and/or decontaminate any waste or environmental media which is characteristically hazardous due to ignitability, corrosivity, reactivity, or toxicity characteristic;
  - Remove and/or decontaminate the affected media and non-hazardous waste to achieve COC concentrations below the applicable residential or commercial/industrial critical PCLs;
- Prevent PCLE zones from expanding during the response action;
- Demonstrate that the affected property is protective for ecological receptors; and
- Eliminate the accumulation of explosive vapors originating from COCs in surface or subsurface structures. This response objective also applies to areas of routine construction such as within utility excavations, for example.

Figure 4 illustrates the same affected property presented in Figure 3 after a response action has been completed under Remedy Standard A. Note that all former PCLE zones have been removed or decontaminated in their entirety such that no critical PCLs are exceeded.

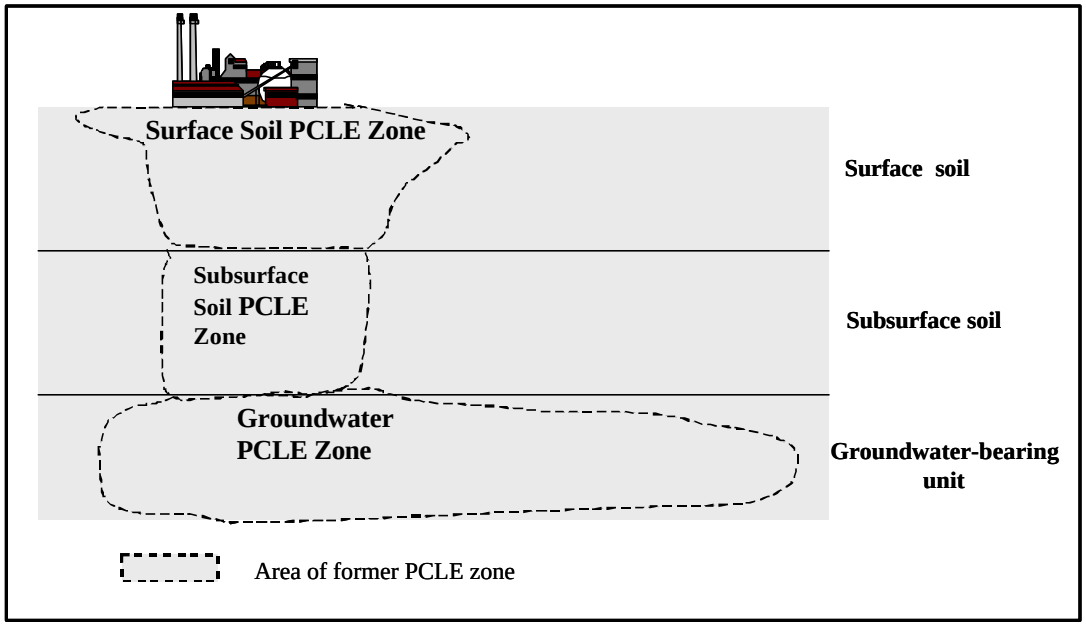

Figure 4. Cross-section view of an affected property following completion of Remedy Standard A.

Remedy Standard A Process

Response actions under Remedy Standard A must result in permanent risk reduction at the affected property and the person may be required by the TNRCC to demonstrate the "appropriateness" of the remedy (*See FAQ Nos. 5 & 6*). Moreover, if Remedy Standard A is used, the person must achieve compliance with PCLs

that are based upon exposure of human and ecological receptors to COCs directly within, above or below a source medium, i.e., lateral transport considerations are not allowed.[1] Other notable distinctions of Remedy Standard A are that a person may not use technical impracticability arguments, migration of COCs in groundwater above the critical PCL must be prevented, and post-response action care is not required.

Figure 5 illustrates the Remedy Standard A process. Following the determination that TRRP is applicable and the completion of the affected property assessment, the person must decide whether Remedy Standard A will be used to address the PCLE zones. If not, then Remedy Standard B must be used. If the person elects to use Remedy Standard A, then the person needs to decide whether to self-implement. If the person chooses to self-implement the remedy, then a *Self-Implementation Notice* (SIN) (TNRCC Form 10323) must be submitted to the TNRCC at least 10 days before the response action is initiated. The SIN will be reviewed by the TNRCC, but the person is authorized to proceed with the response action after that 10^{th} day regardless of whether the TNRCC has responded. If TNRCC determines the planned response action does not appear to be appropriate, then the person will be either directed to demonstrate response objectives can be met or change the response action. The *Affected Property Assessment Report* (APAR) (TNRCC Form 10325) does not have to be submitted to the TNRCC before or with the SIN. If the person does not elect to self implement the response action, then a *Response Action Plan* (RAP)(TNRCC Form 10326) must be submitted for TNRCC approval in advance of conducting the response action (Figure 5). An APAR must be submitted with the RAP unless the APAR has been previously submitted.

After submittal of the SIN or approval of the RAP, the next step is to implement the response action. If the response action takes more than three years to complete, then at the three-year anniversary of the date of submittal of the SIN or date of TNRCC approval of the RAP, a *Response Action Effectiveness Report* (RAER) must be submitted. In specific cases, TNRCC may require earlier submission of the RAER. If the APAR has not already been submitted, submit the APAR with the first RAER. The RAER is a progress report. If upon review of the RAER the TNRCC determines insufficient progress is being made in the context of the schedule provided in the SIN or RAP, the TNRCC will request the response action effectiveness to be improved or the response action to be changed. A RAER will need to be submitted at each subsequent three-year anniversary or other site-specific frequency approved or required by the TNRCC.

When the response action is considered to be complete by the person, confirmation samples will typically need to be collected to verify critical PCLs are met in order to document attainment of Remedy Standard A (Figure 5). In the situation where monitoring has been conducted over a period of time to verify that critical groundwater PCLs are not exceeded, as will typically be the case, then the final monitoring event should be considered to be the confirmation samples. Notify the TNRCC at least 10 days before confirmation samples are collected. Subsequently, if the confirmation samples demonstrate the response action is complete, submit a *Response Action Completion Report* (RACR) (TNRCC Form 10328) within 90 days for TNRCC approval. If an APAR has not been previously submitted, submit the APAR with the RACR. If the confirmation samples indicate critical PCLs are exceeded, then response actions must be continued.

Within 90 days of the date of TNRCC approval of the RACR, the person must submit proof of the filing of any required institutional controls to the TNRCC. After any institutional control requirements are met, the TNRCC will issue a "No Further Action" letter to close the case. Institutional control requirements that may be triggered are identified in the Institutional Control section of this document.

[1] If the risk-based exposure limit for inhalation is based on occupational inhalation criteria for commercial/industrial exposure, then an additional demonstration must be made that air concentrations will also be protective for off-site residents (See §350.74(b)(1)). Also, for the ^{SW}GW pathway, lateral transport may be used to set attenuation action levels for the groundwater source area so that the ^{SW}GW PCL is met in groundwater at the ^{SW}GW POE.

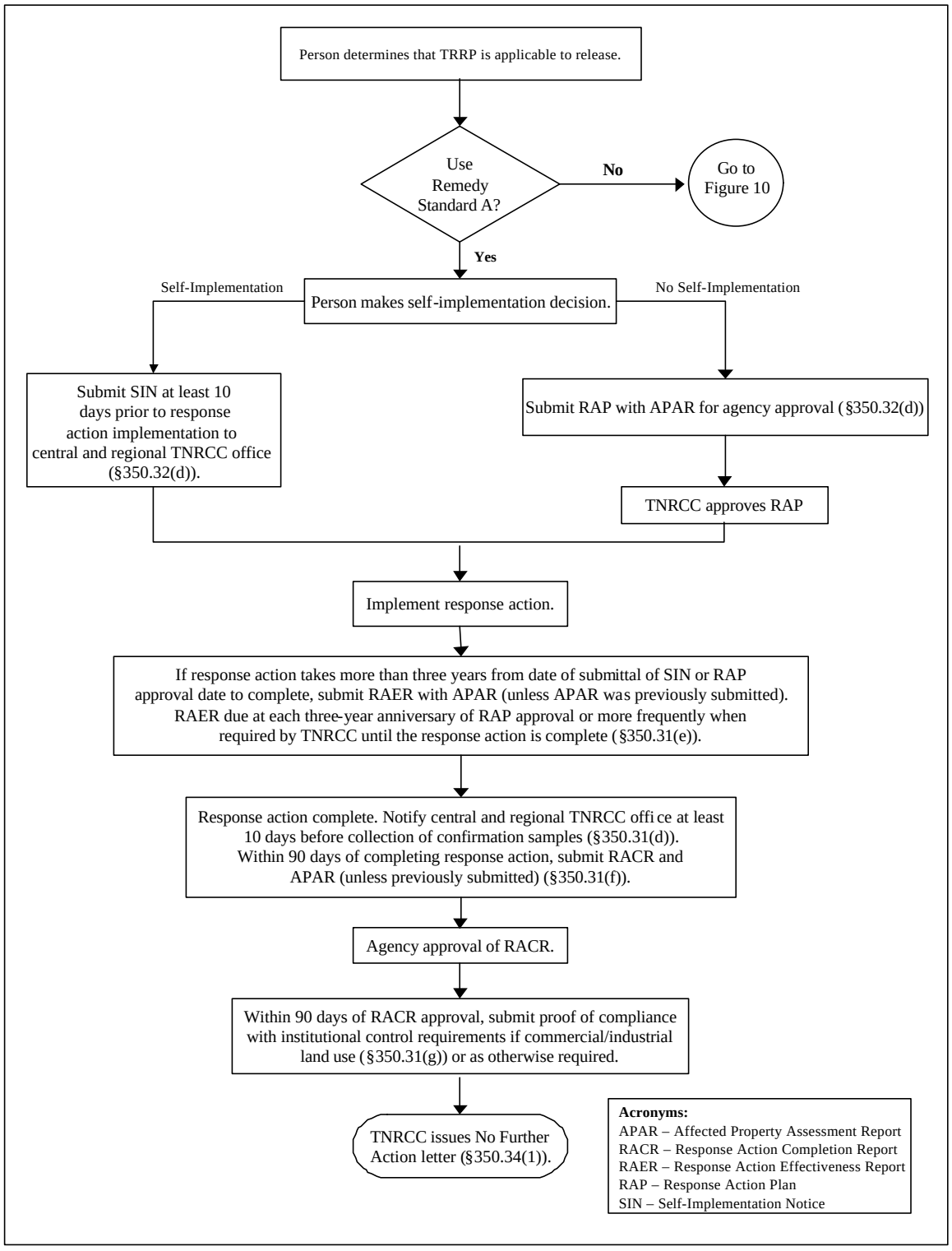

Figure 5. Remedy Standard A Process

Remedy Standard B Requirements

Remedy Standard B provides more options than Remedy Standard A. In addition to removal and/or decontamination remedies, under Remedy Standard B you may also elect to prevent exposure to COCs through the use of physical control measures (Figure 6). For example, in lieu of removing or

decontaminating the soil and groundwater PCLE zones, the soil PCLE zones may be capped and the groundwater PCLE zone may be kept under hydraulic containment and managed such that exposure to the groundwater PCLE zone does not occur. However, the goal of TRRP is to preserve the active and productive use of land. Therefore, use of physical controls such as fences as the sole remedy to prevent exposure is unacceptable, even if in combination with an institutional control.

As a condition of applying exposure prevention remedies, there commonly will be some element of continuous obligation to conduct post-response action care until critical PCLs are not exceeded. Additionally, Remedy Standard B is not self-implementing. A person pursuing action under Remedy Standard B must first obtain written TNRCC approval of the RAP.

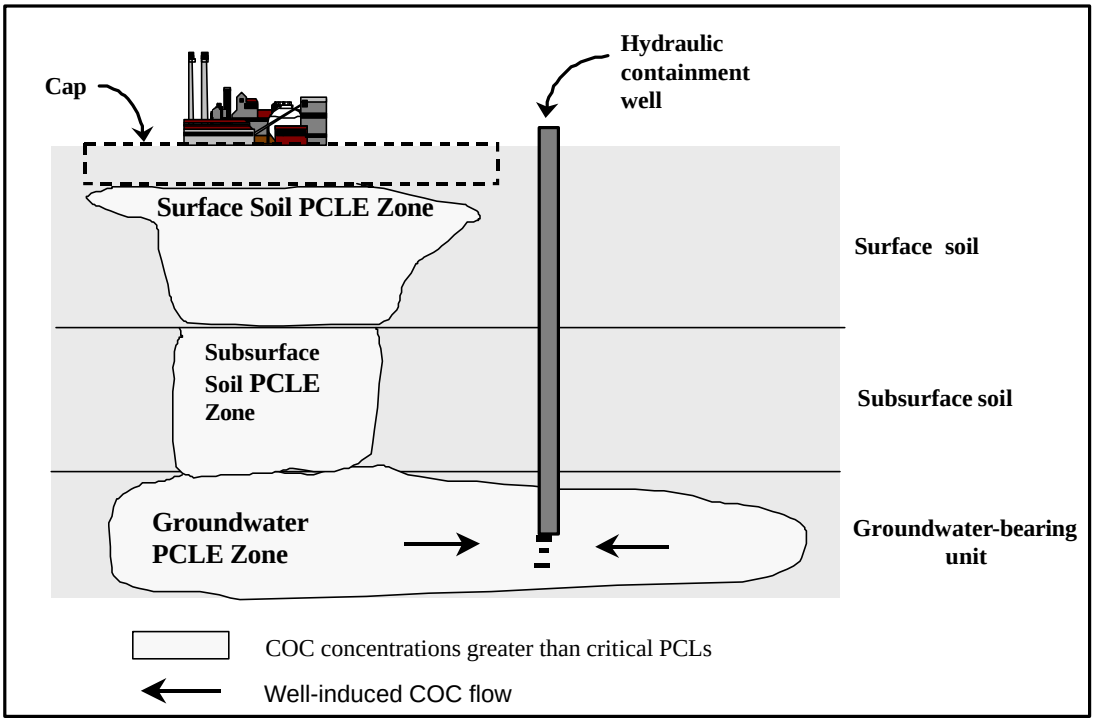

Figure 6. Cross-section view of an affected property after application of a Remedy Standard B remedy.

The standard response objectives for Remedy Standard B are as follows:

- Remove, decontaminate and control, or control PCLE zones (environmental media and hazardous and non-hazardous waste) such that people will not be exposed to COCs at concentrations greater than the human health PCLs;
- Prevent COCs in soil from leaching to class 2 groundwater within an established plume management zone at concentrations that would cause COC concentrations in the groundwater to increase above the COC concentrations measured at the time of RAP submittal;
- Prevent PCLE zones from expanding during the response action other than within the context of a plume management zone;
- Manage exceedances of ecological PCLs by:
  - removing, decontaminating, and controlling, or controlling the COCs that exceed the ecological PCL, or
  - using an Ecological Services Analysis (ESA) option and, where appropriate, provide compensatory ecological restoration; and

- Eliminate the accumulation of explosive vapors originating from COCs in surface or subsurface structures. This response objective also applies to areas of routine construction such as within utility excavations, for example.

Under Remedy Standard B you may combine one or more response actions (remove, decontaminate, control and/or ESA) to achieve compliance with the response objectives (*See FAQ No. 6*). In the RAP, it will be necessary to demonstrate that the response actions will have a high likelihood of success, and if controls are to be used, they will be able to reasonably contain the COCs and prevent exposure to COCs in excess of critical PCLs.

Modifications of the Standard Remedy Standard B Response Objectives

Remedy Standard B provides the following specific areas of flexibility that do not exist under Remedy Standard A:

- If there are only ecological concerns for a portion of an affected property (i.e., only ecological PCLs are exceeded or ecological PCLs are exceeded following completion of a response action to address human health PCLs) and with approval of the Natural Resource Trustees, the person may elect to use an ESA as provided by §350.33(a)(3)(B) to evaluate the affected property and, if appropriate, offset risk through compensatory ecological restoration for that portion of the affected property. (See the TNRCC guidance document *Guidance for Conducting Ecological Risk Assessment at Corrective Action Sites in Texas* (Draft Final, August 28, 2000) for information on ESA.)
- Additional options available upon TNRCC approval for addressing groundwater PCLE zones, referred to as modified groundwater response approaches in §350.33(f), include:
  - waste control unit exclusions,
  - demonstration of technical impracticability, and
  - establishment of a plume management zone for affected class 2 and 3 groundwater.

The following discussion highlights the modified groundwater response objectives available in the rule that are addressed in greater detail in a separate TNRCC guidance document entitled *Soil and Groundwater Response Objectives* (RG-366/TRRP-29).

Waste Control Unit Exclusion

A waste control unit (WCU), as defined in §350.4(a)(91), is a municipal or industrial solid waste landfill, including those Resource Conservation and Recovery Act regulated units closed as landfills, with a liner system (i.e., synthetic or clay) and an engineered cap, that have been closed pursuant to an approved closure plan, previous regulations, or will be closed pursuant to an approved RAP. To be able to use the WCU designation, you must propose it in the RAP and receive approval from the agency.

A WCU exclusion allows the portion of an existing groundwater PCLE zone in class 1, 2 or 3 groundwater that directly underlies the WCU from having to be restored to critical PCLs (Figure 7). However, beyond the perimeter of the WCU, the critical groundwater PCLs must be met unless otherwise changed by another modified groundwater response objective. The perimeter or “edge” of the WCU is defined by the lateral extent of the cap or liner. Therefore, the point of exposure (a monitor well) at which the critical groundwater PCLs must be met is at the perimeter or “edge” of the WCU (Figure 7). In other words, there is no point of exposure for the groundwater beneath a WCU.

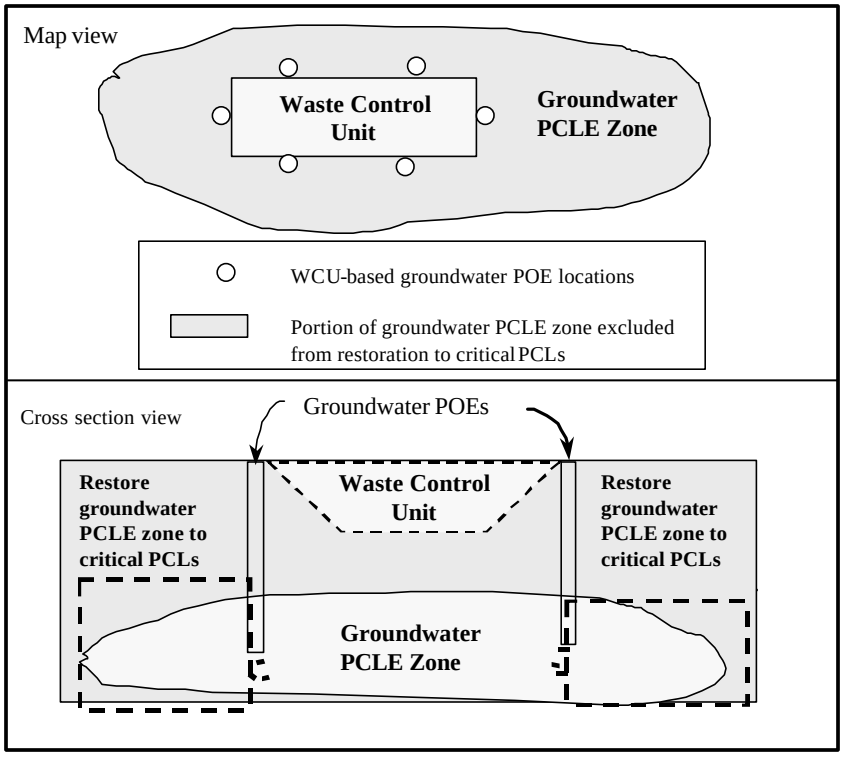

Figure 7. Waste control unit exclusion area within groundwater PCLE zone.

Technical Impracticability

Technical impracticability (TI) is a term used to address situations where the reduction of COCs to the critical PCL within a reasonable timeframe is not feasible due either to hydrogeologic or COC-specific factors using currently available remediation technologies.

As outlined in §350.33(f)(3)(A) through (F), TI may be used for affected class 1, 2 and 3 groundwaters. A person must submit a TI demonstration in a RAP that meets the criteria established in the rule for TNRCC approval. The person is required to restore the groundwater to the critical groundwater PCLs to the extent possible, and establish a plume management zone for the portion that cannot be restored (Figure 8). However, the person is not allowed to take advantage of any of the flexibility that would normally be afforded with a plume management zone in accordance with §350.37(l)(4) or §350.37(m) for expansion of the PCLE zone. The existing limits of the PCLE zone must not be allowed to increase.

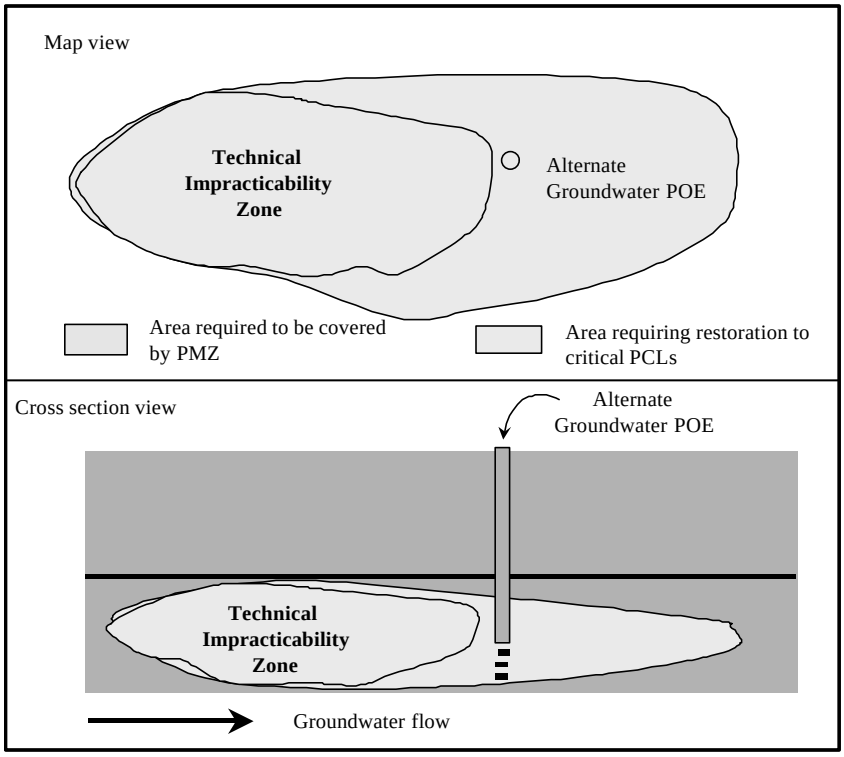

Figure 8. Example of technical impracticability application.

Plume Management Zones

A plume management zone (PMZ) modifies the standard groundwater restoration response objectives to allow the person to control and prevent use of, and exposure to, the groundwater within the PMZ. A PMZ is defined in §350.4(a)(65) as the area of the groundwater PCLE zone at the time of RAP submission, plus any additional area allowed in accordance with §350.37(l)(4) for class 2 groundwater and §350.37(m) for class 3 groundwater. As outlined in §350.33(f)(4)(A) through (F), a person may propose in the RAP to use a PMZ under Remedy Standard B for affected class 2 or 3 groundwaters that presently contain a PCLE zone. With an approved PMZ, the prescribed groundwater POE may be relocated from within and throughout the groundwater PCLE zone to an alternate location in the downgradient flow path of the PCLE zone (Figure 9). The PMZ may be proposed to be smaller than, equal to, or larger than the size of the PCLE zone existing at the time of submission of the RAP. For specific details on determining the limits of a PMZ, see TNRCC guidance document *Human Health Points of Exposure* (RG-366/TRRP-21).

Additional requirements such as monitoring the hydraulic gradient, establishing attenuation monitoring points and action levels, non-aqueous phased liquid (NAPL) reduction, and post-response action care will be necessary.

The use of a PMZ will affect the soil response objectives regarding protection of the underlying groundwater. For surface or subsurface soils associated with a PMZ established for either class 2 and class 3 groundwater, the soil leachate requirements are relaxed because the attenuation of the COC during lateral transport from the groundwater source area to the alternate POE may be considered (Figure 9). Without a PMZ, there is no consideration of the attenuation of the COCs in groundwater due to lateral transport. In the situation of no PMZ, the POE is presumed to be at all points in the groundwater below the COC source area as represented by the "Prescribed Groundwater POE" in Figure 9. Any soil leachate must allow critical groundwater PCLs to be met at the prescribed POE.

There is an additional requirement for a PMZ established for class 2 groundwater. Over the lifespan of the PMZ, any soil leachate cannot be allowed to increase the concentration of COCs in the groundwater above the concentration measured at the time of the submittal of the RAP to the TNRCC. In other words, even if higher COC concentrations in the groundwater source would not result in exceeding the critical groundwater PCL at the alternate POE for class 2 groundwater, the COC concentrations in the groundwater source area cannot be allowed to be increased. This requirement is not applicable when a PMZ is established for class 3 groundwater.

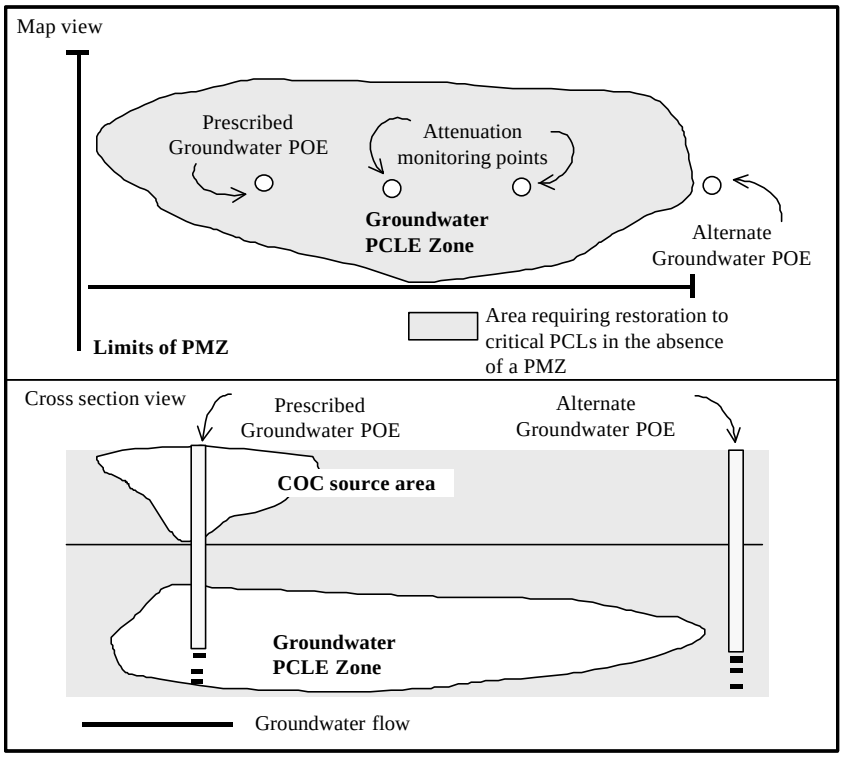

Figure 9. Example plume management zone.

Remedy Standard B Process

Figure 10 illustrates the process for response actions performed under Remedy Standard B. Following determination that TRRP is applicable and the completion of the affected property assessment, the person must decide whether Remedy Standard B will be used to address the PCLE zones. If not, then Remedy Standard A must be used. If the person elects to use Remedy Standard B, then the first step is to submit a RAP for TNRCC approval (Figure 10) as well as the APAR if it has not been previously submitted.

After approval of the RAP, the next step is to implement the response action in accordance with the schedule approved in the RAP. As discussed later in this document, financial assurance or specific institutional controls may be required to be established within 90 or 120 days from the date of TNRCC approval of the RAP. These requirements will need to be met when applicable.

If the response action takes more than three years to complete, then at the three-year anniversary of the date of TNRCC approval of the RAP, a RAER must be submitted. The TNRCC may require earlier submission of the RAER. If upon review of the RAER, the TNRCC determines that insufficient progress is being made in the context of the schedule approved in the RAP, then the TNRCC can request the response action

effectiveness to be improved. The RAER must be submitted at each subsequent three-year anniversary or other site-specific frequency approved by the TNRCC until the response action is completed.
When the response action is considered by the person to be complete, confirmation samples will typically need to be collected to verify critical PCLs are met in the PCLE zone(s) or beyond the limits of the control (Figure 10). In the situation where monitoring has been conducted over a period of time to verify that critical groundwater PCLs are not exceeded in the groundwater, as will typically be the case, then the final monitoring event should be considered to be the confirmation samples. Notify the TNRCC at least 10 days before confirmation samples are collected. Subsequently, if the confirmation samples demonstrate the response action is complete, submit a RACR within 90 days for TNRCC approval.

Following agency approval of the response action, proof of filing of all required institutional controls must be submitted to the TNRCC within 90 days of the approval of the RACR. After all institutional control requirements are met, the TNRCC will issue a Conditional No Further Action letter and the post-response action care period begins (Figure 10). *Post-Response Action Care Reports* (PRACR) (TNRCC Form 10329) must be submitted in accordance with the schedule approved in the RAP. When the person can demonstrate that post-response action care is not warranted in accordance with §350.33(i), then the agency will issue a No Further Action letter to close the case. The following section provides an overview of the post-response action care requirements.

Overview of the Remedy Standard B Post-Response Action Care Requirements

The post-response action care requirements are defined in the rule in §350.33(g)-(n). Post-response action care is only applicable to Remedy Standard B. The type, method, and extent of post-response action care will be determined on a site-by-site basis in the approved RAP. The post-response action care period begins upon the approval of the RACR by the TNRCC.

The default initial post-response action care period is 30 years. However, criteria are outlined in §350.33(h)(1)-(3) that allow the person to demonstrate that a shorter post-response action care period would be appropriate. During the post-response action care period a person may submit a demonstration to the TNRCC that documents one of the conditions outlined in §350.33(i)(1)-(4) is met. Upon written approval by the TNRCC, the remainder of the post-response action care period will be cancelled. In addition, the person will be released from the requirement to maintain financial assurance, and the financial assurance will be returned.

However, if the person cannot make one of the demonstrations in §350(i)(1)-(4) by the end of the initial post-response action care period, the person will be required to continue post-response action care for an additional 30 years unless the criteria for a shorter period or termination of post-response action care can be demonstrated as outlined above.

The person is required to perform the following record keeping during the initial and any subsequent post-response action care period (§350.33(k)):

- Keep a copy of the approved RAP at the property or other specified location;
- Keep records of monitoring data, maintenance and inspection reports and unexpected occurrences affecting any waste control unit or post-response care systems;
- Submit post-response action care reports (PRACRs) as outlined in the RAP; and
- Notify the executive director within 30 days if it is determined that additional response actions will be required at the affected property.

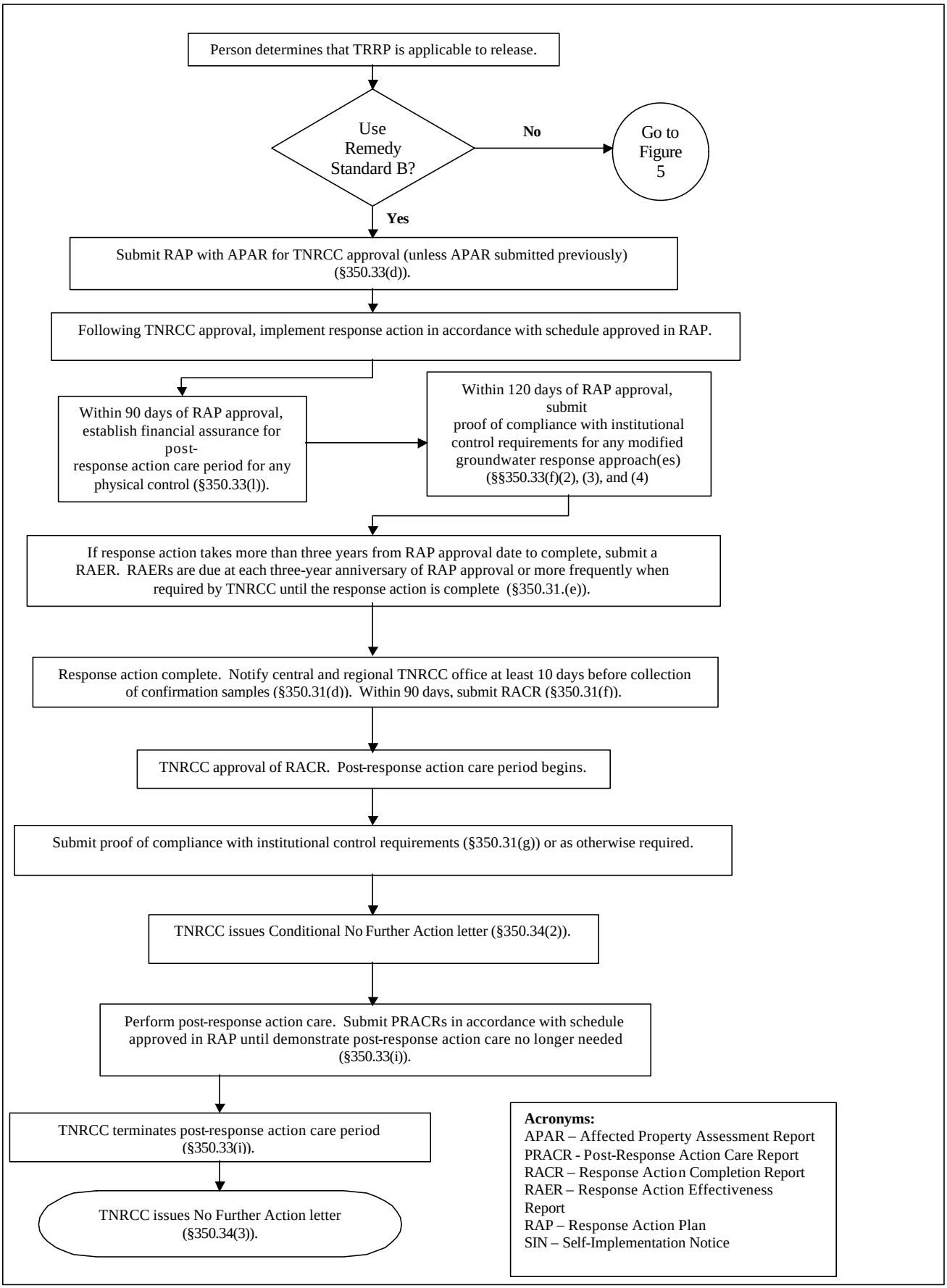

Figure 10. Remedy Standard B process.

For affected properties using physical control measures in response to §350.33(e)(2) and/or (f), financial assurance must be established for the post-response action care in accordance with §350.33(l). Compliance with §350.33(l) involves the following:

- A cost estimate must be included in the RAP of the total cost of the post-response action care activities. The costs must assume a third party is conducting the activities;
- An acceptable financial assurance mechanism must be submitted within 90 days of approval of the RAP, before starting activities approved in the RAP; and
- If the cost estimate is less than $100,000, then the TNRCC may exempt the person from a financial assurance demonstration.

The TNRCC may perform post-response action care activities using the financial assurance funds if it is determined that a person has failed to provide adequate care.

For properties using physical control measures in response to §350.33(e)(2) and/or (f) that require post-response action care beyond the initial post-response action care period, financial assurance must be continued as required by §350.33(m). Compliance with §350.33(m) involves the following:

- Financial assurance must be demonstrated for the continuing post-response action period.
- At least 180 days before the end of the preceding post-response action period, a written cost estimate shall be submitted for continuing the activities; and
- Remaining conditions are the same as those stated above for §350.33(l).

Provisions in §350.33(n)(1) and (2) allow a qualified small business to reduce the amount of financial assurance to be demonstrated if the initial post-response action care period is greater than 10 years. A small business is defined as having fewer than 100 full time employees and net annual receipts of less than $3,000,000. In order to utilize this opportunity, the person must submit an affidavit to the TNRCC in the RAP attesting to the qualifications as a small business.

Institutional Controls

Remedy Standards A and B provide certain areas of flexibility. In some cases, this flexibility requires the use of institutional controls. The situations that precipitate the filing of a control are listed in Table 3. An institutional control is defined in the rule in §350.4(a)(47) as "[a] legal instrument...in the form of a deed notice, Voluntary Cleanup Program Certificate of Completion, or restrictive covenant which indicates the limitations on or the conditions governing use of the property which ensures protection of human health and the environment or equivalent zoning and governmental ordinances." Institutional controls are addressed in the TRRP rule in Subchapter F (Institutional Control) wherein the requirements and applicability of these controls to remedy standards and exposure adjustments are presented. For comprehensive information on TRRP institutional control requirements, see TNRCC guidance document *Institutional Controls* (RG-366/TRRP-16).

Table 3. Institutional Control Situations

Action Requiring Institutional Control	Remedy Standard A	Remedy Standard B
Commercial/industrial land use is assumed	Yes	Yes
Response action to take in excess of 15 years to complete	Yes*	Yes*
Use of non-standard exposure area assumptions	Yes	Yes
Use of occupational inhalation criteria as risk-based exposure limits	Yes	Yes
Use of modified exposure factors for exposure duration and exposure frequency, and averaging time	Yes	Yes
Use of controls • Physical controls • Waste control unit • Plume management zone	Not applicable	Yes
* TNRCC discretion to require institutional controls		

Selection Considerations in Deciding between Remedy Standard A and B

The decision to select Remedy Standard A or Remedy Standard B is highly dependent on site-specific factors and the existing and intended land use of the affected property. Since the major difference between Remedy Standard A and B is the ability to use control remedies, considerations about which remedy standard to select should be focused on issues surrounding application of a control. Table 4 lists some of the primary considerations. Keep in mind that a chief consideration is the ability to get consent from the landowner for the required institutional control. However, for a single affected property where on-site/off-site properties are involved, controls can be placed on the individual properties where consent is not a barrier, and removal or decontamination can be pursued on those individual properties where landowner consent is a barrier to application of a control. On those properties where removal or decontamination is pursued, no consent is required for institutional controls because no institutional control would be applicable to that property (presuming residential land use is assumed). The remedy standard is still Remedy Standard B, but landowner consent would only be required to be obtained for those properties where a control is used.

The feasibility of achieving Remedy Standard A should also be considered, before selecting Remedy Standard B (Figure 11). This is not a formal feasibility evaluation to be submitted to the TNRCC as a justification for selecting Remedy Standard B. Rather, when it is feasible to implement Remedy Standard A, the person should give specific thought to using Remedy Standard A. By doing so, some of the facets associated with Remedy Standard B such as institutional controls, post-response action care and financial assurance may be avoided.

Table 4. Control Application Considerations

Application of a Control	Considerations
Landowner consent for required institutional control	Landowner consent is required for the filing of institutional controls to be accepted by TNRCC, unless: • an existing equivalent zoning or governmental ordinance satisfies the need for an institutional control • technical impracticability has been demonstrated and court procedures are followed: • the landowner cannot be identified (§350.111(c)). If landowner consent cannot be obtained, the control measure cannot be used and the PCLE zone must be removed or decontaminated.
Groundwater classification	Class 1 groundwater must be restored except where WCU exclusions apply or where technical impracticability has been demonstrated.
Effectiveness of control	The control must be capable of containing COCs as appropriate and preventing exposure in consideration of the COC chemical and physical properties, exposure pathway, and property conditions. For example, a cap to address COCs where the primary exposure pathway is inhalation will have different performance requirements than for a cap to address COCs where the primary exposure pathway is via direct contact.
Site conditions	Existing building foundations, pavement, and other impermeable surfaces may be adequate pre-existing control measures where they can be determined to be effective, and may also present logistical difficulties to removal or decontamination. Also, such planned structures as buildings, parking lots, etc. may be effective controls if properly designed for those considerations
Remedial Action Plan	Control remedies must be proposed in a RAP and be approved by the TNRCC before they may be implemented. Where time is an issue, it may be more efficient to self-implement a removal or decontamination remedy.
Post-Response Action Care (PRAC)	• Property transfers could be impacted due to the need to maintain property access rights over the life of the PRAC period. • PRAC must continue until the control can be proven to be effective over the long term or until COC concentrations within the control area no longer exceed critical PCLs. Therefore, long-term costs must be considered. • Financial assurance must be provided for the inspection, operation, and maintenance of the control.

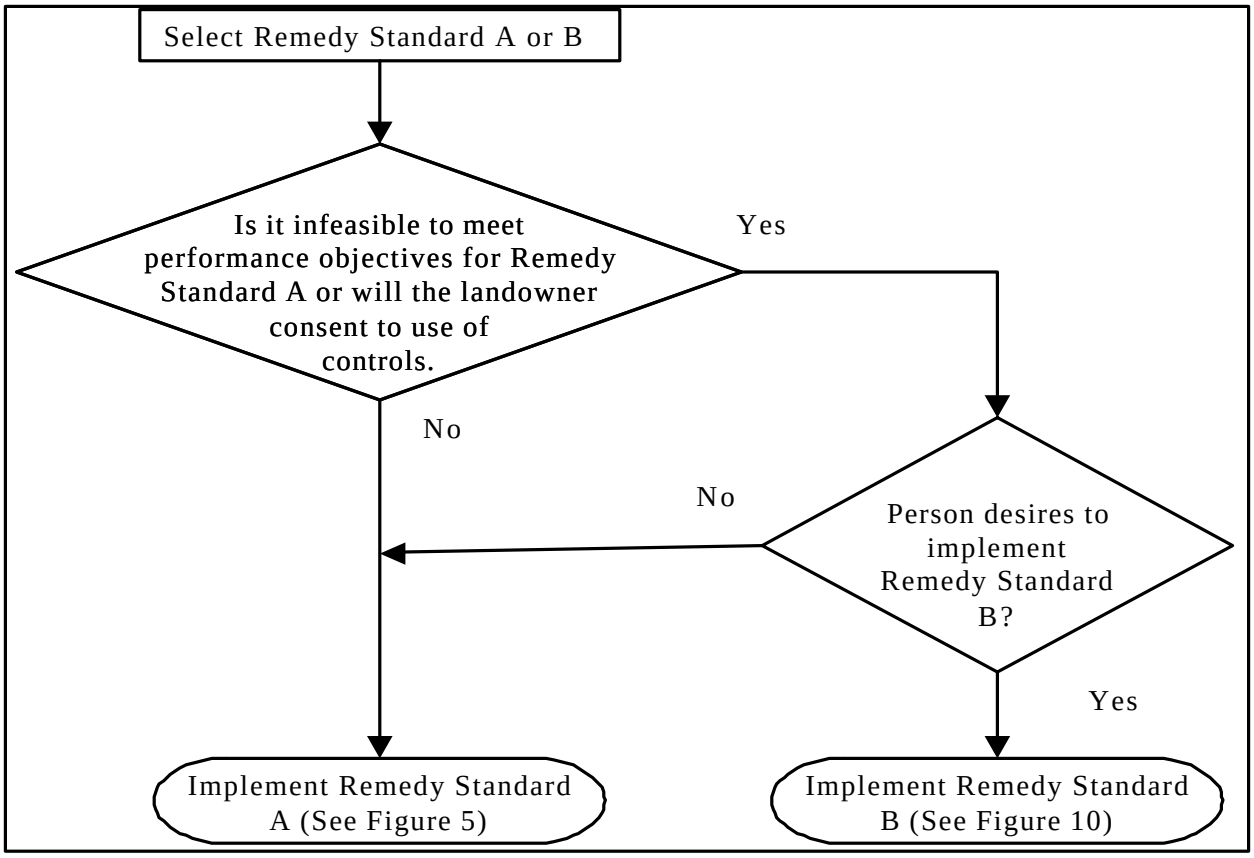

Figure 11. Logic diagram of selecting between Remedy Standard A and B.

Reasonable Timeframes and Acceptable Remedial Progress

In general, factors such as COC chemical and physical properties, the site-specific hydrogeology, current exposure or threatened receptors, ability of the person to prevent exposure during the response action, planned land use or groundwater development time frames are considered in determining whether or not a planned response action is appropriate. The TNRCC is prepared to reject response actions when it is clear from the beginning that they will not work or will work so slowly that the response time cannot be considered "reasonable". The TNRCC ultimately determines if a response action is acceptable and thus decides if a planned schedule is reasonable. The TNRCC does not plan to mandate a standard specific maximum allowable period of time for the completion of response actions. The person will propose a reasonable time frame to the TNRCC with justification in the SIN or RAP for approval. To provide some guidance on the concept of reasonable time frame and conditions that may satisfy the intent of the purpose of this rule, significant site-specific factors and hypothetical cases are described below:

- toxicity/carcinogenicity of the COC (including consideration of the relationship between the length of exposure and manifestation of the toxic/carcinogenic response)

- groundwater classification
- ecological risk
- migration time to POE
- exposure pathway
- land use
- cost of possible response actions
- presence of acute and significant hazard

For example, assume a release at an affected property has impacted a shallow class 1 groundwater with COCs. The groundwater-bearing unit is a highly transmissive, clean sand. A municipal drinking water well is located three-quarters of a mile down gradient from the affected property (beyond the leading edge of the expanding groundwater PCLE zone). At a minimum, hydraulic control of the PCLE zone should be established as soon as possible. Given this scenario, the TNRCC expects a more aggressive time frame for the completion of a response action. As an alternative example, assume a release of COCs has taken place at an operating facility that has resulted in an affected property that is fully contained within the on-site property boundary. Both soil and shallow class 2 groundwater are affected. Little or no COC migration is taking place. It has been proven that the affected property poses no near term risk to human health or environmental receptors. As long as the conditions at the site do not change and the PCLE zone does not expand, a reasonable time frame for the completion of the response action at this affected property might be the operating life of the facility. However, this is not meant to imply that no remedy is required until the end of the operational life of the facility – the point is that the affected property represents low risk, therefore, a remedy standard that requires more time to operate would be acceptable.

The response action must address all exposure pathways for which PCLs are exceeded, and not just the exposure pathway represented by the critical PCL. Additionally, note that the pathway represented by the critical PCL may not be the most urgent pathway. Therefore, response actions may need to be phased in order to first address areas posing increased risk to human health or the environment. The person can undertake a fast-paced response action to address "near term" or immediate exposure concerns, while employing a less aggressive response action to address other areas having no near term or immediate exposure concerns. For example, COC concentrations in surface soil exceed both the PCLs for human exposure ($^{Tot}Soil_{Comb}$) and soil leachate ($^{GW}Soil$). Assume that the PCL for soil leachate is the critical PCL, but given the characteristics of the soils and COCs, concentrations of COCs present do not pose an immediate threat to the underlying groundwater. There is, however, on-going human exposure to the soils. Therefore, focusing the response action on only the exposure pathway underlying the critical PCL in this example is not adequately protective. Rather, while the remediation should address all soils above the critical PCL, the initial focus should be to address the human health exposure to the surface soils.

The TNRCC may require a demonstration of the appropriateness of the remedy. If the TNRCC determines either that insufficient progress is being made toward attainment of the remedy standard or that the response action is inappropriate, then the person will be required to perform an alternative or modified response action. All appropriate remedial alternatives that will meet the time frame and response objectives for the situation may be considered. The performance expectation is that the person is ensuring the response action is monitored, evaluated, and managed such that any ineffectiveness is quickly ascertained and addressed.

Substantial Change in Circumstances

A caveat to any and all response actions undertaken pursuant to TRRP is that, despite the issuance of a no further action letter at the end of the process, the person may be required to undertake additional action if there is a "substantial change in circumstances" that results in an unacceptable risk to human health or the environment (§350.35). The rule specifies that a substantial change in circumstances includes, but is not limited to, the following scenarios:

- changing the land use from commercial/industrial to residential;
- removing, altering or failing to maintain a physical or institutional control;
- a physical or institutional control fails to prevent exposure at the approved performance level;
- an actual exposure condition is determined to be occurring at levels not protective of human health or the environment;
- new information indicates that COCs not identified at the affected property during the assessment are resulting in unacceptable risks to human health or the environment, including potential changes in PCLs due to significant revisions to toxicity factors;
- the size of the exposure area changes resulting in unacceptable risks to human health or the environment; or
- a health and safety plan used to comply with inhalation standards will no longer be maintained.

If the TNRCC determines that a substantial change in circumstances has occurred at an affected property, the person must then address the site conditions using the rule in effect at the time the change occurred.

ATTACHMENT

Frequently Asked Questions Pertaining to Remedy Standards:

1. What are examples of "permanent and irreversible treatment" and of "physical controls"? §350.31(b)

According to §350.31(b), "irreversible treatment" will achieve decontamination by destroying or extracting COCs in a waste or environmental medium to concentrations below the critical PCLs. "Permanent treatment" means that any residue remaining after treatment will not pose a threat of a future release of COCs into environmental media at concentration levels greater than the critical PCLs. Examples of "permanent and irreversible treatment" typically vary depending on the medium.

For soils, sediments and wastes, destruction technologies (e.g., incineration, biological degradation, chemical oxidation) chemically alter the COCs to forms that present negligible risk (e.g. conversion of hydrocarbons to carbon dioxide, water, and other non-toxic breakdown byproducts) or whose risk can be more easily managed. Destruction technologies are typically irreversible for organic COCs and therefore represent permanent remedies. Metals cannot be destroyed but may be converted (e.g., oxidized or reduced) to less toxic valence states. However, metals conversion should not be considered permanent because the reactions are typically reversible, unless permanence is demonstrated. Removal technologies remove the COCs from the soil matrix and transfer them to a medium where they can be more easily managed. Examples of these technologies include steam injection, soils vapor extraction, and surfactant flushing, typically applied *in-situ*. Solvent extraction and thermal desorption are also decontaminant removal technologies, typically applied after excavation of the impacted media (*ex-situ*).

Examples of destruction technologies for groundwater or surface water include UV oxidation, biological treatment, and in some cases monitored natural attenuation. Destruction technologies can be applied either in-situ or ex-situ. Decontamination technologies include air stripping, carbon adsorption, and metals precipitation. However, metals precipitation should not be considered permanent because the reactions are typically reversible, unless permanence is demonstrated.

"Physical controls" do not achieve decontamination by destroying or extracting COCs in a waste or environmental medium, but rather mitigate pathways by creating physical barriers between the impacted medium and the potential receptors. Examples of such controls include containment technologies for solid media (caps for surface barriers, liners for vertical subsurface barriers, and slurry walls for lateral subsurface barriers). In some instances, natural attenuation processes may act as a "natural" physical control against further COC migration.

Physical barriers (e.g., slurry walls, grouting) and hydraulic barriers (e.g., groundwater pumping) may also be applied to contain groundwater plumes.

Stabilization technologies involve solidification of the waste or soil matrix using Portland cement, kiln dust or other pozzolonic material, thereby preventing migration of COCs. In some cases, only sufficient material is added to improve the strength of the matrix to support a cap, which would represent a true physical control application of the technology.

Stabilization is presumed initially by the TNRCC to be a physical control. However, depending on the nature of the waste and the nature and quantity of the additive, significant changes can occur or be achieved that may qualify stabilization as a decontamination technology. For example, if metals and organic COCs can be bound to the matrix and organic liquids can be absorbed into the matrix in such a way as to permanently prevent leaching of COCs into an aqueous medium, then the stabilization could be considered decontamination. Under Remedy Standard B, further measures (e.g. soil and/or vegetative cover) may be required to ensure that direct contact exposure is mitigated. The permanence of a stabilization response action may also need to be demonstrated by consideration of the long-term geotechnical stability of the stabilized matrix.

2. How does a person prove that the treatment residue does not pose a threat of a future release greater than the critical PCLs? §350.31(b)

For soils, sediments, and waste materials subject to decontamination technologies, the proof may be simply to ensure that the concentration of the COC in the treatment residue is less than the critical PCL prior to placement of the residue. See also soil reuse requirements (§350.36).

For *in-situ* treatment technologies, confirmation soil sampling and/or groundwater monitoring may be used to demonstrate the lack of a threat of future release.

For *ex-situ* groundwater treatment, e.g., using air stripping or carbon adsorption, where the groundwater is re-injected, the exit concentration from the treatment unit will need to meet the critical PCL before reinjection, unless an alternate concentration is specifically approved by the TNRCC.

3. What are the criteria to determine if insufficient progress is being made for a remedy? §§350.31(h) and .94(g)

Unforeseen circumstances may occur during implementation of the remediation schedule. If these occur, the person is encouraged to proactively communicate the circumstances and renegotiate the schedule to meet the requirements of the TNRCC by submitting a revised RAP for TNRCC approval. If a serious acute hazard or other imminent and significant environmental threat exists, the schedule may need to be accelerated.

As described in Section §350.94(g), the RAP requires that a schedule for removal actions, decontamination measures, and any physical and/or institutional controls be implemented as the response action for the affected property. Significant delays from the published and approved schedule may be interpreted as insufficient progress. The person therefore should prepare a schedule for the response action that accounts for the magnitude of the risks to human and ecological receptors, and existing and likely future circumstances.

If the TNRCC determines that insufficient progress is being made toward attainment of the remedy standard or that the response action is inappropriate, the agency will require the person to perform an alternative response action. Also, the provision expressed at §350.31(h) allows the agency to require an institutional control to be recorded if a response action is either predicted to take or does take in excess of 15 years to be completed. This process is designed to encourage early completion of response actions.

4. What does the rule mean when it states under Standard A that listed hazardous waste "which is separable from environmental media using simple mechanical removal processes" must be removed? §350.32(a)(1)

The intent of this statement is that discreet layers of hazardous waste should be removed by simple means, to prevent exposure. To illustrate this point, suppose that a response action involves the cleanup of a release from an aboveground storage tank that was used for the storage of a listed hazardous waste (e.g., tetrachloroethene). The tank contents leaked affecting surface and subsurface soils as well as groundwater.

Free liquids contained in low lying areas, such as sumps or ditches, should be removed by simple mechanical means such as vacuum trucks or absorbent pads. Surface soils that can be easily removed by hand tools or backhoes, without the need for structural bracing, are an example of removal by simple mechanical processes.

Examples of mechanical removal processes that are NOT simple would include the use of groundwater pump and treat systems which require engineering design or excavations that require an engineering analysis for structural bracing or special precautions to protect workers or foundations.

Removed wastes and impacted media would need to be managed in accordance with applicable RCRA requirements (see TNRCC guidance document *TRRP Compatibility with RCRA* (RG-366/TRRP-3)). Further response actions may then be conducted in accordance with the requirements for Remedy Standard A.

5. Under what kinds of circumstances would the TNRCC require a demonstration of the appropriateness of a remedy? What are the criteria for that determination? §350.32(b)(3)

Even though the TNRCC does not have to approve response actions performed under Remedy Standard A, the rule does state in §350.32(b)(3) that " *the executive director may require a demonstration of the appropriateness of a remedy in the context of the above-mentioned criteria for any remedy, regardless of the status of self-implementation as allowed in subsection (d) of this section*". The following are some examples of when the TNRCC might ask for a demonstration of the appropriateness of a particular remedy selection. The remedy selection is:

- new or innovative,
- associated with a short time frame until a sensitive receptor is impacted,
- in conjunction with a sensitive receptor which has already been impacted,
- a technology which has historically been documented to be less than effective, or
- an inappropriate application of a particular technology (i.e., air stripping to remove metals from groundwater).

The demonstration of the appropriateness of a particular remedy selection could be provided in the following ways:

- literature documentation,
- pilot field evaluation,
- bench study evaluation,

- conventional industry wisdom, or
- demonstrate that time frame for remedy is appropriate for immediacy of impact.

6. What are examples of control measures and combinations of removal/decontamination response actions? §350.33(a)(3)(A)

An example of a combination type of scenario could be represented by a case where products (e.g., gasoline or diesel fuel) have leaked. The resulting non-aqueous phase liquid (NAPL) "floats" on the groundwater surface and accumulates in the pore spaces of the soil matrix. VOCs dissolve into groundwater that is flowing by the NAPL in a relatively permeable soil causing the formation of a groundwater PCLE zone that is migrating off site.

A plausible response action for this situation may consist of recovery of both NAPL and groundwater (removal from the soil matrix) by groundwater pumping (hydraulic control of the otherwise expanding plume), and treating the extracted groundwater through a biological fluidized bed reactor to destroy hydrocarbons (decontamination), prior to discharge to a municipal wastewater treatment plant.

7. What kinds of demonstrations could be made that physical controls will reliably contain COCs over time? §350.33(e)(2)(A)

Using cement stabilization as an example of a physical control technology, the performance with respect to leachability may be demonstrated by:

- review of technology performance literature;
- treatability testing to establish the nature and quantity of required additives and to predict the expected results;
- construction quality control and assurance plan for implementation to minimize scale-up concerns;
- confirmation sampling of the stabilized matrix; or
- monitoring of groundwater and surface water media may also be required to assure that leachability criteria are not exceeded at the point of exposure.

For a scenario where groundwater pumping is used to provide hydraulic control, groundwater monitoring, possibly coupled with monitored natural attenuation, may be used to demonstrate that a groundwater PCLE zone is contained (i.e., stable) or shrinking.

8. Describe the relationship between "decontamination" and "physical controls" as they pertain to monitored natural attenuation? §350.31(b)

This subject is discussed in detail in the TNRCC guidance document *Monitored Natural Attenuation Demonstrations* (RG-366/TRRP-33). Therefore, this matter will only be briefly addressed here. Section 350.31(b) emphasizes that some MNA processes will be classified as decontamination measures, while others will be classified as physical control measures. This is important since the language at §350.32(b)(3), regarding Remedy Standard A, states in part that "Remedial alternatives, including the use of monitored natural attenuation as a decontamination remedy, must be capable of achieving the Remedy Standard A objectives within a reasonable time frame,… ." In other words, MNA can be used in response to Remedy Standard A, however, it must be a decontamination measure.

The text at §350.33(b)(2), regarding Remedy Standard B, states in part that "Remedial alternatives, including the use of MNA as a decontamination or control remedy." This means that MNA can be used under Remedy Standard B, provided it is capable of meeting the remedy standard response objectives within a reasonable time frame, regardless of whether it's a decontamination or physical control measure.

In general, MNA processes, where degradation is a major component, would be classified as decontamination. In contrast, MNA where dilution and adsorption are primarily responsible for limiting the extent of COCs in excess of PCLs would be classified as control measures.
To summarize, MNA is used under Remedy Standard A to reduce groundwater concentrations throughout the PCLE zone to below PCLs. Under Remedy Standard B, MNA may be used to contain COCs at the alternate POE at the limits of a PMZ.

MNA, like any remedial alternative, is not suitable in all situations. The suitability of MNA is dependent upon the characteristics of the hydrogeology, the COCs, and the exposure conditions. Where there is on-going exposure, then the timeliest remedy is warranted, and MNA is unlikely to be approved by TNRCC unless it can be demonstrated to be as timely as other appropriate remedies. Even in that situation some action to prevent exposure must be taken during the remedial period.

A possible exception to this occurs when an ecological services analysis is conducted according to §350.33(a)(3)(B to address ecological concerns. In this case, MNA could potentially be used as part of the remedial alternative (e.g., when combined with compensatory ecological restoration) at the affected property to address the ecological considerations. In a few instances, the ESA may indicate that MNA is the only appropriate remedial alternative.

9. Can pump and treat be used as a response action for class 1 groundwater? How about reactive treatment walls? §350.33(a),(b)

Response actions for class 1 groundwater are restricted to removal and/or decontamination methods because the response objective for class 1 groundwater is to restore the groundwater to below the critical PCL. Response actions that just control the spread of a PCLE zone are not allowed as the final outcome in class 1 groundwater (although they could be used as an interim measure).

An active pump and treat system that is designed to remove and decontaminate the COC concentrations within the class 1 groundwater PCLE zone to below the critical PCL, within a reasonable time frame, is acceptable. However, physical controls that are designed to merely contain the COCs within a class 1 groundwater are not acceptable as the sole remedy. Hydraulic containment wells and interceptor trenches are classified as physical control measures and, therefore, would generally not be acceptable as sole response actions for class 1 groundwater, unless on a site-specific basis the person demonstrates to the satisfaction of the TNRCC that the remove/decontamination performance objectives for class 1 groundwater can be attained within a reasonable time frame.