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BIOENERGY • CIVIL • MECHANICAL

May 19, 2014

Ricknold Thompson, Section Head
Solid Waste Section
Montana Department of Environmental Quality
P.O. Box 200901
Helena, MT 59620-0901

Re: Adkins Class III Tire Mono-Fill Landfill, Pray, Montana --
Transmittal of Supplementary Analysis for EA Rewrite

Dear Rick:

The enclosed material is submitted for your use in rewriting the EA. The package should be self explanatory as you and Mary get into it.

Maps and documents submitted with the initial application package are not resubmitted herewith unless a specific document is referenced as an attachment in this package. If you need any additional documents, information or analysis, please call or email me. I am standing by to respond promptly to any request you make.

Thank you for your patience in receiving this submittal. I trust it will give you a 'leg up' on rewriting the EA. We appreciate your review and any comments that will expedite your rewrite. Please feel free to call me at your convenience.

Sincerely,
Octagon Consulting Engineers, LLC

William E. Smith

William E. Smith, P.E.
Consulting Engineer

cc: Michael D Adkins, Land Owner w/ enclosures

Adkins Waste Tire Monofill Landfill
Pray, Park County, Montana
Montana Solid Waste Landfill License # 517

Updated Submittal May 19, 2014

1. Landfill Property's Relationship to the Yellowstone River

Refer to the USGS topographic map and FEMA Flood Insurance Rate Map (FIRM) dated 10/18/2011 depicting the vicinity surrounding the landfill property at a scale of 1" = 1000 lin.ft. These maps are labeled "Attachment 1-A" and "Attachment 1-B", respectively. They present in detail the relationship of the landfill property to the reaches of Mill Creek and Yellowstone River in closest proximity to the landfill, and show the 100 year flood plain defined for these channels. The Yellowstone River and Mill Creek are both approximately 2500 ft in horizontal distance from the landfill site. The river bank has an elevation of 4820 ft for a length of over 5000 ft, and Mill Creek flows toward Yellowstone River from an elevation of 4860 to 4800.6 at its confluence over a horizontal distance of 5100 lin.ft (all within the accuracy of the USGS topo map). This lower end of Mill Creek channel lies at an average gradient of 1.1% and this reach of Yellowstone River channel has a gradient of 0.19% as it falls 20 ft (between the 4820 and 4800 contour lines) in a distance of 10,500 lin.ft. The gradient of the river channel in this reach is flatter than the river as a whole due to its west to east flow direction compared to the overall river channel which flows generally north northeast.
The USGS topo map on which is plotted the calculated groundwater gradient and flow direction determined from wells located within $2^1/_2$ miles up gradient of this site (Refer to Section 4.6 of Engineer's Report dated May 20, 2011 submitted with the Landfill Application.) is included as "Attachment 1-C". The gradient and flow direction in that area are 0.4% at 18^0 east of north, respectively, and are consistent with the overall flow direction and gradient of the river channel. This indicates that the massive groundwater aquifer underlying this area of Paradise Valley flows parallel with the river. The river flow seasonally increases sharply over a 6 week period due to spring runoff, makes her high water run between June 15^{th} and 21^{st} each year and gradually decreases flow until the lowest annual flow occurs about November.

The ground elevation of the landfill property is 4875 ft +/-5 ft. Therefore, the elevation at the bottom of the 60 ft deep pit is approximately 4815. Elevations defining the 100 year flood plain in the Yellowstone River channel as shown on the FIRM range between 4827 and 4816. Normal seasonal high water level in the river which is not referenced on the FIRM appears to run approximately 12 to 15 ft below 100 year flood stage.

A survey of the 5 wells existing on the contiguous landfill properties was performed to measure the static water level (SWL) in each well within a 2 hour period and tie the elevation of top of casing into a common datum. The measurements obtained and the calculated gradient and flow direction of the groundwater aquifer are presented on the diagram entitled "Groundwater Flow Direction Under Landfill Property" and labeled "Attachment 1-D" and Attachment 1-C has been updated to include the local flow direction. The elevations of the groundwater aquifer in the 5 wells range between 4779.10 and 4778.04, the calculated gradient is 1.00% and the direction of flow is 15^0 east of north. In addition, the calculation sheet for the 3 point solution to determine the local flow direction and gradient, and well logs for the 5 wells surveyed are provided. The flow direction and gradient of groundwater underlying the landfill site show the influence of Mill Creek's confluence with Yellowstone River and otherwise tie into the parameters presented in these landfill license submittals.

The ground elevation of the landfill property is approximately 55 ft above the river bank and 100 year flood plain. The bottom of the pit is approximately 2 ft lower than the 100 flood plain elevation and 36 ft above the groundwater table.

The depths to SWL measured in Well #1 on the landfill property in the preparation of these submittals are presented in the following table. The nominal depth below bottom of pit to groundwater table assumes average ground surface elevation over the pit is 2 ft below the ground surface at Well #1.

Well #1 Static Water Level Depth below Top of Casing			
Date taken:	Depth to Water (feet)	Top of Casing Above Ground Surface (ft)	Nominal Depth Below Bottom of Pit (ft)
4/21/2010	101.16	2	37
6/2/2010	100.47	2	36
5/24/2011	100.47	2	36
4/16/2014	100.68	2	36
5/16/2014	101.58	2	37

Groundwater level shows fluctuations within a range of 1.11 ft. Compared to the depth measured one month ago, SWL dropped 0.9 ft while during the same period water flow in Yellowstone River has increased enough to raise water level approximately 3 ft. Water flow also increased significantly in Mill Creek. The two measurements almost one year apart being exactly the same is a mere coincidence. The water levels measured in the same months of different years appear to show no correlation to seasonal high water flow in the river and creek. These measurements were randomly taken to determine depth to underlying groundwater table and calculate flow direction and gradient. However, their up and down fluctuations do not indicate any direct influence on groundwater table from water flow in the Yellowstone River and Mill Creek channels.

The Engineer concludes with confidence that the facts presented herein do not identify any naturally occurring events in the environment that could significantly affect the landfill.

The Yellowstone River at maximum flood stage cannot inundate the landfill property.

The underlying groundwater is part of a massive unconfined aquifer and its surface randomly fluctuates up and down within a range of approximately one foot due to atmospheric barometric pressure and other environmental influences independent of the water flows in Yellowstone River and Mill Creek.

Seasonal cycles of flow in the Yellowstone River or Mill Creek channels do not significantly influence the aquifer's SWL.

No normal occurrences in this environment have been identified which could cause the groundwater to rise to a level which would affect the landfill.

The underlying groundwater flow direction and gradient are affected by the proximity of the Mill Creek's confluence with Yellowstone River. However, no phenomena occurring in the natural environment have been identified which could significantly alter this relationship to be detrimental to the landfill.

In summary, the Yellowstone River and Mill Creek could not under normal environmental conditions impact the tire landfill operation or cause the landfill to negatively impact these streams or groundwater.

2. Impacts on Ground Surface, Neighboring Properties and Groundwater Aquifer Due to Water Use for Sprinkler Irrigation, Dust Control and Renegade Dust Discharging Off-Site

The use of water in dust control and sprinkler irrigation is emphasized in the "Operation and Preventative Maintenance Plan" for this landfill. Water alone or water in combination with environmentally responsible dust abatement products will be applied to driving surfaces from the spray bar on a water tender (tank truck). Application of dust abatement products will be limited to areas outside the pit where vehicles and equipment drive. A reasonable assumption for application rate and volume of water for dust suppression on driving surfaces is: one 4000 gallon tender applying ½ inch of water twice per day over an area of 12,800 sq.ft (640 ft long x 20 ft wide). This totals 8000 gallons of water per day Within the pit, water sprinklers will be used as required to dampen soil in order to reduce the airborne loss of the fine grain component of soil structure. Correct and responsible application rates will be specified, monitored, inspected and adjusted to maximize dust reduction through the wetting of gravel and soil to stabilize and bond fine grain soil to coarse particles. This could include an area of approximately 20,000 sq.ft receiving ½ inch of water per day. The prudent and responsible use of water on the landfill property will be demonstrated by all employees. As a consequence, excessive use of water, water ponding and standing in puddles, and areas of saturated soil and mud will be prevented. Properly applied, water will soak a few inches into the ground and water standing on surfaces will evaporate into the air without running off.

Water for irrigation will be applied through correctly sized and positioned sprinklers, and duration of sprinkler sets to deliver adequate but not excessive volumes of water. Applied correctly, irrigation water will nearly saturate the upper 6 to 8 inches of the soil A-Horizon in order to adequately wet the roots of plants. As specified in the Operations Plan (copy attached and labeled "Attachment 2-A"), 1.0 to 1.5 inches of water per week is recognized to be sufficient to develop healthy plants in these climatic and soil conditions. This amount of water uniformly distributed over the ground surface in normal and responsible practice of irrigation will not flow, scour and wash, and cannot result in sediment transport and erosion on or off the landfill property. Considering the small areas required to be irrigated outside and inside the pit, a reasonable assumption is: 2 to 3 sprinklers operating simultaneously each discharging a maximum of 5 gallons per minute (gpm) continuously for a period not to exceed 8 hours will apply the water necessary.

A water sprinkler discharging up to 5 gpm may be used on a continuous basis to reduce dust during operation of the soil screening plant. The soil present in the pit does not possess a significant percentage of cobbles over 4" in size. Therefore, the screening plant is not expected to operate more than 16 hours per week. Correctly and responsibly operated, water spray in the screening plant is limited to dampen the soil in order to reduce the discharge of fine grain soil particles (aka dust) which is an important component in the overall soil structure. Water flow is not intended to saturate the soil or flow from the machine. During operation, the screening plant is continuously monitored, tweaked and adjusted. Therefore, even in the event of a broken water pipe, the volume of water involved would be insufficient to create washing, erosion or damage to the environment. Also, the soil screening plant must meet dust discharge standards established by DEQ in order to operate. As a licensed landfill operation, the screening plant will comply with these standards and will be inspected periodically for compliance.

Assuming that all water used for dust control and irrigation is pumped from one well on the landfill site, the total amount of water required would not exceed 35 gpm for 6 hours per work-day during the warmer months (mid-April through mid-October) for a total of 130 days per year. A total of approximately 5.0 acre-ft of water could be pumped per year. The standard DNRC exemption from water rights permit for pumping groundwater allows a maximum of 35 gpm and 10.0 acre-ft per year. The planned use of water falls within this exemption. Five wells on this contiguous property were surveyed to determine gradient and flow direction of groundwater underlying this property. According to the well logs, Wells 1 through 5 have confirmed yield rates of 60 gpm, 60 gpm, 40 gpm, 70 gpm and 60 gpm, respectively. The calculated hydraulic conductivity for these 5 wells is 118 ft/day by inputting the required parameters from the well logs into the Fetters equation. Well #1 located near the north boundary of the property is not presently in use and is conveniently located to be the water supply for this purpose. Other wells on this property already supply domestic water to the existing buildings. The characteristics of the aquifer as demonstrated by the well logs provided show that Well #1 is adequate to supply this water. In addition, continued use of groundwater for this purpose would not single-handedly result in adverse impact to the underlying aquifer or neighboring wells.

The obvious conclusions to be drawn from the details of landfill operation provided are:
1) water available on-site is adequate to supply the requirements of landfill operation;
2) properly applied irrigation water would not cause ponding, flowing, sediment transport or erosion on the site;
3) water would not cause adverse impacts to surrounding properties including decrease in available groundwater for use by domestic wells and permitted groundwater uses; and
4) dust can be controlled to a level that surrounding neighbors would not be affected.

3. <u>Impacts of Surface Water Run-on to the Pit Surface from Adjacent Properties, and Run-off from the Landfill Property Due to Precipitation and Snow Melt</u>

Stormwater was addressed in detail in the initial submittal and the follow up response prepared to provide additional information to DEQ SW Program. In this process, a package was sent to Brian Heckenberger and Christine Weaver of the DEQ Water Protection Bureau which included maps, spread sheet analysis and detailed explanation. This package demonstrated to DEQ WPB that stormwater resulting from a 100 year-24 hour precipitation event can be detained on-site without being released to surface water. This conclusion is documented in Christine's letter to William E Smith, P.E. A copy of the package is provide in this submittal and labeled "Attachment 3-A". Natural surrounding terrain combined with construction of swales, berms and improvements to routes of drainage will direct stormwater flows originating off-site around the property and thereby minimizing stormwater run-on.

The reader is referred to the attached analysis spread sheet entitled "Stormwater Volume Detained On-Site from 100 yr-24 hour Storm" and labeled "Attachment 3-B". This spread sheet uses the Rational Method to calculate stormwater runoff. The total area of watershed included in this analysis is 18.79 acres which includes all contiguous property except the PCRFD fire station tract, which drains generally toward Chicory Road. This total area is composed of four distinctly different sub-areas with coefficients assigned to account for the imperviousness of the surfaces in that area. These coefficients consider that some percentage of the rainfall will soak into the surface material in the watershed. The calculated total of 73,214 cubic feet is the runoff water which must be detained on-site. This volume of water can be held in a depth not exceeding 30" on 2 acres of the bowl-shaped 4 acre portion of Lot 3 which extends toward the east all the way to the Chicory Road intersection with East River Road. An intuitively obvious but expressible fact is: during long duration rainfall events, such as the 100 year-24 hour intensity storm being discussed here, irrigation of reclaimed areas, application of dust control liquids and water sprinkling to control dust emissions from the screening plant will not occur. Therefore, it is reasonable to assume that there will be no additional sources of water which must be considered in this analysis.

The total area of the water shed includes the entire existing gravel pit even though no stormwater precipitation deposited in the pit can physically flow out as runoff. Due to the permeability of the sand and gravel soil in the pit, a large percentage of rainfall precipitation dropped into the pit will soak in. However, in long duration storm events some water will run to the lowest point in the pit. The stormwater analysis spread sheet entitled "Stormwater Collected in Waste Tire Pit with Maximum Surface Area of 4.0 acres" and labeled "Attachment 3-C" is provided to quantify volume of water that could be expected in the pit. Assuming that all rainfall landing in the pit from the 24 hour duration storm could flow toward the lowest point, the analysis shows that 50% would soak in and the remaining volume would produce a sustained flow of 122 gpm. To address this runoff, a lined basin approximately 10 ft wide by 15 ft long by 2 ft deep shall be constructed in the lowest level in the pit and equipped with an automatically activated sump pump. The pump and discharge pipe must be sized to move 150 gpm to ground surface and discharged where it can flow toward the detention area.

Water collecting in the pit as a result of snowmelt is not a realistic concern. During winter months, snow accumulated in the pit due to snowfall or wind-blown drifting will be removed routinely to prevent delays in landfill operations. Snow is an undesirable material to have incorporated into the compacted lifts of tire pieces/sand-gravel. In addition, the volume of water resulting from snowmelt is small compared to the 37, 200 cu. ft of runoff estimated to land in the pit from a 100 year-24 hour rainfall event on the 4 acre pit. The layers of compacted tire pieces covered with sand-gravel in the open pit are directly exposed to rainfall precipitation. After an area of the pit is filled to ground level, it will be capped with an 18" thick layer of sandy loam soil capable of sustaining healthy grass cover. The cap will be shaped and groomed with a gentle convex crown, seeded with a hearty drought resistant mix of grass seeds and irrigated until the grass

PRAY AREA, PARADISE VALLEY
CALCULATE GROUNDWATER GRADIENT AND FLOW DIRECTION

HSWL = 4771.14 (VACANT WELL)
ISWL = 4769.20 (TY B-2 TEST WELL)
LSWL = 4761.81 (SOUZA WELL)

$$\frac{3065 \text{ (DIST. BTWN H \& L)}}{4771.14 - 4761.81} = 328.51'/\text{ft drop}$$

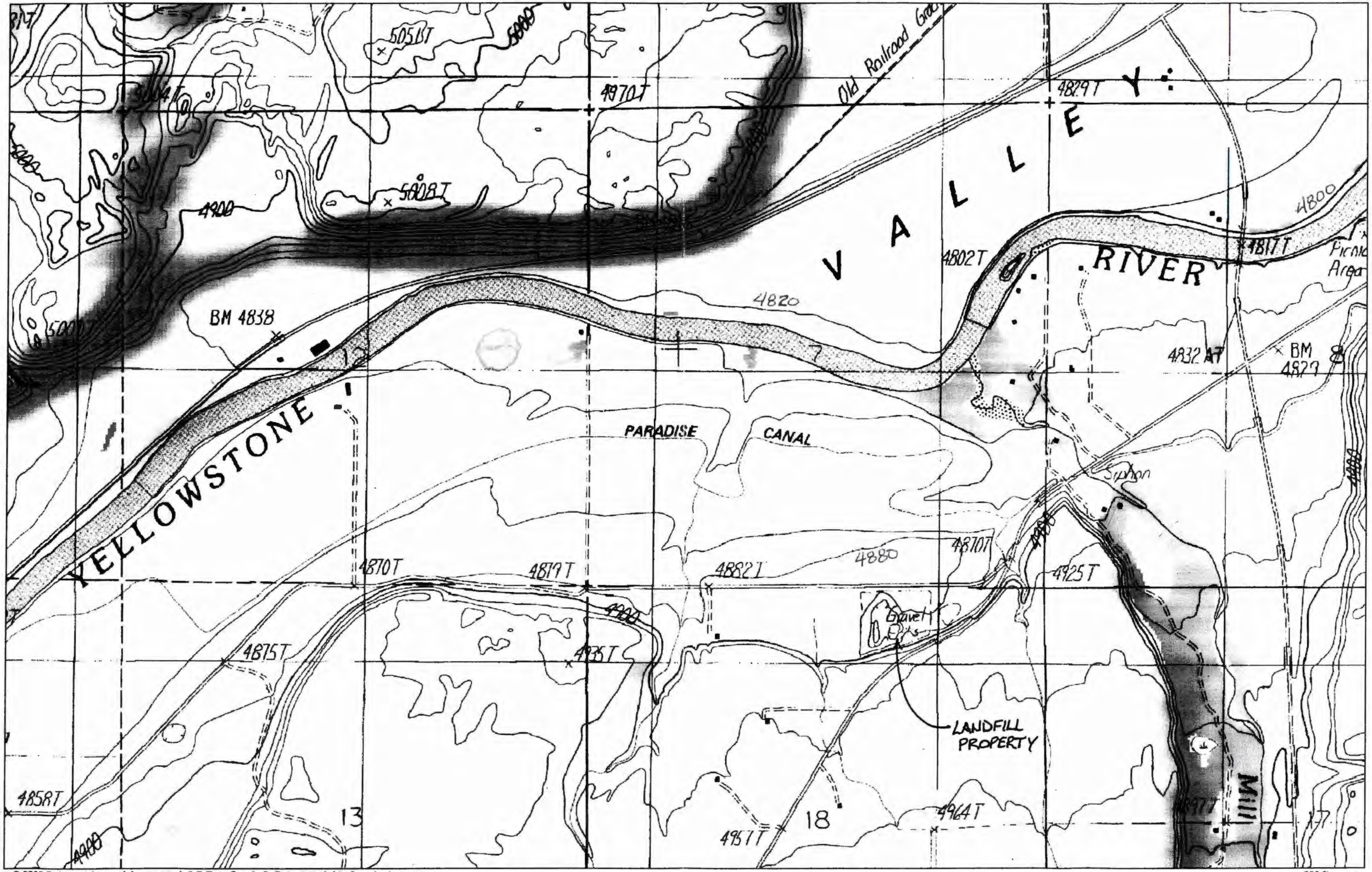
$$(4771.14 - 4769.20) \times 328.51 = 637.31'$$

Dist from HSWL Well to ISWL Contour = 492'
(measured along line ⊥ to ISWL contour)

Hydraulic Gradient = (4771.14 - 4769.20) ÷ 492'
= 0.00394

R8E | R9E

ATTACHMENT 1-A

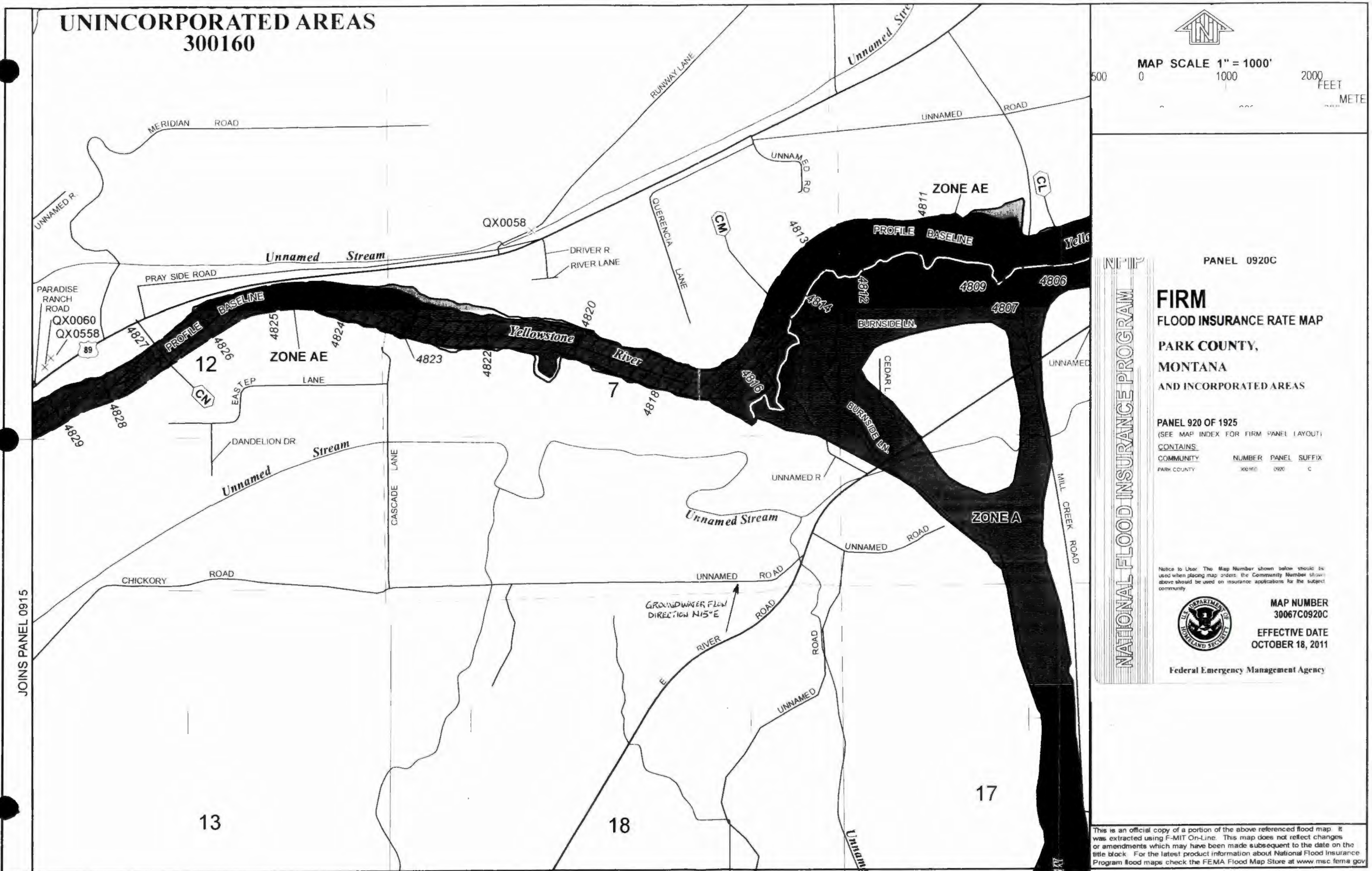


© 2002 DeLorme (www.delorme.com). 3-D TopoQuads ®. Data copyright of content owner.

Scale: 1 : 12,000 Map Rotation: 0° Magnetic Declination: 0.0°E

900 ft

ATTACHMENT 1-B



NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0920C

FIRM

FLOOD INSURANCE RATE MAP

PARK COUNTY, MONTANA

AND INCORPORATED AREAS

PANEL 920 OF 1925

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
PARK COUNTY	300160	0920	C

Notice to User: The Map Number shown below should be used when placing map orders; the Community Number shown above should be used on insurance applications for the subject community.

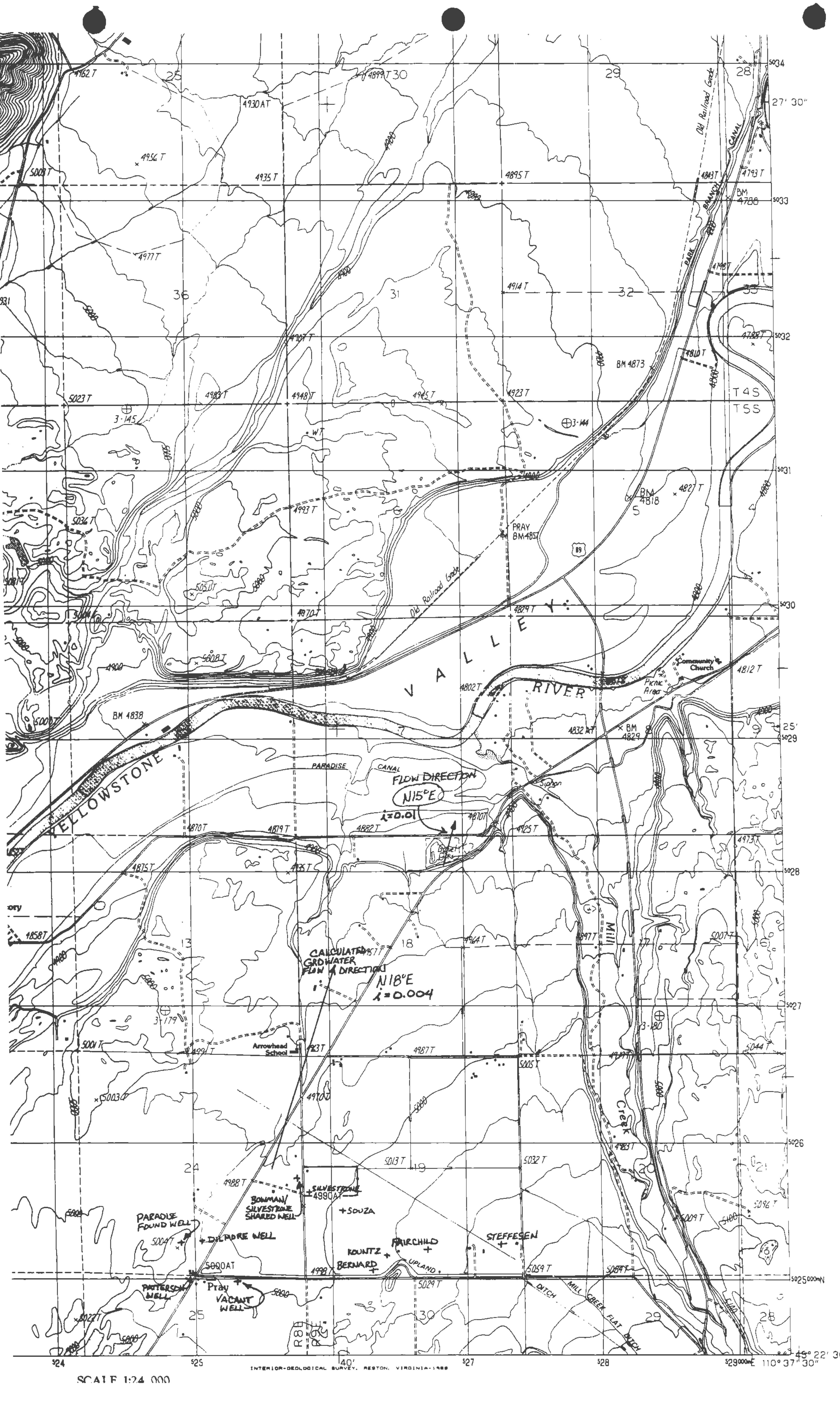
MAP NUMBER
30067C0920C

EFFECTIVE DATE
OCTOBER 18, 2011

Federal Emergency Management Agency

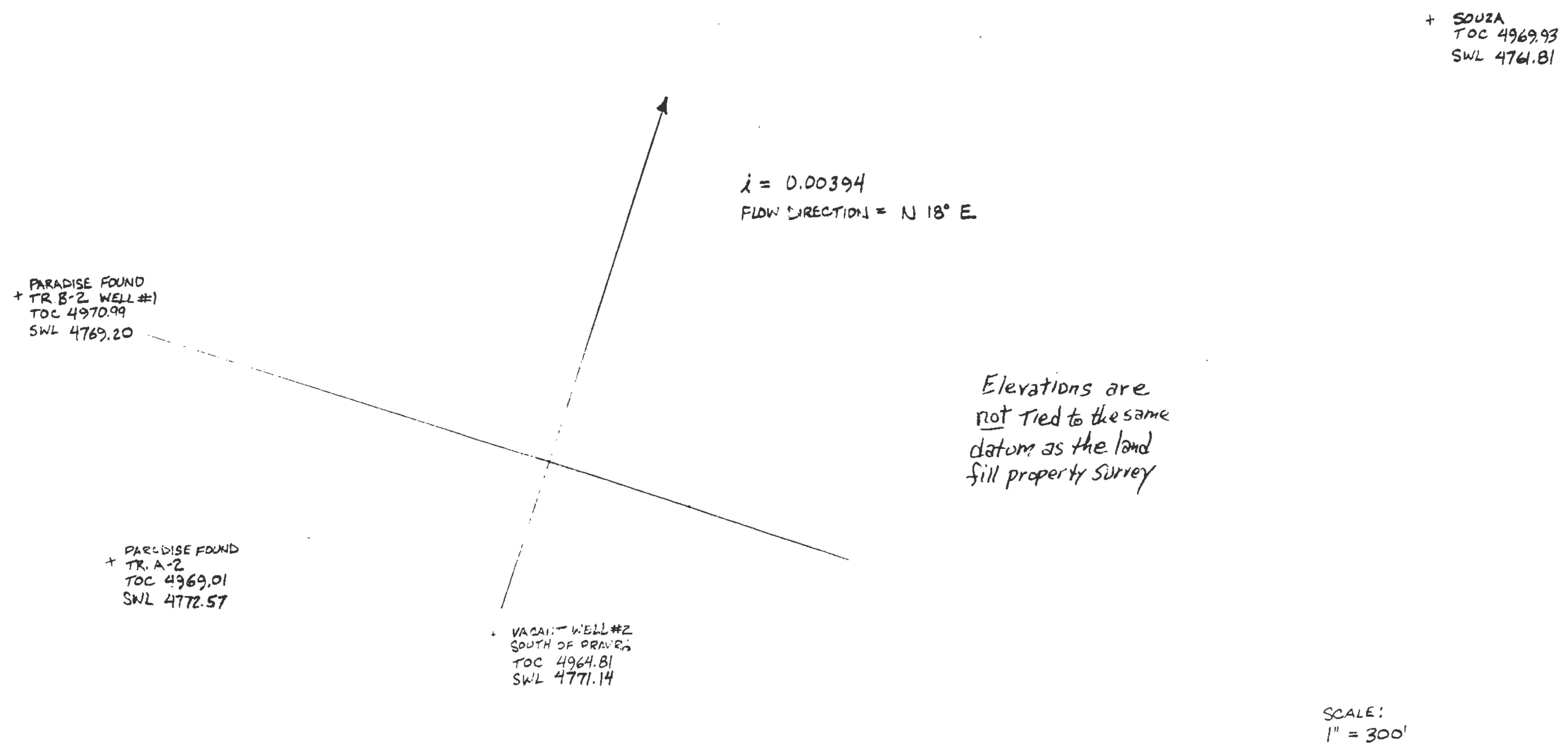
This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov

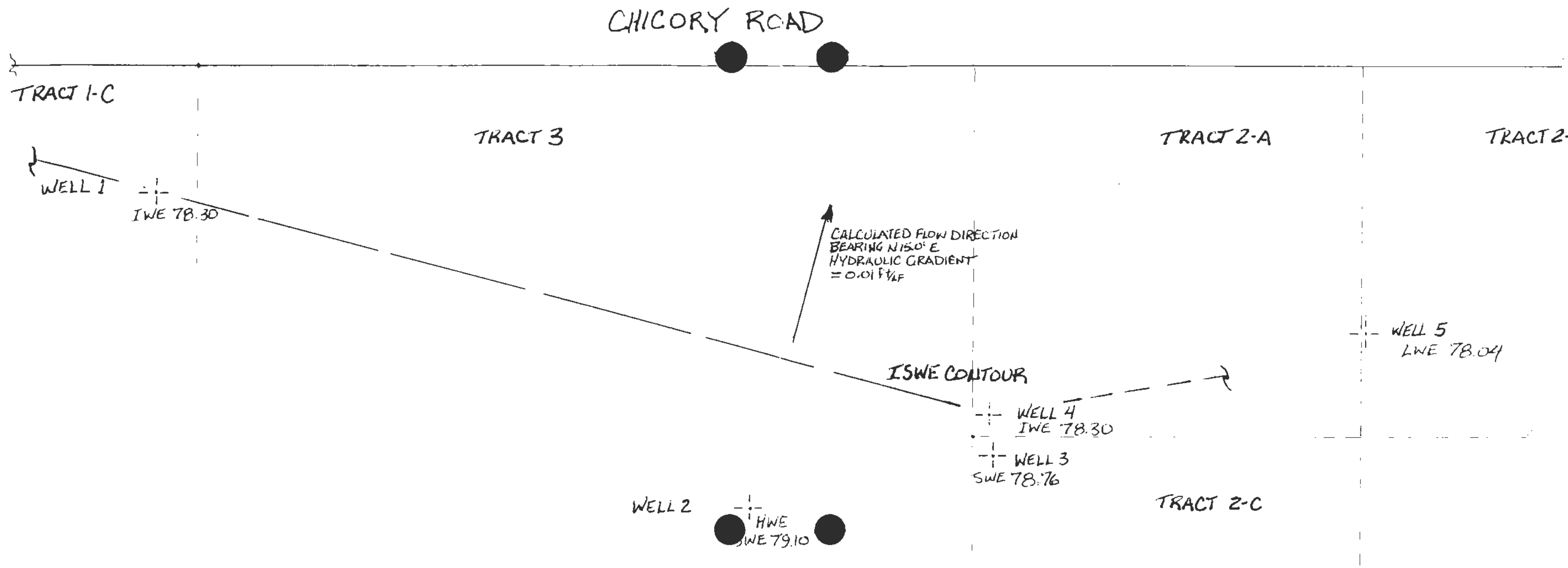
DETERMINATION OF GROUNDWATER FLOW DIRECTION AND WATER TABLE GRADIENT



ATTACHMENT 1-C

GROUNDWATER GRADIENT AND FLOW DIRECTION FOR PRAY AREA CALCULATED BY THREE POINT SOLUTION





Adkins Landfill Property Wells
Measurement Data

Well No.	Well Description	Elevation Top of Casing	Measured Depth to SWL	Static Water Elevation	Rank of Water Elevation
1	Monitoring Tr. 1-C	4878.98	100.68	4778.30	Intermediate SWE
2	Domestic Tr. 3	4876.51	97.38	4779.10	High SWE
3	Domestic Tr. 2-C	4876.71	97.95	4778.76	Not Used
4	Fire Sta. Tr. 2-A	4876.80	98.50	4778.30	Intermediate SWE
5	Domestic Tr. 2-B	4875.46	97.42	4778.04	Low SWE

Water levels in all five wells were measured between 15:00 and 17:00 on 4/16/2014. No occupants were present in the residences or buildings served by these wells during the entire afternoon as the depths to water levels were measured. The Engineer is confident that these elevations represent the static level of the underlying groundwater aquifer.

All elevations are based on a ground level datum of 4875.00 ft assigned to the survey pin between Wells 3 and 4 as determined from the USGS topographic quad map.

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ADKINS WASTE TIRE LANDFILL
Groundwater Flow Direction Under Landfill Property

is established. This will reduce significantly the amount of rain water that can penetrate down into the lower layers of tire pieces before it is held in the soil, taken up into the roots of plants or evaporated into the air.

In conclusion: 1) the tire pieces compacted into the landfill cannot realistically become inundated and saturated with water given the present physical conditions existing in this area; 2) stormwater runoff will not adversely impact landfill operations or create water ponding within the pit; and 3) stormwater remaining in the pit is not expected to cause any significant degradation of tire pieces. The scientific studies cited in Section 6 of this report adequately address the inert characteristics of tire rubber. Therefore, the potential conveyance or leaching of toxic substances from the stored tire pieces is not a credible concern.

4. Control of Dust, Noise, Odor and Vibrations

The release of dust into the air that could blow onto neighboring properties is an air quality issue regulated by State law. Existing regulations covering the operation of screening plants must be met while operating the plant. The use of water applied by sprinkler or spray bar onto the driving surface of driveways and soil backfill material being screened is addressed in Section 2 of this report. In Addition, air quality was addressed in the initial submittal made to DEQ SWP as part of the application review process. Refer to attached correspondence from William E Smith, P.E. to DEQ Air Resources Management Bureau which addresses planned landfill operation, and reply letter from DEQ ARMB's Craig Henrikson, PE. According to the letter received from DEQ ARMB, the planned landfill operation as described in OCE's letter falls below the Montana Air Quality Permit threshold. These letters are labeled "Attachment 4-A". If operational criteria change from what was described in OCE's letter, further contact will be made with ARMB in order to ensure compliance with air quality requirements.

The landfill will operate during normal daytime business hours 5 days per week. During these hours of normal landfill operations, activities will be conducted and undertaken pursuant to making this waste tire processing and landfill business as profitable as possible and employing as many people as is necessary. Activities will include but not be limited to: unloading trucks containing whole waste tire carcasses, tire pieces and shreds; conveying carcasses and pieces around the property and into the pit as necessary; cutting, shredding and processing tire rubber into marketable products using heavy machines manufactured for the intended purpose; excavating to shape and increase existing pit and stockpiling backfill materials; operating trucks, heavy construction equipment and vibratory compacting equipment on the property; operating a screening plant; etc. By the very nature of this industrial/commercial business, noise, odors and vibrations will be produced through routine activities. Prudent and cost effective measures may be taken to mitigate noises, odors or vibrations that are determined to be excessive by management and/or applicable state regulations. By the nature of working below ground surface in the open pit, many noises and vibrations will be mitigated by the surrounding earth. The substantial distance to surrounding residences may serve as a natural mitigation.

This property is surrounded by sprinkler irrigated agricultural land on which farming activities which produce dust, noise, odors and vibrations can routinely occur around the clock during the growing season. Park County requires that subdivisions approved within the last 12 to 15 years include in their filed covenants a restriction against protesting the agricultural activities being conducted on adjacent farming/ranching land. Because this restriction was required as a standard boiler plate in the covenants, conditions and restrictions filed with the final plat for the subdivision, the restriction should also apply to industrial/commercial land which has been continuously occupied and active since approximately 1949 when the sand and gravel pit commenced business.

5. Potential for Landfill to Attract Rodents, Reptiles and Insects, and Potential Negative Effects on Human Health

This property has been a working commercial sand/gravel pit for over 60 years. As a result of the industrial and commercial activities mining sand and gravel from the earth and creating a pit approximately 4 acres at its surface and approximately 300,000 cu. yds in volume, there has never occurred a problem with rodents, snakes, pests and disease infesting in or propagating from this property. Likewise, there is nothing involved in the waste tire monofill landfill that would serve as an attractant for rodents and snakes. This is addressed in the letter from James Barron, Ph.D., Associate Professor of Biology at MSU Billings (labeled as "Attachment 5-A"). The potential risk of mosquitoes breading and resulting in spreading West Nile Virus or other diseases is addressed in the letter written by Gregory Johnson, Ph.D., Professor of Veterinary Entomology at MSU in Bozeman (labeled as "Attachment 5-B").

6. Inert Characteristics of Waste Tires and Their Classification within Group III Solid Waste as Defined by Montana State Law

There is no federal definition for Class III landfills or Group III wastes. Solid wastes are regulated at the state level. The wastes classified in the Montana regulations as Group III wastes were determined to be inert under natural conditions. These solid wastes do not break down or decompose under normal conditions, produce leachate or cause pollution of the ground and water when disposed of in a landfill. Tires, rock dirt, concrete, and clean untreated wood wastes are some of the materials classified as Group III wastes, because they meet the 'inert' criteria. These wastes have been disposed of for decades in the Class III landfills around Montana. In addition, many massive accumulations of unregulated waste tires have existed throughout the United States of America for decades without any incentive to clean them up. If even a small percentage of carcasses in massive unregulated piles or regulated landfills were less stable than the 'inert' criteria required, problems within the local environment would have been uncovered before now. This may be a circumstantial approach to addressing the inert characteristics of waste tires, but a large body of technical and academic evidence exists to be considered.

Scrap tires have many post-consumer uses as whole carcasses and many different applications depending on how they are processed. The processing of waste tire rubber addresses predominantly the size of the rubber particle and the absence of foreign materials, such as fibers, cords and steel. Numerous examples of uses for waste tires and tire pieces are presented in and promoted by the US EPA website, and many other websites specializing in applications for aquatic, marine and dry land environments. Shredded tires are used as light weight fill material, or drainfield rock replacement. Crumbed tires are used as cushioning material on athletic playing fields, in play grounds for children, mixed with sand in riding arenas and as noise reducing additive in road asphalt mix. Many more examples could be listed, however, the above examples demonstrate that rubber tires are not harmful to the environment under natural conditions.

It is acknowledged that studies have been conducted to show that under artificial laboratory conditions, tire pieces placed in water can become toxic and even lethal to certain species of fish or aquatic life. However, those conditions cannot realistically occur in the natural environment nor in the dry conditions of this waste tire mono-fill landfill. Other equally credible studies conducted by highly qualified researchers at universities have shown that tire pieces submerged in flowing water did not cause toxic or lethal conditions for the sensitive aquatic species. Studies identified in this report with copies attached demonstrate that tire pieces placed in dry soil and below water did not result in the release of toxic and in most cases even detectible concentrations of chemicals.

Attachment 6-A: "Water Quality Effects of Tire Chip Fill Placed Above the Groundwater Table" by Dana N. Humphrey, Ph.D., P.E. and Lynn E Katz, Ph.D. (Associate Professors in Dept. of Civil and Environmental Engineering, Un. of Maine), and Michael Blumenthal (Scrap Tire Management Council, Washington, D.C.), 1997. Description/Conclusion: "Two field trials were constructed to investigate the effects on water quality of tire chip fills placed above groundwater. There was no evidence that tire chips increased the level of substances that have primary drinking water standards. Under some conditions iron levels may exceed their secondary standard. It is unlikely that manganese levels will exceed their secondary standards..."

Attachment 6-B: "A Study for the Maine DOT, Water Quality Effects of Using Tire Chips Below the Groundwater Table" by Lisa A Downs, Dana N. Humphrey, Lynn E Katz and Chet A Rock, Dept. of Civil and Environmental Engineering, Un. Of Maine, August 26, 1996.
Description: "The purpose of this project was to gather the data necessary to determine the environmental acceptability of placing tire chips below the groundwater table. The study was divided into three parts: 1) lab [toxicity characteristics leaching procedure] TCLP leaching tests; 2) lab reactor simulation of ground conditions; and 3) small scale field trials with 1.5 tons of steel belted tire chips buried below the groundwater table in glacial till, marine clay and peat."
Conclusion: "In summary, for near neutral pH environments, there is no concern that tire chips will release harmful levels of metals with a primary drinking water standard. However, tire chips placed below the water table do leach iron and manganese at levels that will cause their secondary (aesthetic) drinking water standards to be exceeded. Thus, tire chips should be used below the groundwater table only where higher levels of iron and manganese can be tolerated. Tire chips placed below the water table leach low levels of some volatile and semi-volatile organic compounds. However, the short monitoring period and scatter of the data made it impossible to determine if the levels were high enough to constitute a potential health hazard. Monitoring of organic levels will be continued to clarify the presence or absence of a potential hazard."

Attachment 6-C: "Water Quality Results for Wittier Farm Road Tire Shred Field Trial" by Dana N Humphrey, Ph.D., P.E., Dept. of Civil and Environmental Engineering, Un. of Maine, January 2, 1999.

Description: The purpose of the field trial was to evaluate the insulation and drainage properties of tire shreds beneath a paved road. A secondary purpose was to obtain data on the effects of tire shreds on water quality... Thus, water would come into direct contact with the tire shreds. It is likely that the tire shreds used as bedding beneath the pipe are saturated."
Conclusion: "In this sampling event, tire shreds did not cause the levels of metals to exceed their primary drinking water standard. Moreover, the levels of volatile and semi-volatile organic compounds were all below their test method detection limit. The same results were obtained at the North Yarmouth field trial where shreds were used as subgrade fill above the water table (Humphrey, et.al., 1996)... It is not possible to draw definitive conclusions from the single sampling event covered by this report. However, these results agree with the on-going study in North Yarmouth, Maine (Humphrey, et.al, 1996), namely that tire shreds placed above the water table have a negligible impact on groundwater quality.

Attachment 6-D: "Review of the Human Health & Ecological Safety of Exposure to Recycled Tire Rubber found at Playgrounds and Synthetic Turf Fields", prepared by: Cardno ChemRisk, Pittsburgh, PA, August 1, 2013.
Description: "The purpose of this report is to evaluate the health and ecological risks associated with the use of recycled tire rubber in consumer applications, particularly playgrounds and athletic fields.
Conclusion: "No adverse human health or ecological health effects are likely to result from these beneficial reuses of tire materials; and while these conclusions are supported by existing studies or screening risk assessments, additional research would provide useful supplemental and/or confirmatory data regarding the safety of recycled tire products and enhance the weight of evidence used in risk communication."

Information obtained from the US EPA's official website present 4 areas in which scrap tire carcasses and pieces are used in dry, wet and marine applications. These uses demonstrate the involvement of US EPA and Army Corps of Engineers in innovative applications. Consideration of these innovative applications adds credibility to the 'inert' nature of waste tire rubber, and demonstrates by comparison that storage/disposal of waste tire pieces in the Adkins landfill cannot pose a significant risk to the environment. The following pages are labeled "Attachments 6-E, F, G and H": Science / Technology, Innovative Uses, including "...protect marshland on Gaillard Island, highway sound barriers, and rubber-encased railroad ties; Civil Engineering Applications, including subgrade fill and embankments, backfill for walls and bridge abutments, landfill capping, closure and daily cover material; Using Scrap Tires... Mitigating Bridge Flood Damage; and Artificial Reefs in the Atlantic Ocean off the coast of New Jersey.

7. Notification to Local Fire District Regarding Plan to License and Operate Waste Tire Landfill on Adkins' Industrial Property

Park County Rural Fire District #1 has a fire station (Station 3) on a 1 acre lot which shares a common boundary with the licensed landfill property. The property was donated to the fire district by Mike and Maggie Adkins. This station was constructed in 2002 and fire fighting materials, supplies and apparatus have been in place since 2003. The attached letter from William E Smith, P.E. of Octagon Consulting Engineers, LLC, project engineer for the waste tire landfill submittal, is dated May 16, 2011. This letter (labeled as Attachment 7-A) is provided to document that the local fire district was notified during the preparation of the submittal to DEQ.

Chicory Road runs east to west on the common section line shared by Sections 7 and 18, Township 5 south, Range 9 east. This line also serves to separate the Park County Rural Fire District #1 to the north from the Paradise Valley Fire Service Area to the south. The waste tire landfill and contiguous properties were approved by resolution of the Park County Commissioners to be annexed into the PCRFD#1 on July 30, 2012. However, prior to this decision discussions with and notification to PCRFD#1 regarding the proposed waste tire landfill occurred due the presence of the PCRFD Station 3 and the proactive can-do attitude demonstrated by Chief Dann Babcox. Since the fire station and contiguous property were annexed into District #1, more volunteers, apparatus and improvements to the facility have made Station 3 a viable resource for the surrounding community from which firefighters are responding as the needs arise.

8. <u>Potential Risk of Fire in Waste Tire Pieces Deposited in the Pit and Routinely Covered with Sand/ Gravel Soil in Accordance with Requirements of Issued Landfill License</u>

The U.S. EPA website addresses scrap tire fires under Scrap Tires/Basic Information. This page was last updated on 8/20/2013 (refer to sheet labeled "Attachment 8-A"). Under the section entitled "Extinguishing Tire Fires" it states, "Waste tires are difficult to ignite, but once a tire fire starts, it is generally very hard to control and extinguish. Using water and/or foam to extinguish a tire fire is often futile. Water is best used to keep adjacent, unburned tires from igniting. Smothering a tire fire with dirt or sand is usually the best option for extinguishing fires. Typically, the sand or dirt is moved with heavy equipment to cover burning tires. Putting out a tire fire can also be facilitated by removing unburned tires from the pile to lessen the fuel load."

In the "Civil Engineering Applications" section of the U.S. EPA website under "Scrap Tires" and "Markets/Uses" (refer to sheet labeled "Attachment 6-F), scrap tire material is promoted for many uses. The website states, "In almost all applications, scrap tire material replaces some other material currently used in construction such as lightweight fill material like expanded shale or polystyrene insulation blocks, drainage aggregate, or even soil or clean fill." "Subgrade fill and embankments", "Backfill for walls and bridge abutments, "Subgrade insulation for roads", "Landfills", "Septic system drainfields" and "Other uses" are highlighted. Obviously the EPA is not concerned about the potential fire in tire rubber pieces mixed into soil for these applications. The lifts in the Adkins Waste Tire Monofill Landfill once covered with backfill soil will not look much different that the photo of "Shredded scrap tires used as road base in Odessa, Texas" except the pieces may be somewhat larger and the soil cover may be somewhat thicker in the landfill application.

From the design, setup and operational point of view the priority regarding fire is on prevention and preparation. The documents entitled "Landfill Operations Plan" and "Fire Plan to Guide Physical Plant Infrastructure and Day to Day Operations" are provided as "Attachment 8-B" and "Attachment 8-C", respectively. These documents were submitted as part of the Application review process. Two security precautions will be installed in accordance with solid waste landfill license conditions: a 10 ft high fence surrounding the landfill property with gates closed and locked when the property is unattended; and lightning rods. Additional security measures will include bright overhead yard lights installed on poles approximately 25 ft above the ground; and a number of all-weather surveillance monitors to detect visual, infrared and physical motion will be installed on the overhead light poles. Another priority is placed on training in response to a fire scenario at the landfill. At least two members of management are currently volunteer firefighters with Park County Rural Fire District #1 (PCRFD#1), respond out of Station #3 and train regularly with other District #1 firefighters who respond out of Station #1. Employees will be encouraged to become volunteer firefighters with the District and at minimum receive appropriate training in response to fire in order to increase their situational awareness in the event of an emergency. Once the monofill is operational, firefighter training exercises under Chief Dann Babcox and other Fire District officers as Incident Commander will be conducted periodically at the site with designated apparatus and personnel responding from both Station #3 and Station #1.

The primary design and operational priorities for the monofill landfill are to cut tire carcasses into no fewer than 4 pieces and place them into the pit in lifts no deeper than 5 ft. The exposed lifts of tire rubber must be backfilled with granular sand/gravel soil in a nearly continuous operation as the tire pieces are placed and the lift is walked down with the heavy earthmoving equipment and vibratory compactors present in the pit in order to ensure that voids between tire pieces are adequately filled to minimize settlement and maximize stability. A minimum continuous backfill thickness of 6 inches shall be placed over each 5 ft thick lift of tire pieces before the next lift of tire pieces can be placed. Conditions to the landfill license require covering the exposed face of each lift no more than every 2 to 3 weeks to ensure that the maximum open face of tire pieces does not exceed 9000 sq. ft. Also in accordance with the conditions of the issued landfill license, no more than 250 cu. yds in volume (approximately 2000 average size whole tire carcasses) may be staged outside of the pit at any time.

The letter from Dann Babcox, Chief PCRFD #1 (labeled "Attachment 8-D"), addresses several fire related considerations from the Fire Authority's point of view. Training landfill employees to respond appropriately within the context of the fire will be a priority. Chief Babcox has justifiable reason to believe that a tire fire would not have time to mature before firefighters would be on-scene, knowing that a fire at this site would elicit numerous calls to 911. The location is within plain view from U.S. Hwy 89 South and East River Road, and surrounded by residences and people. Utilizing the resources housed in Station #3 located on the property and mobilizing Station #1 apparatus and personnel which are approximately 20 minutes away in Livingston, PCRFD#1 is equipped, staffed and trained to respond effectively and aggressively to any fire scenario at this tire monofill landfill.

In response to discussions and planning with fire services, a 20 ft wide access corridor terminating in a 100 ft diameter cul-de-sac will be constructed from Chicory Road along the west boundary into the southwest corner of the landfill property. This will enable firefighters and equipment to stage and approach the pit with the prevailing wind at their backs in the event of a fire.

9. Analysis of Truck Traffic and Estimation of Delivery Trips to Landfill

The site of the proposed waste tire monofill landfill is currently an active industrial and commercial operation. Heavy truck traffic in and out of this site is routine. Diesel powered 18 and 22-wheel tractor/trailer rigs including lowboy and flatbed trailers loaded with heavy construction materials, earth moving equipment, rocks and boulders and more, and 20 cu. yd side dump and belly dump trailers loaded with sand/gravel, pit run soil, rocks and boulders; 10 cu yd 10-wheel end dump trucks loaded and unloaded; and pickup trucks often pulling trailers loaded with construction equipment and materials are common place. Although the number of truck trips vary from day to day based on the job and need to haul materials into/out of the site, a minimum of 10 truck trips per day is reasonable. In addition, other contractors live, operate and/or serve customers up Chicory Road and also routinely travel this paved county road with heavy trucks.

The landfill is designed to receive and process up to 5000 waste tire carcasses per day 5 days per week. This landfill will receive tires from three sources: 1) cut, chopped and shredded tire pieces that have been processed by company trucks at source locations; 2) whole carcasses delivered by hired tractor/trailer rigs from commercial businesses; and 3) whole carcasses dropped off by private individuals a few tires at a time. Transportation of tire carcasses to this site is recognized as one of the largest expenses this business will incur on a regular basis. Therefore, in order to be a viable business, the Adkins Landfill must use the most cost effective methods of transporting waste tire carcasses. That almost always means transporting the greatest number of tires per load. The US EPA publication entitled "Scrap Tires: Handbook on Recycling Applications and Management for the U.S. and Mexico", dated December 2010 (document EPA530-R0-0101) and labeled "Attachment 9-A" is an important reference. Chapter 6 "Transportation and Processing Economics" effectively addresses the issue of transportation. It states, "Scrap tire collecting and hauling are critical components in effective use of the tire resource. The impact of efficient collection on the economic viability of scrap tire management alternatives is often underestimated." (Refer to page 71, "Collection and Transportation".) "Scrap tires are normally generated where replacement tires are installed, such as at tire stores, car dealerships and repair shops. Tires can be collected on scheduled intervals or an as-needed basis. Route collection generally involves trucks travelling scheduled routes at designated frequency...Trailers are often parked at stores with high volumes and adequate space... The store is generally charged a fixed fee per trailer based on distance, and other cost-sensitive factors."

Use of the right equipment is necessary for transporting tires in the most cost effective manner. As discussed in our initial submittal to DEQ SWP, Adkins Monofill Landfill intends to use company trucks properly sized and equipped to cut or chop carcasses at each pickup location, and complete an entire route in a specified amount of time in order to optimize productivity. For example, a 27 ft trailer can hold 500 to 750 whole carcasses (per Scrap Tire Handbook pg 71). If the carcasses are chopped into smaller pieces on-site at the point of pickup by an adequately equipped truck/trailer unit, at least 1500 tire carcasses could be delivered per truck load. The load of 1500 carcasses in this trailer would weigh 15 tons, which is considerably less than maximum highway loading. The landfill company plans to start with 2 trucks equipped with choppers.

However, in the initial stages not all of the landfill's daily quota can be delivered by company trucks. Therefore, the transport of whole waste tire carcasses must also be optimized. Although box and pickup trucks are expected to haul waste tires from small local commercial sources and individuals as incidental unscheduled deliveries, prescheduled deliveries made by tractor/trailer rigs with standard 48 ft trailer must be the primary means of transportation. The EPA Scrap Tire Handbook states that a 48 ft trailer can haul 1400 whole tires if the load is tightly laced. The weight of 1400 average sized tires is approximately 14 tons which is substantially below allowable highway load capacity. It is reasonable to assume that cost of labor to properly stack and lace the whole tires will be factored into the cost in order to maximize transportation. An average of 2 truck loads per day will net an estimated 2800 carcasses. In total, 2 company trucks delivering 3000 chopped carcasses and 2 commercial rigs delivering 2800 whole carcasses exceeds the maximum daily operating standard for the landfill. And these trucks will be operated by trained, commercially licensed and tested professional drivers. This explanation demonstrates that the delivery of 5000 carcasses per day can be met by 4 properly loaded tractor/trailer trucks without being left to chance and drop-bys. It is estimated that not more than 10 truck loads per day will be required to maintain landfill disposal operations at the designated license amount and accommodate local sources.

Due to the large size and sparse population of Montana, distances of 200 to 300 miles will be common hauling distances. Appendix F of the EPA Scrap Tire Handbook is entitled "Comparative Transportation Cost Example". This table shows cost per mile for the four vehicle types delivering a load of tires. For sake of comparison in this report, delivery costs from a distance of 200 miles for Pickup Truck, Pickup with Trailer, Box Truck and Tractor with 48 ft Trailer are considered. The unit costs are \$3.40, \$0.78, \$0.67 and \$0.32 times the number of tires loaded, respectively. The chart shows quantity of tires loaded to be 50, 250, 400 and 1400, respectively, which results in total transportation costs of \$170, \$195, \$268 and \$448, respectively, per load. Clearly, the loaded tractor/trailer delivers for the most cost effective price. The Scrap Tire Handbook states in its summary, "Attention to travel distance, volume and frequency of tire collection, loading techniques, and other aspects can help to lead to optimal equipment usage and ultimately achieving an economically sound transportation and tire collection program."

As described in the application submittal and included as a condition to the license, truck access to the property shall be specified. All pre-scheduled contracted trucks must access from U.S. Highway 89 South on Mill Creek Road to East River Road and approach the Chicory Road intersection from the north. This provides for a right turn onto Chicory Road. The reverse route must be followed by all trucks as they egress from the property. In addition, operational conditions set forth in the license restrict time of delivery by large trucks to mitigate potential interference with school bus traffic on the highways. The landfill business cannot effectively regulate or control the random pickup truck dropping off a few tires, but large contracted loads will be pre-arranged and scheduled.

In conclusion, the calculated volume of heavy truck traffic generated by the landfill is not expected to differ significantly from the current volume of heavy truck trips generated by Adkins' industrial and commercial businesses currently being operated out of this property. At our request, the Montana Highway Patrol records department provided a list of all the reported vehicle crashes occurring on the entire length of East River Road within the last 3 years. This list is labeled as "Attachment 9-B". A total of 26 reportable crashes occurred and only one of these involved a truck. The Freightliner CMV was a water tank truck owned by Park County which ran off the road and overturned on 8/29/2012 as it shuttled water to the Pine Creek Fire. Needless to say there was more than the average amount of urgency and stress associated with this situation in which numerous structures burned to the ground in a matter of hours. These data speak to the fact that East River Road is a safe secondary state highway, and that highway safety, deterioration to the highway structures and potential risk to neighborhood traffic will not significantly increase due to the operation of this monofill.

10. After Market Sales of Processed Tire Rubber

In the Engineer's Report (dated May 20, 2011) provided in the submittal to DEQ with the Class III Landfill application, Section 7.18 stated "The Owner's business plan also contemplates the possibility of unearthing and retrieving the rubber pieces at some future date, provided there becomes viable economic value based on future developments in technology and regulations. In this scenario, the land-filled rubber pieces would be excavated from the pit and removed from the sand and gravel backfill by screening. The salvaged rubber would be hauled from the site in truck loads that meet DOT highway requirements. Sand and gravel material rejected from the screened tire pieces would be returned and compacted into the pit along with adequate volume of imported pit run sand and gravel soil to replace the salvaged rubber pieces."

At the time that was written, we had knowledge regarding the state of the market for recycled tire rubber, and the Owners of this project are astute enough in business to not bury money. But we understood that two important components had to be balanced: 1) Montana law specifies that a waste tire carcass unsuitable for its intended use can only be disposed of in a licensed landfill; and 2) contracts to receive waste tires for a disposal fee cannot be jeopardized by an inability to ship processed tire rubber. Therefore, the waste tire monofill landfill, serving the same role as a storage tank in water supply system, is an essential component in the business strategy.

Provided that the three legs on this business strategy 'stool' are stable, i.e. receiving waste tires for a disposal fee, processing the carcasses to the specifications required for the recycled tire rubber, and shipping the processed rubber to the purchaser for the contract price, the business can remain strong as a primary employer. This business will benefit Park County by: providing good paying jobs in the local economy; receiving an estimated 1.3 million waste tire carcasses per year; and recycling an estimated 10,660 tons of tire rubber and 1950 tons of steel while hauling to the landfill only 390 tons of fabric belts (until a recycled use can be found or created for this material). With all three legs of the business strategy balanced over the broader duration of this business, the recycling can be done without permanently disposing of a single tire in the monofill. Because supply and demand are not directly related and cannot be expected to balance uniformly all the time, but rather are controlled by distinctly separate contracts, fluctuations will inevitably occur. The landfill is required to provide for the licensed storage of a raw material when demand for recycled tire rubber temporarily dips below the incoming stream of waste tire carcasses.

Several attachments are provided and all are from the US EPA website to demonstrate that EPA is strongly behind the science, technology and practical implementation of waste tire recycling. The first 2 pages from the introduction to the 1999 update of the EPA "State Scrap Tire Programs, A Quick Reference Guide" is included to present data from 1996 which show an average of 1.00 waste tire was generated per year per capita, 57% of waste tires are combusted for energy recovery and 24% of waste carcasses went into licensed landfills and illegal dumping. These percentages are about the same today. As shown in EPA "Basic Information" updated 11/14/2012 with data from 2003, 44.7% were used as fuel and 17% found their way in landfills or dumps. These documents are labeled "Attachment 10-A". Appendix A, B, C, E, G and H from the EPA "Scrap Tires: Handbook on Recycling Applications..." are provided and labeled "Attachment 10-B" to demonstrate the breadth and detail of information and the wide range of uses for recycled tire rubber.

The presence of a licensed landfill in this area of Montana would provide a significant benefit to Park County and the Paradise Valley. Park County Solid Waste system pays the City of Livingston to haul the county's garbage to Great Falls. The garbage is delivered to the City's transfer station where it is loaded for shipment. Every tire carcass found in the garbage was charged $5.00 extra, and some months the extra disposal fee was a significant percentage of the cost. Currently, the Park County "green-box" station at Chico provides a roll-off bin for disposal of waste tire carcasses. These tires are hauled to the County's landfill where they are staged. After a sufficient quantity is collected, an outside contractor with a cutting machine quarters or shreds each carcass for a disposal fee after which the pieces are disposed of in the landfill or hauled away by the contractor. When all related costs involved in the hauling, cutting and disposing of these tires are tallied including the cumulative impact on landfill volume, we believe a favorable arrangement can be made between this monofill and Park County.

ATTACHMENT 1-D.1
6 pages

Adkins Landfill Property
CALCULATE GROUNDWATER GRADIENT AND FLOW DIRECTION

4/17/2014

HSWE (well #2)	4779.10
ISWE (Wells 1 & 4)	4778.30
LSWE (well #5)	4778.04

Distance btwn HE & LE wells = 354'   HE-LE = 1.06 ft.

Unit Gradient = $\frac{354'}{1.06'}$ = 333.96 LF/FT drop

HE-IE = 79.10-78.30 = 0.80'

Horiz distance btwn HE well & LE well to IE contour
= 333.96/ft x 0.80' = 267.17'

This distance is superseded by 2 wells at IE ∴
Use line btwn these wells as IE contour and
plot line ⊥ to contour through HE well.

Horiz distance HE well to IE contour = 83'

Hydraulic Gradient = 0.80'/83 ft = 0.0096 = 0.01 ft/LF

MONTANA WELL LOG REPORT

This well log reports the activities of a licensed Montana well driller, serves as the official record of work done within the borehole and casing, and describes the amount of water encountered. This report is compiled electronically from the contents of the Ground Water Information Center (GWIC) database for this site. Acquiring water rights is the well owner's responsibility and is NOT accomplished by the filing of this report.

Other Options

Return to menu
Plot this site on a topographic map
View scanned well log (7/31/2007 1:45:13 PM)

1

Site Name: ADKINS MIKE
GWIC Id: 236365

Section 1: Well Owner(s)

1) ADKINS , MIKE (MAIL)
P.O. BOX 465
LIVINGSTON MT 59047 [04/09/2007]

Section 2: Location

Township	Range	Section	Quarter Sections
05S	09E	18	NW¼ NE¼ NW¼ NE¼

County	Geocode
PARK	

Latitude	Longitude	Geomethod	Datum
45.408725	110.657786	TRS-SEC	NAD83

Ground Surface Altitude	Method	Datum	Date

Addition	Block	Lot

Section 3: Proposed Use of Water

DOMESTIC (1)

Section 4: Type of Work

Drilling Method: ROTARY
Status: NEW WELL

Section 5: Well Completion Date

Date well completed: Monday, April 09, 2007

Section 6: Well Construction Details

Borehole dimensions

From	To	Diameter
0	160	6

Casing

From	To	Diameter	Wall Thickness	Pressure Rating	Joint	Type
-2	159	6	0.25		WELDED	STEEL

Completion (Perf/Screen)

From	To	Diameter	# of Openings	Size of Openings	Description
159	159	6			OPEN BOTTOM

Annular Space (Seal/Grout/Packer)

From	To	Description	Cont. Fed?
0	0	BENTONITE	Y

Section 7: Well Test Data

Total Depth: 159
Static Water Level: 104
Water Temperature:

Air Test *

60 gpm with drill stem set at 155 feet for 1 hours.
Time of recovery 1 hours.
Recovery water level 104 feet.
Pumping water level _ feet.

** During the well test the discharge rate shall be as uniform as possible. This rate may or may not be the sustainable yield of the well. Sustainable yield does not include the reservoir of the well casing.*

Section 8: Remarks

I.R. DRIVE SHOE

Section 9: Well Log

Geologic Source

Unassigned

From	To	Description
0	18	SAND
18	110	SANDY GRAVELS AND COBBLES
110	160	SLIGHTLY CLAYBOUND GRAVELS, COBBLES, SMALL BOULDERS AND SAND

Driller Certification

All work performed and reported in this well log is in compliance with the Montana well construction standards. This report is true to the best of my knowledge.

Name: WILLIAM HAYES
Company: HAYES DRILLING
License No: WWC-361
Date Completed: 4/9/2007

MONTANA WELL LOG REPORT

This well log reports the activities of a licensed Montana well driller, serves as the official record of work done within the borehole and casing, and describes the amount of water encountered. This report is compiled electronically from the contents of the Ground Water Information Center (GWIC) database for this site. Acquiring water rights is the well owner's responsibility and is NOT accomplished by the filing of this report.

Other Options

Return to menu
Plot this site on a topographic map
View scanned well log (2/26/2010 10:29:22 AM)

Site Name: ADKINS MIKE
GWIC Id: 210235

Section 1: Well Owner(s)
1) ADKINS , MIKE (MAIL)
CHICORY RD
LIVINGSTON MT 59047 [02/18/2004]

Section 2: Location

Township	Range	Section	Quarter Sections
05S	09E	18	NW¼ NW¼ NE¼ NE¼

County	Geocode
PARK	

Latitude	Longitude	Geomethod	Datum
45.408725	110.65517	TRS-SEC	NAD83

Ground Surface Altitude	Method	Datum	Date

Addition	Block	Lot

Section 3: Proposed Use of Water
DOMESTIC (1)

Section 4: Type of Work
Drilling Method: ROTARY
Status: NEW WELL

Section 5: Well Completion Date
Date well completed: Wednesday, February 18, 2004

Section 6: Well Construction Details

Borehole dimensions

From	To	Diameter
0	160	6

Casing

From	To	Diameter	Wall Thickness	Pressure Rating	Joint	Type
-2	159	6	.250		WELDED	STEEL

Completion (Perf/Screen)

From	To	Diameter	# of Openings	Size of Openings	Description
159	160	6			OPEN BOTTOM

Annular Space (Seal/Grout/Packer)

From	To	Description	Cont. Fed?
0	20	BENTONITE	

Section 7: Well Test Data

2

Total Depth: 161
Static Water Level: 95
Water Temperature:

Air Test *

60 gpm with drill stem set at 155 feet for 1.5 hours.
Time of recovery 30 hours.
Recovery water level 95 feet.
Pumping water level _ feet.

* *During the well test the discharge rate shall be as uniform as possible. This rate may or may not be the sustainable yield of the well. Sustainable yield does not include the reservoir of the well casing.*

Section 8: Remarks

Section 9: Well Log
Geologic Source
Unassigned

From	To	Description
0	18	SAND
18	80	SAND GRAVEL COBBLES AND SMALL BOULDERS
80	161	SAND GRAVEL AND COBBLES AND SLIGHTLY

Driller Certification
All work performed and reported in this well log is in compliance with the Montana well construction standards. This report is true to the best of my knowledge.

Name:
Company: HAYES DRILLING
License No: WWC-361
Date Completed: 2/18/2004

MONTANA WELL LOG REPORT

This well log reports the activities of a licensed Montana well driller, serves as the official record of work done within the borehole and casing, and describes the amount of water encountered. This report is compiled electronically from the contents of the Ground Water Information Center (GWIC) database for this site. Acquiring water rights is the well owner's responsibility and is NOT accomplished by the filing of this report.

Other Options

Return to menu
Plot this site on a topographic map
View scanned well log (2/26/2010 10:30:56 AM)

Site Name: ADKINS MIKE
GWIC Id: 201775

Section 1: Well Owner(s)

1) ADKINS , MIKE (MAIL)
PO BOX 465
LIVINGSTON MT 59047 [01/06/2003]

Section 2: Location

Township	Range	Section	Quarter Sections
05S	09E	18	NE¼ NE¼ NW¼ NE¼

County	Geocode
PARK	

Latitude	Longitude	Geomethod	Datum
45.408725	110.656478	TRS-SEC	NAD83

Ground Surface Altitude	Method	Datum	Date

Addition	Block	Lot

Section 3: Proposed Use of Water

DOMESTIC (1)

Section 4: Type of Work

Drilling Method: ROTARY
Status: NEW WELL

Section 5: Well Completion Date

Date well completed: Monday, January 06, 2003

Section 6: Well Construction Details

Borehole dimensions

From	To	Diameter
0	141	6

Casing

From	To	Diameter	Wall Thickness	Pressure Rating	Joint	Type
-2	139	6	0.250			STEEL

Completion (Perf/Screen)

From	To	Diameter	# of Openings	Size of Openings	Description
139	141	6			OPEN HOLE

Annular Space (Seal/Grout/Packer)

From	To	Description	Cont. Fed?
0	20	BENTONIE	

Section 7: Well Test Data

(3)

Total Depth: 139
Static Water Level: 91
Water Temperature:

Air Test *

40 gpm with drill stem set at 135 feet for 1 hours.
Time of recovery 1 hours.
Recovery water level 91 feet.
Pumping water level _ feet.

** During the well test the discharge rate shall be as uniform as possible. This rate may or may not be the sustainable yield of the well. Sustainable yield does not include the reservoir of the well casing.*

Section 8: Remarks

Section 9: Well Log

Geologic Source

Unassigned

From	To	Description
0	4	GRAVEL AND SAND
4	18	SAND LITTLE GRAVEL
18	75	SAND AND GRAVEL
75	130	TIGHT CLAYBOUND GRAVELS AND BOULDERS
130	141	SAND GRAVEL AND COBBLES

Driller Certification

All work performed and reported in this well log is in compliance with the Montana well construction standards. This report is true to the best of my knowledge.

Name:
Company: HAYES DRILLING
License No: WWC-361
Date Completed: 1/6/2003

MONTANA WELL LOG REPORT

This well log reports the activities of a licensed Montana well driller, serves as the official record of work done within the borehole and casing, and describes the amount of water encountered. This report is compiled electronically from the contents of the Ground Water Information Center (GWIC) database for this site. Acquiring water rights is the well owner's responsibility and is NOT accomplished by the filing of this report.

Other Options

Return to menu
Plot this site on a topographic map
View scanned well log (2/26/2010 10:31:32 AM)

4

Site Name: RURAL 1 FIRE DISTRICT
GWIC Id: 199471
DNRC Water Right:

Section 1: Well Owner(s)

1) RURAL 1 FIRE DISTRICT (MAIL)
15 CHICORY RD
PRAY MT 59065 [05/22/2002]

Section 2: Location

Township	Range	Section	Quarter Sections
05S	09E	18	NE¼ NE¼ NW¼ NE¼

County	Geocode
PARK	

Latitude	Longitude	Geomethod	Datum
45.408725	110.656478	TRS-SEC	NAD83

Ground Surface Altitude	Method	Datum	Date

Addition	Block	Lot

Section 3: Proposed Use of Water

DOMESTIC (1)

Section 4: Type of Work

Drilling Method: ROTARY
Status: NEW WELL

Section 5: Well Completion Date

Date well completed: Wednesday, May 22, 2002

Section 6: Well Construction Details

Borehole dimensions

From	To	Diameter
0	160	6

Casing

From	To	Diameter	Wall Thickness	Pressure Rating	Joint	Type
-2	159	6	0.250			STEEL

Completion (Perf/Screen)

From	To	Diameter	# of Openings	Size of Openings	Description
159	160	6			OPEN HOLE

Annular Space (Seal/Grout/Packer)

From	To	Description	Cont. Fed?
0	0	CONT FED BENTONITE	

Section 7: Well Test Data

Total Depth: 159
Static Water Level: 98
Water Temperature:

Air Test *

70 gpm with drill stem set at 155 feet for 1.5 hours.
Time of recovery 0.5 hours.
Recovery water level 98 feet.
Pumping water level _ feet.

** During the well test the discharge rate shall be as uniform as possible. This rate may or may not be the sustainable yield of the well. Sustainable yield does not include the reservoir of the well casing.*

Section 8: Remarks

Section 9: Well Log

Geologic Source

Unassigned

From	To	Description
0	25	SAND SOME GRAVEL
25	115	SAND GRAVEL AND COBBLES
115	136	CLAYBOUND SAND AND GRAVEL LOTS OF LARGE BOULDERS
136	160	SAND GRAVEL AND COBBLES

Driller Certification

All work performed and reported in this well log is in compliance with the Montana well construction standards. This report is true to the best of my knowledge.

Name:
Company: HAYES DRILLING
License No: WWC-361
Date Completed: 5/22/2002

MONTANA WELL LOG REPORT

This well log reports the activities of a licensed Montana well driller, serves as the official record of work done within the borehole and casing, and describes the amount of water encountered. This report is compiled electronically from the contents of the Ground Water Information Center (GWIC) database for this site. Acquiring water rights is the well owner's responsibility and is NOT accomplished by the filing of this report.

Other Options

Return to menu
Plot this site on a topographic map
View scanned well log (5/23/2006 8:04:31 AM)

Site Name: ADKINS MIKE
GWIC Id: 225593

Section 1: Well Owner(s)

1) ADKINS , MIKE (MAIL)
P.O. BOX 465
LIVINGSTON MT 59047 [02/10/2006]

Section 2: Location

Township	Range	Section	Quarter Sections
05S	09E	18	NW¼ NW¼ NE¼ NE¼

County	Geocode
PARK	

Latitude	Longitude	Geomethod	Datum
45.4089	110.6544	NAV-GPS	NAD27

Ground Surface Altitude	Method	Datum	Date

Addition	Block	Lot

Section 3: Proposed Use of Water

DOMESTIC (1)

Section 4: Type of Work

Drilling Method: ROTARY
Status: NEW WELL

Section 5: Well Completion Date

Date well completed: Friday, February 10, 2006

Section 6: Well Construction Details

Borehole dimensions

From	To	Diameter
0	160	6

Casing

From	To	Diameter	Wall Thickness	Pressure Rating	Joint	Type
-2	159	6	0.250		WELDED	STEEL

Completion (Perf/Screen)

From	To	Diameter	# of Openings	Size of Openings	Description
159	160	6			OPEN BOTTOM

Annular Space (Seal/Grout/Packer)

From	To	Description	Cont. Fed?
0	20	BENTONITE	

Section 7: Well Test Data

5

Total Depth: 160
Static Water Level: 94
Water Temperature:

Air Test *

60 gpm with drill stem set at 155 feet for 1 hours.
Time of recovery 0.5 hours.
Recovery water level 94 feet.
Pumping water level _ feet.

** During the well test the discharge rate shall be as uniform as possible. This rate may or may not be the sustainable yield of the well. Sustainable yield does not include the reservoir of the well casing.*

Section 8: Remarks

Section 9: Well Log

Geologic Source

Unassigned

From	To	Description
0	3	SAND AND GRAVEL
3	40	SAND AND SOME GRAVEL
40	104	SAND GRAVELS COBBLES AND SMALL BOULDERS
104	112	BOULDER PATCH
112	160	SAND GRAVEL COBBLES SOME CLAY

Driller Certification

All work performed and reported in this well log is in compliance with the Montana well construction standards. This report is true to the best of my knowledge.

Name:
Company: HAYES DRILLING
License No: WWC-361
Date Completed: 2/10/2006

ATTACHMENT 2-A
5 pages

Adkins Class III Waste Tire Mono-Fill Landfill

Operation and Preventative Maintenance Plan

1. This landfill will receive only waste tires at an operational maximum rate of 5000 carcasses per day from three sources: 1) cut, chopped and shredded waste tire pieces that have been processed by company trucks at source locations and hauled to landfill; 2) whole carcasses delivered to the landfill by hired trucks from maintenance shops and retail businesses that generate waste tires; and 3) whole carcasses dropped off at landfill one to four-at-a-time by private individuals. Upon arriving at the landfill, waste tire pieces processed off-site will be conveyed directly into the pit. Whole tire carcasses delivered to the landfill will be off-loaded into the processing building located within the licensed landfill boundary, chopped, cut or shredded and then conveyed into the pit.
2. Tire carcasses will be cut, chopped or shredded to significantly reduce void volume and increase the number of carcasses that can be placed into each cubic yard of pit volume. It is estimated that the chopped rubber pieces produced from between 33 and 62 average size car tires can be disposed per cubic.
3. Landfill will operate Monday through Friday, except legal holidays, and daily hours of operation will comply with parameters set by the conditions in the landfill license. Additional hours could include 8:00 am to noon on Saturday depending upon potential level of business on that day. The Owners expect the facility to be staffed by 4 to 6 full time and 2 part time employees. A front desk clerk will be available to check-in and document loads of tires, collect money, give receipts, etc. during business hours.
4. This site is accessed directly off of Chicory Road, a paved county road. The main entrance into the proposed landfill property is approximately 1000 ft from the Chicory Road intersection with East River Road, state highway 540. The facility will be accessed through double gates to provide clearance for larger trucks. A secondary access into the pit side of the property will be controlled by a pair of locked gates. The public access area and the pit operation will be separated by fence and gates, and vehicles entering into the property will be greeted by a front desk attendant who has visual oversight of the public area.
   Less than 1 mile to the northeast, East River Road intersects with Mill Creek Road (a paved county road). In this distance between Chicory Road and Mill Creek Road, East River Road crosses over Mill Creek. Although the bridge is slightly narrower than the paved width of the road, the double yellow centerline continuous across the bridge indicates it to be two driving lanes wide. According the Montana Department of Transportation, the bridge is structurally sound for trucks running at legal highway loads, and is maintained by MDT along with the state highway. Mill Creek Road crosses over Yellowstone River on a late model full highway width and load bridge and intersects with US Highway 89 South in a distance of approximately 1.5 miles from the landfill entry gate.

5. The old gravel pit, which dates back to the late 1940's, occupies an area equal to approximately 40% of the licensed landfill property. The maximum depth of this pit is 60 feet but the pit bottom slopes up in all directions. As part of routine landfill operation, the landfill will be excavated to a nominal depth of 60 ft below natural ground surface, and perimeter excavation into native soils will be sloped to maintain stable soil conditions in the surrounding terrain.

6. At the outset of pit operations, consideration will be paid to future retrieval and sale of the rubber pieces placed into the landfill. The current technology and markets are economically viable for the profitable sale of processed tire rubber for its use in a wide range of products.

7. Chopped rubber pieces will be placed into the pit in lifts approximately 5 ft thick; backfilled with native sand and gravel excavated from the pit; and mechanically compacted to fill voids and stabilize each lift. The compacted lift will then be covered with a 6" layer of sand/gravel.
   The lift will grow in surface area at the rate of approximately 3000 sq. ft per week. Lifts will be routinely backfilled, compacted and covered every 2 to 3 weeks as the fill operation proceeds across the open pit, so that no more than 6 to 9 thousand sq. ft of rubber pieces remain exposed at any one time. When the eleventh lift finally reaches ground surface, an 18" thick finish layer of sand/gravel excavated from the pit and a 6" cover of loamy topsoil retrieved from on-site stockpiles will be placed to cap the pit. This finished layer will be contoured to an average slope of 2% toward the perimeter of the pit to enhance stormwater runoff.
   A stormwater control berm approximately 2 ft high will be constructed within not more than 10 ft of the edge of the open pit (as shown in schematic Section A-A on the attached drawing sheet C) to protect from stormwater running into the pit.

8. All processed rubber pieces will be placed into the pit as carcasses are cut, chopped or shredded. Carcasses will be processed at a rate that will control and minimize the number of waste tires stockpiled and the time they remain in standby. At the outset of operations, a hydraulic cutter may be attached to a track excavator and used to cut whole carcasses in the pit. As business develops, hydraulic cutters / shredders are planned to be installed in the building on site and used to cut carcasses. In addition, heavy excavation equipment, such as rubber tired front loader, track excavator, track bulldozer, vibratory sheep-foot compactor, and material handling conveyors adequately sized to efficiently handle the volume of rubber pieces and earthen backfill material will be operated within the designated perimeter of the landfill.

9. The west area is designated as Phase 1. Phase 1area is shown on the attached aerial photo labeled "Existing Conditions" (sheet 2 of 4), Site Layout (sheet 3 of 4) and Plan Schematic (sheet B). Additional activities also conducted within Phase 1 area will include: staging and processing whole tire carcasses in the processing building to be constructed immediately to the north of the existing shop building; and maintaining equipment in the existing shop building.

10. As the surface area of the pit is enlarged, topsoil on the natural ground surface shall be stripped and stockpiled on-site for use in future reclamation of landfill surface. In addition, erosion control measures shall be implemented in accordance with recognized Best Management Practiced (BMP's) to mitigate effects of stormwater runoff and wind. Silt fences shall be erected and maintained to minimize erosion and sediment transport due to stormwater. Growth of vegetation on the stockpiled topsoil will be encouraged to protect it against wind erosion. The existing stockpiles of topsoil exhibit heavy growth of volunteer vegetation demonstrating the soil to be laden with plant seeds ready to germinate in favorable conditions.
    Soil excavated from the pit will be screened on-site as required and used to provide sand, gravel and cobble material adequate for backfilling lifts of rubber pieces. Dust abatement measures, which may include use of water sprinklers in the screening equipment, shall be implemented as required. Larger dimension reject cobbles, rocks and boulders will be hauled off site.

11. Water and environmentally responsible dust suppression products will be applied on driving corridors, parking areas and other areas on-site which produce dust.

12. The line separating Phase 1 from Phase 2 will be fenced with a durable steel fencing material at least 4 ft in height, and maintained as long as landfill operations are limited to the Phase 1 area. The location of this fenced line with access gates between Phase 1 and Phase 2 is shown on the attached Site Layout.

13. As the pit fills up with waste tire pieces from the southwest corner of the property in Phase 1 and the surface is reclaimed to form natural ground, excavation and landfill will proceed to the north and east. As the pit encroaches upon the gravel screening operation, this operation will be relocated from the northern area to the southern area of Phase 1 made available by reclaiming the pit. Landfill operations will continue uninterrupted throughout Phase 1. As the pit in Phase 1 nears completion, excavation will continue east along the south boundary of the licensed landfill property into the south portion of Phase 2 area. Then pit excavation will continue north until the processing building, maintenance shop and storage building are encroached upon. These buildings may then be temporarily relocated onto the reclaimed Phase 1 area or removed from site. Because this scenario is at least 15 years off into the future, exact details of this transition are not clear at this writing.

14. The number of tires used per unit volume, the rate at which a lift of compacted rubber pieces will grow, and area of each lift required to be covered in each 2 to 3 week interval is discussed as follows:
    Completed lifts will be backfilled and covered with native pit run and screened earthen material consisting of sand and gravel with varying content of loam and fines at intervals not to exceed 13 weeks. This is the maximum interval set by the laws and rules of the State of Montana. In general, the operational standard will be to keep the lifts covered within four weeks of placement in order to reduce the visual impact and the danger from fire. A total of eleven lifts of compacted rubber pieces will be placed in the full depth of the pit.

15. Density of rubber shreds averages between 24 and 33 lb/cu. ft (pcf) for loose material and between 40 and 52 lb/cu. ft once compacted into place. (Refer to NEWMOA Fact Sheet, "Beneficial Use of Tire Shreds As Lightweight Fill", dated April 6, 2001 prepared by Northeast Waste Management Officials' Association, and "Source Users Guidelines for Waste and By-Product Materials in Pavement Construction" Federal Highway Administration, FHWA-RD-97-148, April 1998.) Rubber pieces will be placed and compacted into the landfill at a nominal rate of 110 cu. yds per day. Each lift will be nominal 5 ft in depth and will be backfilled and compacted in several passes to ensure stability as the lift is brought up. Each lift will grow at a rate of 3000 sq. ft per week, and each completed lift measuring 9,000 sq. ft in area will be covered with 6 inches of sand and gravel soil at least every 3 weeks.

16. When the final lift of waste rubber pieces brings a portion of the landfill's surface at least 6000 sq. ft in area to within +/-1 ft of surrounding ground level, an 18" thick layer of sand/gravel covered by a 6" minimum thick layer of loam and clayey loam topsoil shall be placed over top of the lift. The final topsoil layer spread over the sand/gravel layer shall be capable of sustaining a healthy stand of surface vegetation. Prior to placing the topsoil layer, the final layer of sand/gravel spread over the finished lift shall be contoured to a gentle crown across the finished surface of the landfill pit and slightly compacted. Weather permitting, the topsoil shall be planted with a mix of grass seeds. If hot summer weather is present, seeded areas should be sprinkler irrigated to establish a durable, erosion resistant stand of surface vegetation.

17. As each lift is brought to ground surface, covered with the required layer of sand/gravel, contoured to finish shape and planted, measures shall be taken to prevent stormwater runoff from flowing into the open pit and causing erosion and transport of sediment into the pit. The edges of the open pit shall be protected with a small berm of compacted topsoil or silt fence and the surface crowned toward the perimeter of the pit to cause stormwater collected on the finished surface to be drained toward the outside edges.

18. During the growing season, the freshly reclaimed and seeded areas will be sprinkler irrigated. Water can be diverted from the Mill Creek Irrigation Pipeline, pumped from the existing monitoring well located near the north boundary of Phase I area, or the well located within Phase 2 for use in irrigating the reclaimed and seeded areas of finished pit surface. Irrigation water should be applied at a rate of 1 inch to 1.5 inches per week during the growing season for at least two consecutive growing seasons to establish and maintain a durable stand of grass and surface vegetation.

19. Reclamation will be completed on areas of the pit approximately 7000 to 9000 sq. ft in size (approximately every two to three weeks) as they are brought to ground level. Finish topsoil will be spread to the required thickness, graded to a gentle slope toward the property boundary and planted with a mix of native and drought resistant grass seeds. Stormwater received on the finished surface during a rainfall event will drain toward the perimeter of the landfill but most will soak in

to the root zone of the plants. The exterior perimeter between the edge of the pit and the licensed boundary of the landfill shall be protected with an earth swale approximately 2 ft deep by 5 ft wide contoured into the natural ground surface and planted with grass. The swale is dimensioned to provide adequate capacity to convey flows generated by the 100 year storm event without over topping it banks, thereby ensuring that stormwater is not received on the reclaimed pit surface. This swale fits into the natural topography of the ground and serves as the path of least resistance to convey stormwater runoff around the landfill. Stormwater runoff from the surface of the landfill, and from surrounding land will be intercepted by the swale and channeled around the perimeter of the licensed landfill and off the property.

20. Stormwater landing inside the open pit shall be channeled into a lined stormwater detention basin from which it can be pumped. The lined basin should be excavated into the bottom of the pit at its lowest point. A pumping sump must be provided in the lowest end of the lined basin to accommodate a pump intake. A basin 10 ft wide x 15 ft long x 2 ft average depth will contain the total volume of runoff generated by design storm event. Water discharged from the pump outlet must be spread and dispersed onto ground surface outside pit in such a manner to prevent soil scour and erosion.

21. Routine maintenance and preventive maintenance must be conducted on all equipment on a periodic basis. Maintenance schedules shall be established and implemented for each machine and piece of equipment in order to ensure the reliable operation.

22. The waste tire mono-fill landfill is not expected to attract a significant amount of litter. However, maintaining an uncluttered appearance throughout the facility will be emphasized to the employees. They will be encouraged to keep their work areas in tidy and orderly condition. In the same manner, rodents, insects and other nuisance creatures are not expected to be attracted to this facility.

Calculation of Hydraulic Conductivity
by Fetters Equation
(k = ft/day)
Adkins Waste Tire Landfill

Well ID	GWIC ID	Well Yield Q (gpm)	Well Yield Q (cf/day)	Static level h (ft)	Pump leve h0 (ft)	Drawdown (ft)	Aqu depth b (ft)	Conductiv k (ft/day)
Well 1	236365	60.0	11,551	104.0	155.0	51.0	10.0	127.12
Well 2	210235	60.0	11,551	95.0	155.0	60.0	10.0	114.00
Well 3	201775	40.0	7,700	91.0	135.0	44.0	10.0	106.95
Well 4	199471	70.0	13,476	98.0	155.0	57.0	10.0	130.83
Well 5	225593	60.0	11,551	94.0	155.0	61.0	10.0	112.75
Average K value								118.33

ATTACHMENT 2.B

ATTACHMENT 3-A
7 pages

OCTAGON
Consulting Engineers, LLC
BIOENERGY • CIVIL • MECHANICAL

September 26, 2011

Brian Heckenberger
Christine Weaver
Water Protection Bureau -- DEQ
P.O. Box 200901
Helena, MT 59620-0901

Re: Stormwater Discharge Permit for Proposed Waste Tire Mono-Fill Landfill

Dear Brian and Christine:

In my telephone calls to WPB seeking details on stormwater discharge regulations and need to obtain discharge permit for a Class III tire landfill, I spoke with Brian on 8/24/11 and Christine on Friday 9/23/11. We discussed in general terms threshold parameters that apply to the Class III mono-fill waste tire landfill as an industrial application which is currently under review by the Solid Waste Program. State law requires that stormwater cannot be allowed to leave a property and end up in state waters without first being permitted. Christine recommended that I write this letter to inform WPB of the factors relating to this property. Terrain, topography, ownership of property, tract boundaries and historic stockpiling of topsoil berms along property boundaries combine to make solid justification that no stormwater discharge from the property owned by the landfill owners is anticipated for storm events up to 100 year-24 hour intensity. Stormwater volume produced by this intensity storm event is significantly larger than stormwater produced by the 25 year-24 hour storm event required by RCRA regulations. Therefore, it is my understanding that permitting under Montana's stormwater permit regulations for industrial facilities is not required.

The site proposed for this landfill is an existing old sand/gravel pit located near the intersection of Chicory Road and East River Road (state highway 540) in Park County, within the $N^1/_2$ $NW^1/_4$ Section 18 T. 5 south, R. 9 east, PMM. The property is owned by Michael and Magdalen Adkins. Over the years as the pit expanded, topsoil removed from the ground surface was placed in berm stockpiles along the perimeter boundary of this property. Today, berm exists along portions of the north, west and south sides of the property.

The existing pit, which is up to 60 ft deep and approximately 4 acres in area at ground surface, will be used to immediately begin landfill operations. Excavation, placing processed tire pieces in lifts, and backfilling/covering lifts in a routine order will all occur within the pit. No stormwater discharge is possible from inside the pit. A lined collection basin will be installed in a low point in the pit to collect stormwater. In the event stormwater is collected, it will be pumped to the surface and land applied in a manner that will prevent runoff.

P.O. Box 78 • Emigrant, MT 59027 • (406) 333-9040 • octagon@wispwest.net

Stormwater volume calculated to be produced by the 100 year-24 hour intensity storm is documented on the attached spread sheet. A stormwater runoff volume of 73,214 cu. ft is calculated to be accumulated on the 18.8 acre site associated with this landfill. Due to surrounding terrain and development, stormwater run-on from surrounding off-site area is limited to insignificant amount. The undeveloped portion of Tract 3 east of the designated licensed boundary of the landfill (approximately 4.5 acres in area) provides a naturally depressed detention basin to collect stormwater runoff. This calculated volume of stormwater when detained in this area a maximum of 30" deep and an average of 12" deep would occupy an irregular area of less than 2 acres. A detention pond this size can easily be accommodated on this tract.

A map identifying the tracts of record which comprise this overall property is attached. In addition, two aerial photos are provided to show how the natural terrain flows surface water into the east portion of Tract 3. At the outset of preparation and prior to commencing landfill operations, grading and contouring of selected areas will be completed as required to ensure surface stormwater runoff will flow toward the detention area.

Based on the information provided herein, I conclude that discharge of stormwater beyond the boundaries of tracts associated with this license during landfill operations is not likely for the specified intensity storm event. I request your determination of requirement to obtain a storm-water discharge permit for this landfill industrial activity. Thank you for your consideration of this request. If you have any questions or comments, please call me.

Sincerely,
OCTAGON CONSULTING ENGINEERS, LLC

William E Smith, P.E.
Consulting Engineer

cc: Mary Louise Hendrickson, DEQ SWLP

OCTAGON
Consulting [illegible]neers LLC
BioEnergy, Civil, Mechanical

(406) 333-8040
Box 78, Emigrant, MT 59027
email: octagon@wispwest.net

MONTANA
WILLIAM E SMITH
8021 E
REGISTERED
PROFESSIONAL ENGINEER

PROJECT NAME:
Adkins Class III
Waste Tires
Monofill L:andfill

CLIENT NAME:
Mike Adkins

DRAWN BY	ENGINEERING APPROVAL	CLIENT APPROVAL	CIVIL APPROVAL	DATE	REV. NUMBER

REVISION SCHEDULE

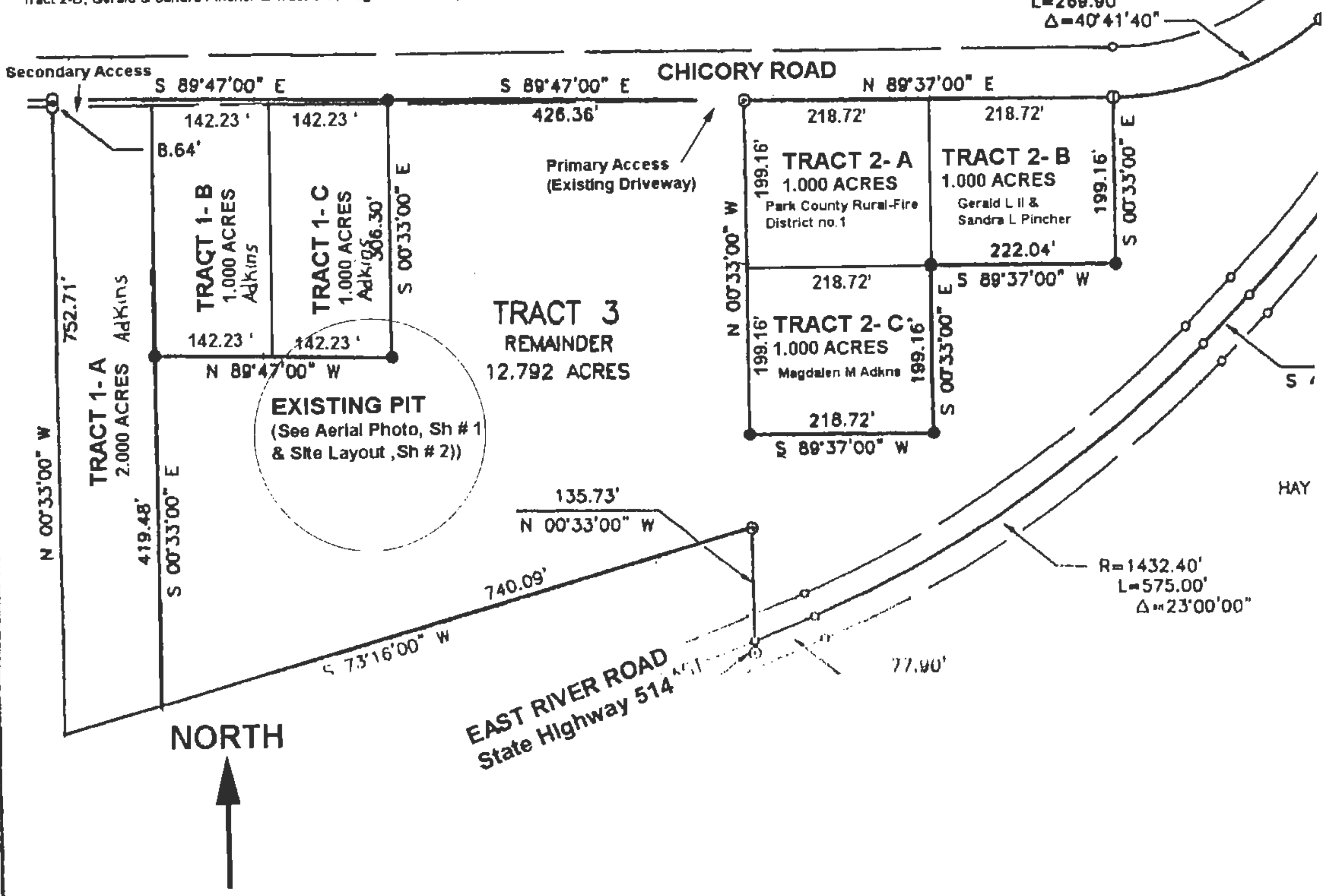
SHEET TITLE
Property Boundaries in accordance with; COS 1906 FE, 1810 FE & 1772 FE of TRACT A of COS 1699

SHEET NUMBER
1 OF 4

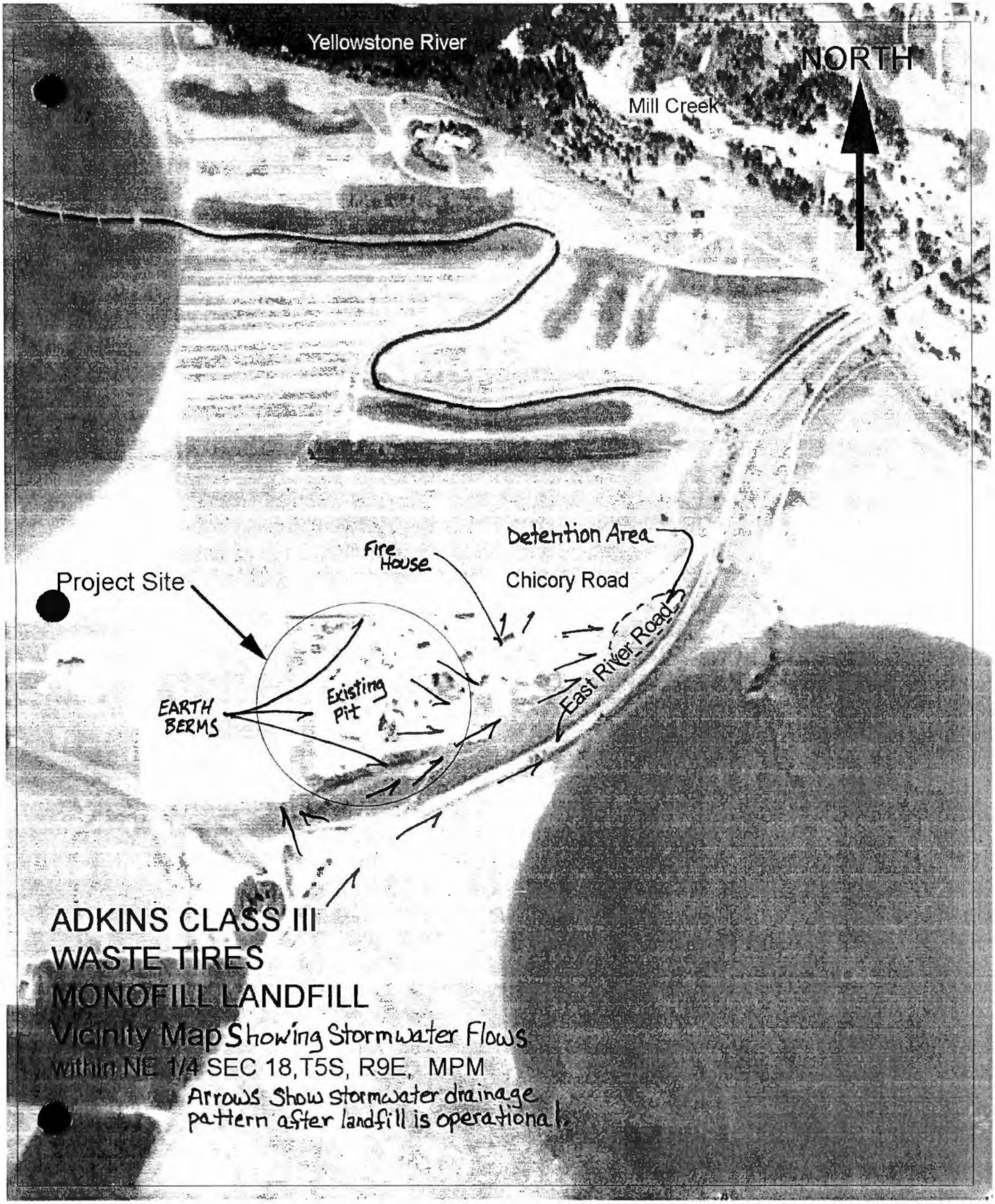
CERTIFICATE OF SURVEY: 1772FE
Three Tracts of land being all of Tract A of COS 1699
located in the SE 1/4 of Sec. 7 and NE 1/4 of Sec. 18,
T5S, R9E, P.M.M. Park County Montana (Creates Tract 1;Magdelen Adkins, Tract 2, Heather Michelle Adkins & Tract 3; Remainder)

CERTIFICATE OF SURVEY: 1906FE
Three Tracts of land being all of Tract 1 of COS 1772
located in the NE 1/4 of Sec. 18, T5S, R9E, P.M.M. Park County Montana (Creates Tract 1- A; Michael Adkins, Tract 1-B; Margrit Fehlman & Tract 1-C; Remainder)

CERTIFICATE OF SURVEY: 1810FE
Three Tracts of land being all of Tract 2 of COS 1772
located in the SE 1/4 of Sec. 7 and Ne 1/4 of Sec. 18,
T5S, R9E, P.M.M. Park County Montana (Creates Tract 2-A, Park County Rural-Fire District #1, Tract 2-B; Gerald & Sandra Pincher & Tract 2-C; Magdalen Adkins)



SCALE: 1-IN = 200-FT


Yellowstone River
NORTH
Mill Creek
Detention Area
Fire House
Chicory Road
Project Site
East River Road
EARTH BERMS
Existing Pit
ADKINS CLASS III
WASTE TIRES
MONOFILL LANDFILL
Vicinity Map Showing Stormwater Flows
within NE 1/4 SEC 18,T5S, R9E, MPM
Arrows show stormwater drainage pattern after landfill is operational.

OCTAGON
Consulting Engineers
CIVIL & LAND DEVELOPMENT

(406) 333-9040
Box 78, Emigrant, MT 59027
email: octagon@wispwest.net

MONTANA
WILLIAM E SMITH
8021 E
REGISTERED
PROFESSIONAL ENGINEER

PROJECT NAME:
Adkins Class III Waste Tires Monofill Landfill

CLIENT NAME:
Mike Adkins

DRAWN BY	ENGINEERING APPROVAL	CLIENT APPROVAL	CIVIL APPROVAL	DATE	REV. NUMBER
KB				6/2/10	3

REVISION SCHEDULE

SHEET TITLE

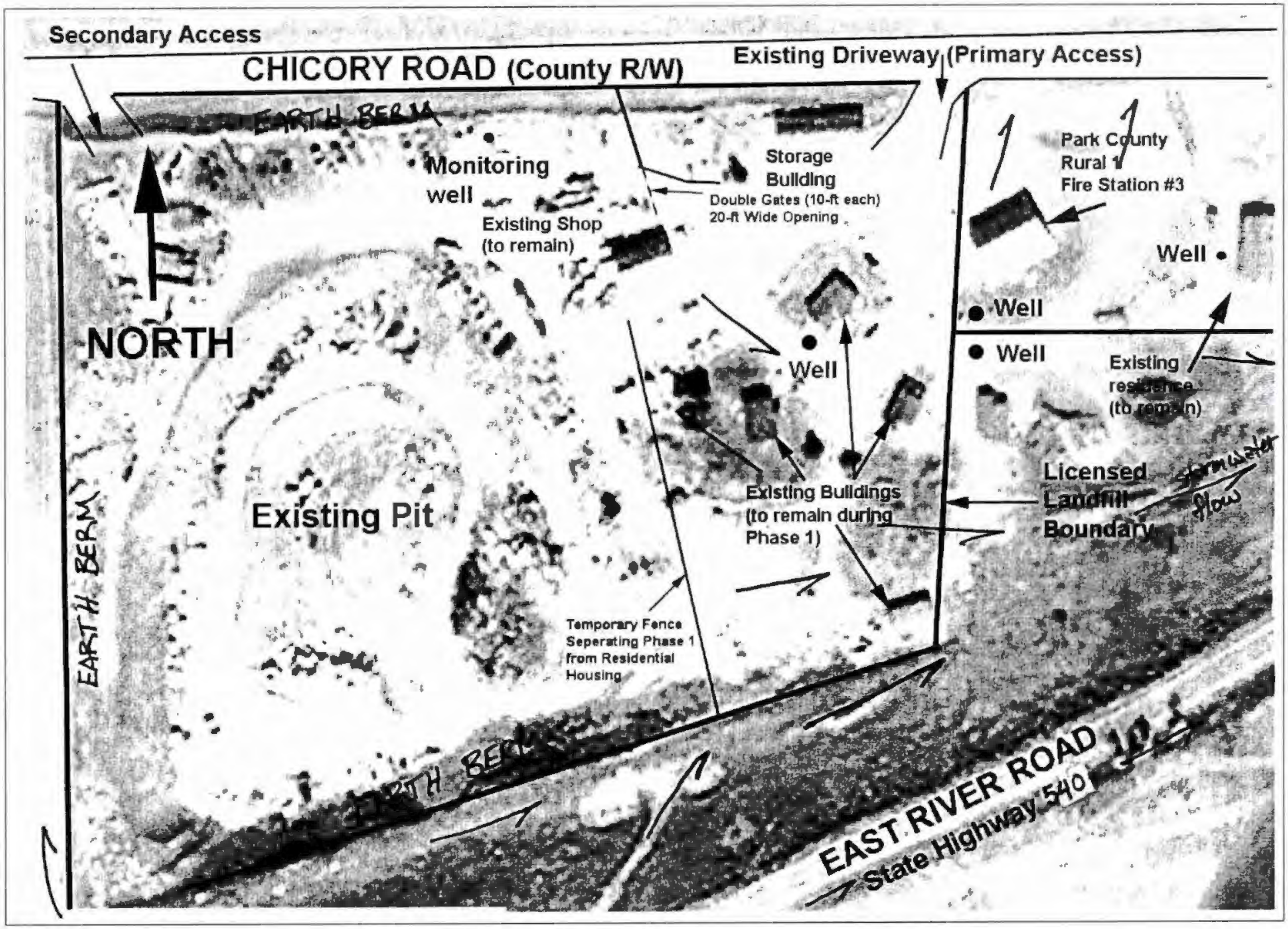
Landfill Operation Plan

Aerial Photograph showing Existing Development & Activities

Project Site Layout

SHEET NUMBER

1



Arrows show stormwater drainage pattern after landfill is operational.

Licensing Application for Adkins [illegible]ss III Monofill Waste Tire Landfill

Stormwater Volume Detained On-Site from 100 yr-24 hour Storm

Stormwater accumulation from:

Landfill Comprised of Trs 1-A, 1-B, 1-C & west portion of Tr. 3 plus land east of landfill boundary consisting of Trs 2-B, 2-C and detention area in east portion of Tr. 3 (4.5 acres) (Refer to Site Map Showing Tracts of Record on Sheet 1 of 4)

REQUIRED STORMWATER DETENTION VOLUME:

RELATIVE IMPERVIOUSNESS FACTORS:		**(C Range)**	**(C Used)**
PAVED AREAS/STRUCTURES	=	(0.8-0.9)	0.9
GRAVELED AREAS	=	(0.35-0.8)	0.8
UNIMPROVED RANGELAND	=	(0.15-0.4)	0.3
LANDSCAPED (lawn, shurbs,trees)	=	(0.1-0.3)	0.1

100 YEAR -24HOUR STORM EVENT:	i	**3.20** in. per 24 hr	**(Input Site Rainfall Intensity 100-yr 24-hr)**
	T	3600 sec/hr	

		NEW SITE LAYOUT		**EXISTING SITE LAYOUT**	
AREAS:		**AREA (Ft2)**		**AREA (Ft2)**	
TOTAL AREA OF WATERSHED	=	**818,580** sq. ft.	18.79 acres		
		Input Only		**Input Only**	
PAVED AREAS/STRUCTURES	=	**12,000.00** sq. ft.	0.28 acres	**0.00** sq. ft.	0.00 acres
GRAVELED AREAS	=	**130,680.00** sq. ft.	3.00 acres	**0.00** sq. ft.	0.00 acres
UNIMPROVED	=	**458,100.00** sq. ft.	10.52 acres	**0** sq. ft.	0.00 acres
LANDSCAPED (landfill fin. Surface)	=	**217,800.00** sq. ft.	5.00 acres	**0.00** sq. ft.	0.00 acres
TOTAL	=	**818,580** sq. ft.	18.79 acres	**0** sq. ft.	0.00 acres

VOLUMES REQUIRED: Volume of runoff = (C*I*A)*(43560/12)
Total Volume Difference = New Volume - Existing Volume

PAVED AREAS/STRUCTURES	=	2880.00 C.F.	106.67 C.Y.	0.00 C.F.	0.00 C.Y.
GRAVELED AREAS	=	27878.40 C.F.	1032.53 C.Y.	0.00 C.F.	0.00 C.Y.
UNIMPROVED	=	36648.00 C.F.	1357.33 C.Y.	0.00 C.F.	0.00 C.Y.
LANDSCAPED	=	5808.00 C.F.	215.11 C.Y.	0.00 C.F.	0.00 C.Y.
TOTAL VOLUME	=	73214.40 C.F.	2711.64 C.Y.	0.00 C.F.	0.00 C.Y.
FLOW IN C.F.S.	=	3.39 C.F.S.		0.00 C.F.S.	

TOTAL VOLUME DIFFERENCE	**=**	**73,214 C.F.**	**2712 C.Y.**
TOTAL FLOW IN C.F.S.	=	0.85 C.F.S.	

Montana Department of
ENVIRONMENTAL QUALITY

Brian Schweitzer, Governor
Richard H. Opper, Director

P.O. Box 200901 • Helena, MT 59620-0901 • (406) 444-2544 • www.deq.mt.gov

November 23, 2011

William E. Smith, PE
Octagon Consulting Engineers, LLC
PO Box 78
Emigrant, MT 59027

RE: Storm Water Industrial Permitting – Tire Mono-Fill Landfill

Dear Mr. Smith:

The Department of Environmental Quality (Department) reviewed your letter dated September 26, 2011. We agree that, as long as the proposed waste tire mono-fill landfill does not have the potential for storm water to leave the property, it is not necessary for you to obtain coverage under the "General Permit for Storm Water Discharges Associated with Industrial Activity."

Permit authorization will be required if the design or operation of the facility could allow storm water that comes into contact with the landfill and supporting operations (such as access roads, storage and maintenance areas, and any other industrial activities) to be discharged to any state surface waters. It is the obligation of the landfill owner/operator to ensure that their facility has permit coverage prior to discharging any regulated storm water.

Any discharge from this site to state waters without a current permit constitutes a violation of the Montana Water Quality Act [75-5-605, Montana Code Annotated] and the federal Clean Water Act. Violation of the Montana Water Quality Act subjects the discharger to civil penalties of up to $25,000 per day for each day the violation occurs.

Should you have any questions, feel free to contact me at (406) 444-3927 or email at cweaver@mt.gov.

Sincerely,

Christine A. Weaver

Christine A. Weaver
Environmental Science Specialist
Water Protection Bureau

Cc: Mary Louise Hendrickson, DEQ SWLP

Licensing Application for Adkins Class III Monofill Waste Tire Landfill

Stormwater Volume Detained On-Site from 100 yr-24 hour Storm

Stormwater accumulation from:

Landfill Comprised of Trs 1-A, 1-B, 1-C & west portion of Tr. 3 plus land east of landfill boundary consisting of Trs 2-B, 2-C and detention area in east portion of Tr 3 (4.5 acres) (Refer to Site Map Showing Tracts of Record on Sheet 1 of 4)

REQUIRED STORMWATER DETENTION VOLUME:

RELATIVE IMPERVIOUSNESS FACTORS:		**(C Range)**	**(C Used)**
PAVED AREAS/STRUCTURES	=	(0.8-0.9)	0 9
GRAVELED AREAS	=	(0.35-0.8)	0.8
UNIMPROVED RANGELAND	=	(0.15-0.4)	0.3
LANDSCAPED (lawn, shurbs,trees)	=	(0.1-0.3)	0.1

100 YEAR -24HOUR STORM EVENT: i **3.20** in. per 24 hr **(Input Site Rainfall Intensity 100-yr 24-hr)**

T 3600 sec/hr

		NEW SITE LAYOUT		**EXISTING SITE LAYOUT**	
AREAS:		**AREA (Ft2)**		**AREA (Ft2)**	
TOTAL AREA OF WATERSHED	=	**818,580** sq ft	18.79 acres		
		Input Only		**Input Only**	
PAVED AREAS/STRUCTURES	=	**12,000.00** sq ft.	0.28 acres	**0.00** sq ft.	0 00 acres
GRAVELED AREAS	=	**130,680.00** sq ft.	3.00 acres	**0.00** sq ft.	0.00 acres
UNIMPROVED	=	**458,100.00** sq ft	10.52 acres	**0** sq. ft	0.00 acres
LANDSCAPED (landfill fin. Surface	=	**217,800.00** sq ft	5.00 acres	**0.00** sq ft.	0 00 acres
TOTAL	=	**818,580** sq ft	18.79 acres	**0** sq. ft	0 00 acres

VOLUMES REQUIRED: Volume of runoff = (C*I*A)*(43560/12)

Total Volume Difference = New Volume - Existing Volume

PAVED AREAS/STRUCTURES	=	2880 00 C F	106 67 C Y.	0 00 C F.	0 00 C Y
GRAVELED AREAS	=	27878.40 C F	1032.53 C Y	0.00 C F	0 00 C Y
UNIMPROVED	=	36648 00 C F	1357.33 C Y	0 00 C.F	0 00 C Y
LANDSCAPED	=	5808 00 C F	215.11 C Y	0.00 C.F.	0 00 C.Y
TOTAL VOLUME	=	73214 40 C.F	2711.64 C Y	0 00 C F	0 00 C Y
FLOW IN C F S	=	3 39 C.F S		0 00 C F S	

TOTAL VOLUME DIFFERENCE	=	**73,214 C.F.**	**2712 C.Y.**
TOTAL FLOW IN C F S	=	0.85 C.F S	

ATTACHMENT 3-B

Stormwater Volume from 100 yr-24 hour Storm
Collected in Waste Tire Pit with Maximum Surface Srea of 4.0 acres

Stormwater accumulation from:

Landfill Comprised of Trs 1-A, 1-B, 1-C & west portion of Tr. 3 plus land east of landfill boundary consisting of Trs 2-B, 2-C and detention area in east portion of Tr. 3 (4.5 acres) (Refer to Site Map Showing Tracts of Record on Sheet 1 of 4)

REQUIRED STORMWATER DETENTION VOLUME:

RELATIVE IMPERVIOUSNESS FACTORS:		**(C Range)**	**(C Used)**
PAVED AREAS/STRUCTURES	=	(0.8-0.9)	0.9
GRAVELED AREAS	=	(0.35-0.8)	0.5
UNIMPROVED RANGELAND	=	(0.15-0.4)	0.3
LANDSCAPED (lawn, shurbs,trees)	=	(0.1-0.3)	0.1

100 YEAR -24HOUR STORM EVENT: i **3.20** in. per 24 hr **(Input Site Rainfall Intensity 100-yr 24-hr)**
T 3600 sec/hr

		NEW SITE LAYOUT		EXISTING SITE LAYOUT	
AREAS:		**AREA (Ft2)**		**AREA (Ft2)**	
TOTAL AREA OF WATERSHED	=	**174,240** sq. ft.	4.00 acres		
		Input Only		**Input Only**	
PAVED AREAS/STRUCTURES	=	**-** sq. ft.	0.00 acres	**0.00** sq. ft.	0.00 acres
GRAVELED AREAS	=	**174,240.00** sq. ft.	4.00 acres	**0.00** sq. ft.	0.00 acres
UNIMPROVED	=	**-** sq. ft.	0.00 acres	**0** sq. ft.	0.00 acres
LANDSCAPED (landfill fin. Surface)	=	**-** sq. ft.	0.00 acres	**0.00** sq. ft.	0.00 acres
TOTAL	=	**174,240** sq. ft.	4.00 acres	**0** sq. ft.	0.00 acres

VOLUMES REQUIRED: Volume of runoff = (C*I*A)*(43560/12)
Total Volume Difference = New Volume - Existing Volume

PAVED AREAS/STRUCTURES	=	0.00 C.F.	0.00 C.Y.	0.00 C.F.	0.00 C.Y.
GRAVELED AREAS	=	23232.00 C.F.	860.44 C.Y.	0.00 C.F.	0.00 C.Y.
UNIMPROVED	=	0.00 C.F.	0.00 C.Y.	0.00 C.F.	0.00 C.Y.
LANDSCAPED	=	0.00 C.F.	0.00 C.Y.	0.00 C.F.	0.00 C.Y.
TOTAL VOLUME	=	23232.00 C.F.	860.44 C.Y.	0.00 C.F.	0.00 C.Y.
FLOW IN C.F.S.	=	1.08 C.F.S.		0.00 C.F.S.	
TOTAL VOLUME DIFFERENCE	=	**23,232 C.F.**	**860 C.Y.**		
TOTAL FLOW IN C.F.S.	=	0.27 C.F.S.			

ATTACHMENT 3-C

ATTACHMENT 4-A
3 pages

OCTAGON
Consulting Engineers, LLC
BIOENERGY • CIVIL • MECHANICAL

September 8, 2011

Vickie Walsh, Permitting Supervisor
ARMB -- DEQ
P.O. Box 200901
Helena, MT 59620-0901

Re: Determination of Need for Air Quality Permit for Proposed Tire Landfill

Dear Vickie:

In a telephone conversation I made to ARMB seeking details on air quality regulations for Class III landfills, I spoke with Ed. We discussed in general terms threshold parameters that may apply to the Class III mono-fill waste tire landfill application which is currently under review by the Solid Waste Program. Tire landfills are designated Class III because the rubber does not significantly breakdown resulting in releases into the atmosphere. He recommended I write this letter as a step to formally request your determination of need for permitting under Montana's air quality regulations.

The site proposed for this landfill is an existing old gravel pit located near the intersection of Chicory Road and East River Road (state highway 540) in Park County, within the N$^1/_2$ NW$^1/_4$ Section 18 T. 5 south, R. 9 east, PMM. The property is owned by Michael and Magdalen Adkins.

The operation plan calls for 5000 waste tire carcasses to be received and processed per day. Chopped tire pieces will be placed into the pit in 5 ft thick lifts, and the lift will grow in area 3000 sq. ft per week. Exposed rubber pieces will be covered with native gravel/sand every 2 to 3 weeks, mechanically compacted to fill voids with soil backfill and stabilize each lift, and finally the lift covered with a 6" layer of sand/gravel as it grows out into the open pit.

The compacted density of rubber pieces will result in void ratio of 35 to 40% that must be backfilled. The calculated weight of backfill required per week is 454 tons. Visual evaluation of native sand/gravel stratum of this pit shows that not more than 50% of excavated backfill material will require screening in order to produce backfill significantly free of oversized rocks. A small screening plant will be set up on-site and operated on average 8 hours per day, 2 days per week at a production rate of 15 tons per hour. Three phase electric power is available on-site from the local power utility, so diesel generator sets will not be required.

Truck traffic and movement of heavy excavation equipment around the site will be minimal. Trucks delivering tires will unload in front of the processing building a short distance into the site, and chopped rubber pieces will be moved extensively by conveyors.

Based on this information provided, I request your determination of required air quality permit. Thank you for your consideration of this request. If you have any questions or comments, please call me at 406-333-9040.

Sincerely,
OCTAGON CONSULTING ENGINEERS, LLC

William E Smith

William E Smith, P.E.
Consulting Engineer

P.O. Box 78 • Emigrant, MT 59027 • (406) 333-9040 • octagon@wispwest.net

Montana Department of
ENVIRONMENTAL QUALITY

Brian Schweitzer, Governor

P. O. Box 200901 Helena, MT 59620-0901 (406) 444-2544 Website: www.deq.mt.gov

September 15, 2011

William E. Smith
Octagon Consulting Engineers, LLC
P.O. Box 78
Emigrant, MT 59027

RE: Montana Air Quality Permit Determination for Proposed Group III Tire Landfill

Dear Mr. Smith:

On September 13, 2011, the Department of Environmental Quality (Department) received your request to determine if a proposed tire landfill would require a Montana Air Quality Permit (MAQP). The landfill would be a Group III classification according to Administrative Rules of Montana (ARM) 17.50.503(1)(b) (ii), for inert materials such as vehicle tires where no decomposition is expected; therefore, no emissions of greenhouse gases (GHGs) such as carbon dioxide (CO_2) or methane is projected. The trigger mechanism for gravel operations is often associated with emissions from diesel generators used to power screening equipment or due to emissions associated with high throughput rate screens and conveyors. Your correspondence indicated that the facility will have landline power available at the site and the proposed screen is has a maximum rated design capacity of 15 tons per hour. The Department determined that the potential emissions associated with this proposed operation fall below the MAQP threshold.

In reviewing your proposed project, the Department assumed a single screen at a maximum production rate of 15 tons/hour. The Department also assumed up to 3 conveyors could be incorporated from the point of excavation to final installation and compaction over the tire lifts. Three piles of material storage were also assumed including raw material storage prior to screening, pile formation after screening, and also conveyance into the landfill as a pile forming process. Some minor truck loading operations and emissions due to truck travel on unpaved roads are also included. Based on your description of the proximity of the proposed equipment, the emissions due to truck travel on unpaved roads is likely over-estimated in this analysis.

A summary of the emission inventory is shown directly below.

	Emissions Tons/Year [PTE]		
Emission Source	PM	PM_{10}	$PM_{2.5}$
Screen (Assume all material backfill is screened at 15 tons/hr)	2.07	0.99	0.00
Transfer Points (Assume 3 Transfer Points that are Controlled)	0.59	0.22	0.00
Pile Formation (At screen rate)	0.21	0.10	0.02
Truck Loading (Assume 15 tons/hr are loaded into trucks at some point)	0.01	0.00	0.00
Unpaved Roadways (Haul Roads)	5.39	1.49	0.15
TOTAL EMISSIONS >	8.27	2.79	0.16

The Department has reviewed the applicable Administrative Rules of Montana (ARM) and other Department documents pertaining to permitting requirements for gravel screening equipment and made the following determination.

Based on the information submitted, the proposed 15 ton per hour screen, conveyors and pile forming operations would not require an MAQP. If in the future a significantly higher throughput screen is required or additional processing equipment is needed, a new permit determination should be conducted.

If there are additional questions, please contact me via e-mail at chenrikson@mt.gov or by telephone at (406) 444-6711.

Sincerely,

Craig Henrikson, PE
Environmental Engineer
Air Resources Management Bureau

ATTACHMENT 5-A
2 pages

MONTANA
STATE UNIVERSITY
BILLINGS

Department of Biological
and Physical Sciences

November 11, 2013

To Those Concerned,

Mr. Mike Adkins contacted me concerning the potential for colonization by rattlesnakes of a proposed filled-in gravel pit on his property. As I understand it, Mr. Adkins intends to use cut-up tires and sand in layers to fill a gravel pit. Apparently an injunction has been issued against this action, citing, as one reason, the potential for increased rattlesnake density in the area due to snakes burrowing into the fill. In other words, the suggestion here is that Mr. Adkins is essentially, unintentionally, providing attractive habitat for the snakes. I do not think this will be the case.

Rattlesnakes do not make their own burrows. While they certainly do use burrows dug by mammals (ground squirrels, rabbits, prairie dogs, kangaroo rats etc.) they have no ability to "dig" a burrow themselves. Indeed, no snakes can dig a burrow in solid ground; some snakes are adapted to moving under loose sand, but the rattlesnake we have in Montana (*Cratalus viridis*) is not one of those species.

I assume that the concern in this case is that there will be voids under the ground (caused by the tire pieces) that could potentially be used by snakes as hibernacula (places to spend the winter). I have no idea whether this type of fill will produce those types of voids, but even if it does, unless the voids are connected to the surface (like the opening to a small cave) the snakes in the area will never be able to sense that the voids exist, or access them even if they could sense them. Thus, I see no reason to expect that snakes will be "drawn" to this fill material because of any characteristics of the fill itself.

Our species of rattlesnake does hibernate in high densities in suitable areas; these are generally naturally-occurring cracks, crevices and caves in rock outcroppings. I would not expect snakes to congregate at this site unless the fill mimics some of these types of natural hibernacula, and this seems unlikely to me (perhaps a question for a civil engineer).

However, if this type of fill proves to be especially attractive to food sources for the snakes (i.e. small burrowing mammals), then it is possible that local populations of snakes may increase and snakes may use the fill area. I have no special expertise in mammals (I have been

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studying snakes and lizards for over 20 years) but it would seem to me that a sand-filled habitat would not be particularly attractive to small mammals due to the frequent collapse of burrows. Still, I would encourage consultation with a mammal ecologist on this point.

In conclusion, it is my opinion that the fill proposed by Mr. Adkins is unlikely to cause any local change in the number of rattlesnakes in the area. Rattlesnakes will certainly not burrow, of their own accord, into the fill to access any voids that may be present underground; and I see no other reason to expect that a sand/tire fill of this type would be overly attractive to rattlesnakes. Feel free to contact me with any further questions.

Sincerely,

James Barron, Ph.D.
Associate Professor of Biology
Montana State University Billings
1500 University Drive
Billings, MT 59101
(406) 657-2918
jbarron@msubillings.edu

ATTACHMENT 5-B
3 pages

July 26, 2012

Mr. Michael Adkins
Mr. William Smith
P.O. Box 32
Pray, MT 59065

RE: Mosquito Production Related to Waste Tires

Dear Gentlemen:

Thank you for the opportunity to visit the Adkins Waste Tire Monofill Landfill (Landfill) on the morning of July 13, 2012 for a tour of the facility and description of the operation plans for receiving and processing waste tires. During our meeting you provided me copies of letters regarding the licensing (DEQ) and license validation (Park County Environmental Health) of the Landfill. The letter (dated May 4, 2012) from Mary Louise Hendrickson, DEQ, informed you the application for licensure was approved, pending review and validation by the Park County Environmental Health Office. The letter (dated May 18, 2012) from Dr. Douglas Wadle, Public Health Officer, noted deficiencies in your licensing application and for reasons stated in his letter was unable to validate the license. One of his concerns was an increased risk of mosquito production and mosquito-borne pathogens such as West Nile virus associated with waste tires at the Landfill.

You have asked for my professional opinion regarding mosquito production associated with waste tire processing at the Landfill. I should indicate my expertise in mosquito biology and management comes from over 30 years of entomological experience (26 years with MSU) many of which have been spent working on insects and other arthropods of medical and veterinary importance. Also, I have been responsible for a statewide mosquito and West Nile virus surveillance program for the state since the pathogen arrived in Montana in 2002.

In responding to the concern of waste tires and mosquito production, some background information on mosquito bionomics may be helpful in understanding the situation.

Mosquitoes can be placed in one of three broad categories based on where they lay their eggs: 1) Permanent pool mosquitoes deposit eggs on the surface of standing water of open sunlight pools, wetlands, sewage treatment lagoons, etc. 2) Floodwater mosquitoes lay their eggs on damp soil during the summer that will be flooded the following spring. 3) Container mosquitoes lay their eggs in water trapped in artificial containers including flower vases, tin cans, plugged roof gutters, abandoned water tanks, discarded tires, etc. Species in these categories exhibit a strong preference for these specific egg-laying sites.

In Montana there are approximately 50 species of mosquitoes. Over 80% of these species belong in the floodwater category. Two permanent pool species, *Culex tarsalis* and *Culex pipiens*, are capable of using containers mentioned above for oviposition, but rarely do so because of the ubiquitous nature of preferred egg-laying sites such as open sunlight pools and organically rich water, respectively. Fortunately, we do not have the species in southwest Montana that strictly use containers for oviposition as are present in other parts of the US. Consequently, in southwest Montana because of the lack of container breeding mosquitoes (in the strict sense) the presence of whole waste tires does not automatically equate to an increase in mosquito production.

It is general knowledge that water must be continually present for mosquitoes to complete immature development (i.e., egg to adult). When conducting West Nile virus surveillance in many parts of the state, I would, on occasion, examine discarded tires on premises where I was sampling mosquitoes and routinely find them empty of both water and mosquitoes. I did have the opportunity to examine two premises in Montana where a large number of whole, discarded tires were stockpiled – one south of Bozeman and the other near Columbus, MT. The Bozeman site was sampled on several occasions during the summer of 2002. A few of the approximately 100 tires contained small amounts of water (<8 oz.) during June but were dry in July and August; the inside of the tires were void of immature mosquitoes each month we sampled. The Columbus site was examined once in early July 2005 and all tires were void of water. The point here is that in semi-arid regions like southwest Montana, water in discarded, whole tires does not exist long enough to support mosquito development. And even if it did, the mosquito species in our area would not find tire carcasses a suitable place for egg-laying.

Please note that my observations mentioned above address whole tires. The Landfill Operations Plan states that waste tires will be cut into at least four pieces, placed into the landfill pit in lifts, compacted and covered with a 6" layer of sand/gravel. I have not had an opportunity to examine processed tires (quartered, chopped or shredded) for their water holding capacity or ability to support mosquito production. Intuitively, I think tires processed in this manner as outlined in the Landfill Operations Plan would not hold water let alone support immature mosquito development to completion.

I appreciate Dr. Wadle's concern relative to mosquito-borne pathogens. Arthropod-transmitted diseases are complex biological and physical systems involving an arthropod, pathogen, amplifying reservoir, host and appropriate weather events, especially high ambient temperatures and periodic rainfall. All biological components must be present in sufficiently high numbers for an arthropod disease to surface. The absence of one or more of these components greatly reduces or eliminates the risk of disease transmission. Since I do not see a positive correlation between mosquito production and the Landfill, I conclude that there will not be an increased risk in mosquito-borne pathogens associated with the Landfill and its operations.

Thank you for the opportunity to comment on the concerns mosquito issue. Please let me know if I can provide additional information.

Sincerely,

Gregory Johnson, Ph.D.
Professor, Veterinary Entomology
Montana State University
gdj@montana.edu
406.994.3875

Dana N. Humphrey[1], Lynn E. Katz[1], and Michael Blumenthal[2]

WATER QUALITY EFFECTS OF TIRE CHIP FILLS PLACED ABOVE THE GROUNDWATER TABLE

REFERENCE: Humphrey, D.N., Katz, L.E., and Blumenthal, M., "**Water Quality Effects of Tire Chip Fills Placed Above the Groundwater Table**", Testing Soil Mixed with Waste or Recycled Materials, ASTM STP 1275, Mark A. Wasemiller, Keith B. Hoddinott, Eds., American Society for Testing and Materials, 1997.

ABSTRACT: Two field trials were constructed to investigate the effect on water quality of tire chip fills placed above the groundwater table. Control wells were used to distinguish the substances naturally present in groundwater from those that leached from tire chips. There was no evidence that tire chips increased the level of substances that have a primary drinking water standard. In addition, there was no evidence that tire chips increased the levels of aluminum, zinc, chloride or sulfate which have secondary (aesthetic) drinking water standards. Under some conditions iron levels may exceed their secondary standard. It is likely that manganese levels will exceed their secondary standard, however, manganese is naturally present in groundwater in many areas. Two sets of samples were tested for organics. Results were below the method detection limit for all compounds.

KEYWORDS: tires, tire chips, tire shreds, waste tires, water quality, metals, organics, road construction

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Tire chips are waste tires that have been cut into 25 to 300 mm pieces. They offer the following advantages when used as a fill material: lightweight, low lateral pressure, low thermal conductivity, and free draining. Because of these advantages they have been used on more than 70 road construction projects across the United States. While their

[1]Associate Professor, Department of Civil and Environmental Engineeri University of Maine, Orono, ME 04469-5711.

[2]Scrap Tire Management Council, Washington, D.C.

effect on groundwater quality is thought to be small, there has been little study of the effects for field conditions.

Previous laboratory leaching studies have shown that tire chips are not a hazardous waste. However, low levels of some metals and organic compounds were found in the leachate (Radian, 1989; Minnesota Pollution Control Agency, 1990; Edil and Bosscher, 1992; Ealding, 1992; Downs et al., 1996). This indicated that testing the effects of tire chips on water quality under field conditions was warranted.

A limited field study was performed for the Minnesota Pollution Control Agency (1990). Unfortunately, samples were taken on only one date from open boreholes. This sampling procedure casts doubt on the validity of the results. Edil and Bosscher (1992) installed two pan lysimeters beneath tire chip layers in a test road embankment. The study had no control for sampling an area with no tire chips, so it was not possible to separate the effects of the tire chips from the compounds naturally present in the groundwater.

The objective of the two studies presented herein were to measure the water quality effects of tire chips placed above the water table. The studies include control sections to measure the levels of substances naturally present in the groundwater. A separate study of the effect on water quality of tire chips placed below the groundwater table is ongoing. In this latter study 1.5 tons of tire chips were buried below the water table in glacial till, marine clay, and peat. Preliminary results are given in Downs et al. (1996).

RICHMOND FIELD TRIAL

The purposes of the Richmond Field Trial were to test the use of tire chips as thermal insulation to limit the depth of frost penetration beneath a gravel surfaced road and to measure the effect of tire chips placed above the water table on groundwater quality. The tire chips have reduced the depth of frost penetration by up to 40% and the road surface has remained stable throughout the spring thaw (Humphrey and Eaton, 1995). The thermal resistivity of the tire chips has been found to be approximately eight times greater than a typical granular soil (Humphrey et al., 1997). The site, groundwater monitoring program, and monitoring results are described in the following sections.

Site and Monitoring Well Descriptions

The test site is located on Dingley Road in the Town of Richmond, Maine. The road follows the northeast shoulder of a broad, flat ridge that trends northwest-southeast. During the summer and fall no standing water or wet areas are evident near the test site. However, during the spring melt, the generally flat topography leads to poor drainage and areas of standing water.

The native soils range from gray silty clay to gray-brown silty gravely sand. Probes were conducted with a 127-mm diameter power auger. Refusal occurred at depths ranging from 2.7 m to 5.5 m. The general geology of the area suggests that refusal was either glacial till with boulders or bedrock.

The test site is 290 m long and is broken up into five tire chip test sections and one control section. Two different thicknesses of tire chips (152 and 305 mm) were used to investigate the thickness that is required to provide adequate insulation and three different thicknesses of granular soil (305, 457, and 610 mm) were placed over the tire chips to investigate the thickness needed to provide a stable riding surface. The general layout is shown in Fig. 1.

The tire chips were uniformly graded and had a nominal maximum size of 51 mm. Almost all the tire chips were retained on the No. 4 (4.75 mm) U.S. standard sieve size. They were made from a mixture of steel and glass-belted tires. The tire chips were irregular in shape and many had steel belts protruding from the cut edge of the chip. The tire chips were donated by Pine State Recycling of Nobleboro, Maine. Approximately 20,000 tires were used in this small project, which clearly shows the potential of this application to use large quantities of scrap tires. The gravel fill used over the tire chips was a well graded mixture of sand and gravel with less than 5% passing the No. 200 (0.075 mm) U.S. standard sieve size. Flake calcium chloride was applied to the road surface for dust control.

Groundwater monitoring wells were installed in the shoulder of the road at six locations. Well no. 0+69 is the control well and is located adjacent to the control section, which has no tire chips. Moreover, the control section is located upgradient of the sections with tire chips. The other five wells are adjacent to sections with tire chips. The horizontal distance from the edge of the tire chip fill to the well was between 1 and 2 m. The wells consist of 51-mm diameter Sch. 40 PVC pipe. The pipe was placed in a 127-mm diameter hole and the slotted lower portion was backfilled with concrete sand. Then a 0.3 to 0.6-m thickness of bentonite balls were placed to form an impermeable seal to prevent surface water from reaching the slotted tip. The remainder of the hole was backfilled with native soil. However, no bentonite seal was constructed in well no. 3+42. Well installation is summarized in Table 1. Further details are given in Humphrey and Katz (1995). In the summer and fall, the water table is 0.2 to 2.2 m below the bottom of the tire chip layer. During the spring melt, the water table varies from approximately 0.5 m below the bottom of the tire chip layer in Section A to even with the bottom of the tire chip layer in Section E.

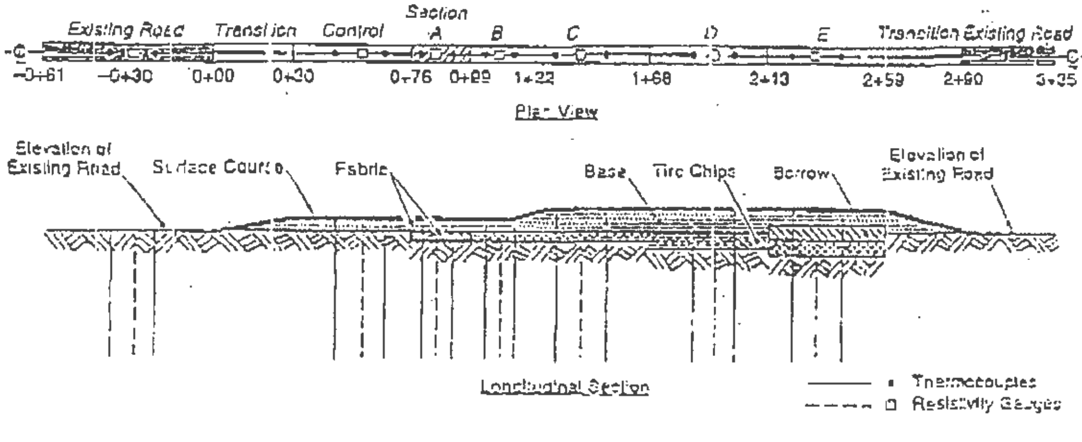

FIG. 1—Plan view and longitudinal section of the Richmond Field Trial.

TABLE 1—Summary of well installation at Richmond Field Trial.

Well no.	Elev. of top of sand backfill (m)	Elev. of bottom of sand backfill (m)	Elev. of bottom of adjacent tire chip layer (m)
0+69	12.17	11.47	Not applicable
3+00	10.95	10.22	13.16
3+42	Not recorded	10.09	13.03
6+19	7.23	6.47	13.03
6+77	8.58	7.88	11.97
8+32	9.85	8.60	11.41

Note: Elevations are referenced to an arbitrary site datum.

Sampling and Testing Procedures

Water samples were obtained with a 1-liter capacity high density polyethylene (HDPE) bailer. Just prior to sampling, approximately three wells volumes were bailed from the well, then the samples were taken from the groundwater that recharged the well. The following sample types were taken from each well: leachate filtered through a 0.3-micron filter and preserved with nitric acid (1.5-ml/L) as appropriate for determination of dissolved metals (Clesceri, et al., 1989); leachate unfiltered and preserved with nitric acid (1.5-ml/L); and unfiltered leachate with no acid. Samples were stored in HDPE bottles and were refrigerated to minimize degradation of sample quality. In addition, on two dates samples were taken for biological oxygen demand (BOD_5) determination.

The samples were tested for the substances listed in Table 2. Samples for metals analysis except for lead and selenium were prepared in accordance with EPA Method 200.7 (Inductively Coupled Plasma - Atomic Emission Spectrometric Method for Trace Element Analysis) (EPA, 1991). The metals were then measured with a Thermo Jarrell Ash Model 975 Plasma Atomcomp Inductively Coupled Plasma Emission Spectrometer. Samples for lead and selenium were prepared in accordance with EPA Method 200.9 (Determination of Trace Elements by Stabilized Temperature Graphite Furnace Atomic

TABLE 2—List of substances tested for in study.

Aluminum (Al)**	Magnesium (Mg)
Barium (Ba)*	Manganese (Mn)**
Cadmium (Cd)*	Selenium (Se)*
Calcium (Ca)	Sodium (Na)
Copper (Cu)*	Zinc (Zn)**
Chromium (Cr)*	Chloride (Cl^-)**
Iron (Fe)**	Sulfate (SO_4)**
Lead (Pb)	

*Has primary drinking water standard

** Has secondary drinking water standard

Absorption Spectrometry) (EPA, 1991). The tests were carried out in accordance with EPA Method 7421 Lead (Atomic Absorption, Furnace Technique) and EPA Method 7740 Selenium (Atomic Absorption, Furnace Technique) (EPA, 1987). Chloride and sulfate were measured in accordance with EPA Method 300.0 (Determination of Inorganic Anions by Ion Chromatography) (EPA, 1983). Water quality index tests such as pH, alkalinity, BOD_5, chemical oxygen demand (COD), conductivity, total dissolved solids, and hardness were also performed.

For most substances, tests were performed on both acid preserved filtered and acid preserved unfiltered samples. The unfiltered samples generally contained some fine grained soil that imparted a slight turbidity to the water. Since most of the inorganic substances that were of interest are present in small amounts in soil, it would not be representative to compare the results from unfiltered samples to drinking water standards. This recognizes that wells for drinking water are designed to prevent any significant amount of particulate matter from entering the well. Thus, results from unfiltered samples provide supplementary information only and were not compared to drinking water standards.

Results

Results for filtered samples are given in Table 3. Results for unfiltered samples and water quality index tests are given in Humphrey and Katz (1995). Results for filtered and unfiltered samples were generally similar, except that the concentration of aluminum (Al), iron (Fe), and manganese (Mn) were higher in the unfiltered samples. However, the unfiltered concentrations of these substances were about the same in the control well and the five wells adjacent to the tire chip sections. Since these substances are present in Maine soils (Downs et al., 1996), the higher concentrations are most likely due to the presence of suspended soil particles in the unfiltered samples.

The first group of substances in Table 3 have a primary drinking water standard indicating that they pose a known or suspected health risk. This includes barium (Ba), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), and selenium (Se). These substances were present in trace amounts or were below the detection levels. Filtered sample results for cadmium (Cd), lead (Pb), and selenium (Se) were below detection levels for all wells on all three sampling dates. It should be noted that for the first two sampling dates the detection limit for lead (Pb) was above its drinking water standard due to testing difficulties. This problem was corrected prior to the third sampling date. The significant result is that for substances that were detected, the concentrations were below applicable drinking water standards. This can be seen for the chromium (Cr) results which are plotted in Fig. 2. Chromium (Cr) levels were consistently higher in the control well than the wells adjacent to the tire chip sections. This suggests that trace levels of chromium (Cr) are naturally present in the soil and illustrates the importance of having a control well when assessing the effect of tire chips on water quality.

The second group of substances in Table 3 has secondary drinking water standards indicating that they are of aesthetic concern. This includes: aluminum (Al), iron (Fe), manganese (Mn), zinc (Zn), chloride (Cl^-), and sulfate (SO_4). The results were below the applicable standard except for manganese (Mn). As shown in Fig. 3, for some sampling dates the manganese concentration was above the secondary standard in the control well

TABLE 3—Water quality results on filtered samples for Richmond Field Trial.

Well No.	Date	Concentrations with primary limit (mg/L) Ba	Cd	Cr	Cu	Pb	Se	Concentrations with secondary limit (mg/L) Al	Fe	Mn	Zn	Cl-	SO4	Solids	Conc. with no limit (mg/L) Ca	Mg	Hard.	Na
R.A.L.		2	0.005	0.1	1.3	0.015	0.05	0.2	0.3	0.05	5	250	250	500	N.A.	N.A.	N.A.	N.A.
0+69	12/23/93	<0.01	<0.005	0.015	<0.01	<0.057	N.D.	<0.1	<0.1	0.145	<0.01	94.7	65.3	N.D.	58.0	10.4	N.D.	30.3
0+69	5/24/94	0.023	<0.005	0.013	0.006	<0.057	N.D.	<0.2	<0.01	0.022	<0.005	122.0	57.3	N.D.	76.2	15.0	N.D.	30.0
0+69	1/18/95	0.030	N.D.	0.011	0.006	<0.005	N.D.	<0.015	<0.1	0.003	0.010	140.0	22.3	430	76.1	15.1	252	32.1
3+00	12/23/93	<0.01	<0.005	<0.01	<0.01	<0.057	N.D.	<0.1	<0.1	0.021	<0.01	135.9	13.2	N.D.	63.4	15.4	N.D.	24.2
3+00	5/24/94	0.015	<0.005	0.009	<0.005	<0.057	N.D.	<0.2	<0.01	0.008	<0.005	123.9	2.7	N.D.	54.6	13.4	N.D.	23.0
3+00	1/18/95	0.028	N.D.	<0.002	<0.004	<0.005	N.D.	<0.015	<0.1	<0.002	<0.003	50.2	12.5	210	27.5	6.6	96	16.0
3+42	12/23/93	<0.01	<0.005	<0.01	<0.01	<0.057	N.D.	0.176	<0.1	0.081	<0.01	5.6	11.8	N.D.	6.4	1.7	N.D.	7.9
3+42	5/24/94	0.005	<0.005	0.005	<0.005	<0.057	N.D.	<0.2	0.010	0.057	<0.005	12.8	4.1	N.D.	9.1	2.3	N.D.	7.8
3+42	1/18/95	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6+19	12/23/93	<0.01	<0.005	<0.01	<0.01	<0.057	N.D.	<0.1	<0.1	0.294	<0.01	5.8	8.2	N.D.	21.8	2.0	N.D.	7.1
6+19	5/24/94	0.007	<0.005	0.006	0.005	<0.057	N.D.	<0.2	<0.01	0.042	<0.005	5.0	3.1	N.D.	20.6	1.7	N.D.	6.2
6+19	1/18/95	0.008	N.D.	<0.002	<0.004	<0.005	N.D.	<0.015	<0.1	0.006	<0.003	2.2	4.0	80	20.6	1.7	58	5.8
6+77	12/23/93	<0.01	<0.005	<0.01	<0.01	<0.057	N.D.	<0.1	<0.1	0.252	<0.01	3.7	15.8	N.D.	19.9	1.6	N.D.	10.8
6+77	5/24/94	<0.005	<0.005	0.005	<0.005	<0.057	N.D.	<0.2	<0.01	0.080	<0.005	2.8	5.0	N.D.	18.0	1.3	N.D.	7.7
6+77	1/18/95	0.004	N.D.	0.002	<0.004	<0.005	N.D.	<0.015	<0.1	0.009	<0.003	1.6	4.8	40	17.6	1.2	49	8.1
8+32	12/23/93	<0.01	<0.005	<0.01	<0.01	<0.057	N.D.	<0.1	<0.1	<0.01	<0.01	109.4	7.1	N.D.	78.4	12.8	N.D.	14.5
8+32	5/24/94	0.023	<0.005	0.011	<0.005	<0.057	N.D.	<0.2	<0.01	0.015	<0.005	170.3	1.0	N.D.	105.0	18.3	N.D.	15.0
8+32	1/18/95	0.024	<0.005	0.005	<0.004	<0.005	N.D.	<0.015	<0.1	0.006	0.004	144.0	12.4	490	84.1	16.4	278	19.2
D.L.	12/23/93	0.01	0.005	0.01	0.01	0.057	N.D.	0.1	0.1	0.01	0.01	0.64	2.71	N.D.	1	1	N.D.	1
D.L.	5/24/94	0.005	0.005	0.005	0.005	0.057	N.D.	0.2	0.01	0.001	0.005	0.64	2.71	N.D.	1	0.2	N.D.	2
D.L.	1/18/95	0.001	0.005	0.002	0.004	0.005	0.001	0.015	0.1	0.002	0.003	0.05	0.05	1	0.1	0.1	0.662	0.5

NOTES: R.A.L. = regulatory allowable limit

D.L. = detection limit

N.D. = not determined

N.A = not applicable

Hard. = hardness expressed in mg/L as $CaCO_3$

[shading] = average of results of two tests

Well no. 3+42 destroyed prior to 1/18/95 sampling date

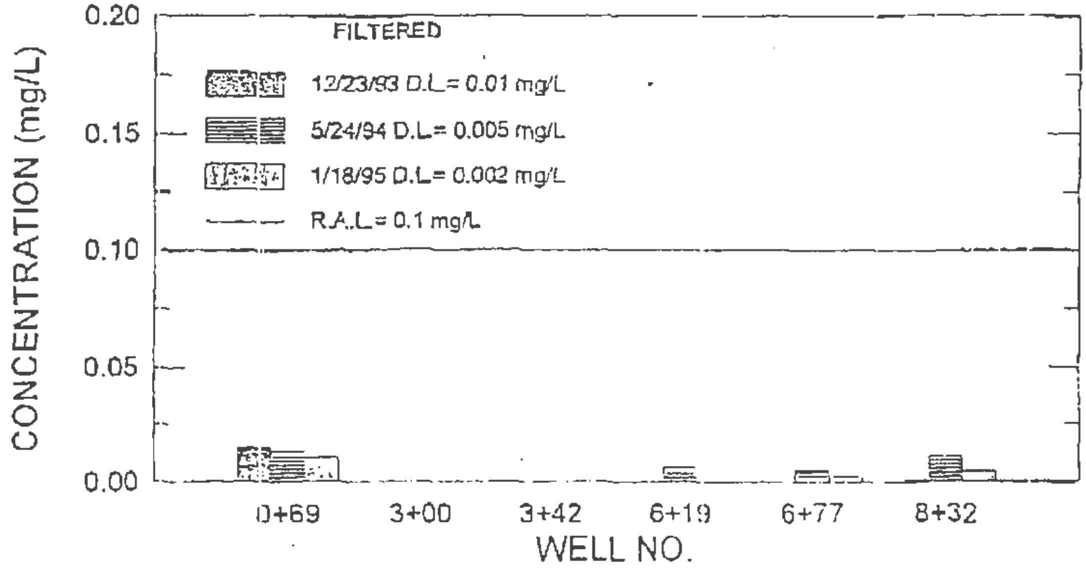

FIG. 2—Filtered chromium (Cr) concentrations on Richmond Field Trial.

(no. 0+69) and three of the wells adjacent to tire chip sections (nos. 3+42, 6+19, and 6+77). However, it appears that manganese is present in the natural groundwater since levels above the standard were detected in the control well. Dissolved solids, which have a secondary drinking water standard, were measured on the third sampling date. The result was 460 mg/L for the control well and ranged from 70 to 460 mg/L for the wells adjacent to tire chip sections. These levels are below the applicable standard.

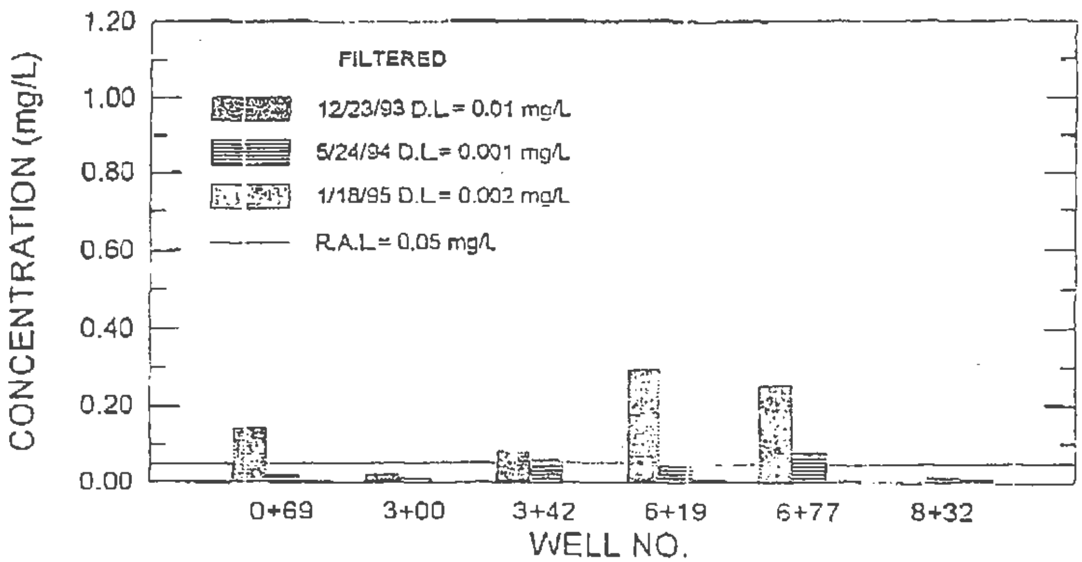

FIG. 3—Filtered manganese (Mn) concentration on Richmond Field Trial.

The third group of substances in Table 3 and water quality index test results given in Humphrey and Katz (1995) have no drinking water standards. This includes: calcium (Ca), magnesium (Mg), sodium (Na), conductivity, hardness, alkalinity, pH, BOD_5, and chemical oxygen demand (COD). The levels of calcium and magnesium indicate that the water is hard as confirmed by the hardness results. The levels of sodium as well as chloride are higher in well nos. 0+69, 3+00, and 8+32. A possible source is road salt (NaCl) used for deicing in the winter. Calcium chloride ($CaCl_2$) used for dust control in the summer could contribute to Cl^- as well as the higher calcium levels measured in these same three wells. The BOD_5 and COD were low (less than 7 and 50 mg/L, respectively) and are acceptable for drinking water. It is difficult to measure BOD_5's as low as obtained from this study. The results have an accuracy sufficient only to indicate that the BOD_5 is very low.

Water quality monitoring for the project continued for 28 months after construction. Since the native soils would be expected to have some sorptive capacity, it is possible that the elapsed time may have been insufficient for potential contaminants to migrate from the tire chip layer to the wells even though the wells were located only 1 to 2 m away from the tire chips. Thus, it can be concluded from this project only that no significant levels of inorganic contaminants migrated from the tire chips to the wells in the first 28 months after construction. The North Yarmouth Project discussed in the next section was designed to eliminate the uncertainty imposed by the sorptive capacity of the soil between the tire chips and the sampling point.

NORTH YARMOUTH FIELD TRIAL

The purposes of the North Yarmouth Field Trial were to measure the effect of a compressible tire chip layer on asphaltic concrete pavement performance and to carry out long term monitoring of the effect of tire chips placed above the water table on groundwater quality. To date there has been no difference in pavement performance for sections underlain by tire chips compared to the control section. Further details are given in Nickels (1995), and Humphrey and Nickels (1997). The site, groundwater monitoring program, and monitoring results are described in the following sections.

Site and Monitoring Well Descriptions

The North Yarmouth Field Trial is located on Route 231, a secondary highway in North Yarmouth, Maine. It consists of four 33-m long sections each with a 0.61-m thick tire chip layer. The tire chip layer was covered with a total thickness of between 0.76 m and 1.37 m of granular soil prior to paving. The pavement was 0.13 m thick. In addition, two sizes of tire chips were used (passing a 75-mm sieve and passing a 305-mm sieve) to investigate the effect of soil cover thickness and tire chip size on pavement deflection. Approximately 100,000 tires were used in this test project. In addition, there was a 33-m long control section designed according to Maine Department of Transportation standards with conventional soil fill.

Two seepage collection basins were installed beneath sections with tire chips passing the 75-mm sieve to collect samples for water quality testing. The seepage collection basins were 3-m by 3-m in plan and were lined with a HDPE geomembrane. A drain in the center of the liner lead to a collection tube located along the side of the embankment as shown in Fig. 4. The design was similar to that used by Edil and Bosscher (1992). The basin projected beyond the edge of the pavement so that runoff from the pavement and from the embankment sideslope could infiltrate into the basin. With this design, there is no opportunity for substances leached from the tire chips to be sorbed onto the soil prior to sampling, an advantage over the monitoring wells used at the Richmond Field Trial. The basins were located directly below the tire chip layer. One basin (Section C) was overlain by 0.61-m of tire chips followed by 1.37-m of granular soil and the other (Section D) was overlain by 0.61-m of tire chips followed by 0.72-m of granular soil. A third seepage collection basin was installed in the control section. It was overlain by 0.72-m of granular soil. In the subsequent sections, this basin is referred to as the 'Control'. Further details are given in Nickels (1995), and Humphrey and Nickels (1997).

Sampling and Testing Procedures

Quarterly samples have been taken since January, 1994. Eleven sets of samples have been taken to date. For the period January, 1994, through September, 1995, samples were taken from the water that accumulated in the collection tube since the previous sampling period. On each sampling date the tubes were full and it was apparent that water had been flowing out of each tube's overflow pipe. After sampling, the tube was bailed dry in preparation for the next sampling period. This procedure raised the concern that sediments could accumulate in the bottom of the tube. For this reason, the sampling procedure was changed starting with the December, 1995, sample. From this date onward, the tubes were bailed dry two to three weeks prior to the desired sampling date. Samples were subsequently taken from the water that had accumulated over this short period. Prior to sampling, the water in the tube was agitated. Samples were obtained with a 1-liter capacity high density polyethylene (HDPE) bailer.

The sample types and testing procedures for inorganic compounds and water quality index tests were the same as were used for the Richmond Field Trial. On selected sampling dates, samples were also taken for BOD_5 determination. In addition, on December 28, 1995, and April 5, 1996 samples were taken for volatile organic compounds (VOC's) and semivolatile organic compounds (SVOC's). The containers used for the

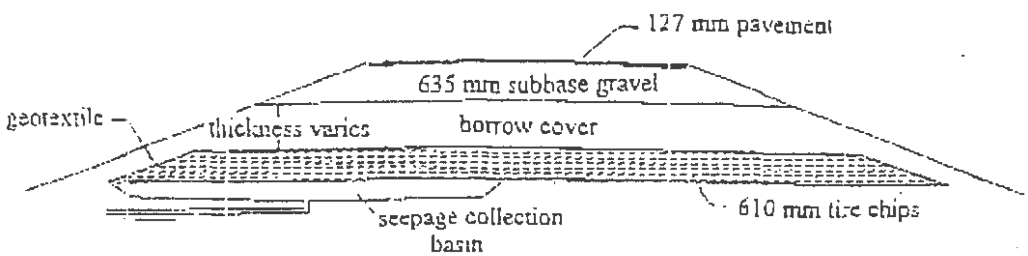

FIG. 4—Typical cross section of North Yarmouth Field Trial.

VOC samples were clear 40 mL borosilicate glass vials with polypropylene closures and Teflon faced silicone septa. The samples were preserved by adding 4 drops of ultrapure hydrochloric (HCl) to each vial before collecting the samples. Leachate from the bailer was placed directly in the vial with no sample preparation. The VOC samples were tested in accordance with EPA Method 8260 (Determination of Volatile Organics by Purge-and-Trap Capillary Column GC/MS). SVOC samples were collected in 1 L amber borosilicate glass bottles with polypropylene closures with Teflon liners. Leachate from the bailer was placed directly in the bottles with no sample preparation. The SVOC samples were tested in accordance with EPA Method 8270 (Determination of Semivolatile Organics by Capillary Column GC/MS). Further details of the testing procedure are given in Humphrey and Katz (1996).

Inorganic Results

Detailed test results are given in Humphrey and Katz (1996). Substances with a primary drinking water standard were present in trace amounts or were below the detection limit. The level of cadmium (Cd) in the control section for the April 1995 sample and in Section D for the June, 1995 sample slightly exceeded the regulatory allowable limit (RAL). However, for all other sampling dates the levels were below the test method detection limit. It is believed that the two samples that exceeded the RAL are due to testing inaccuracies as no cadmium was detected on the other sampling dates. For all other substances with primary drinking water standards, the levels were well below the applicable RAL. The results on filtered samples for barium (Ba), chromium (Cr), and lead (Pb) are shown in Figs. 5, 6, and 7, respectively. All three substances are present in the control well, indicating that they are naturally present in the soil. However, there is no significant difference between the levels found in the two tire chip sections and the control section. This indicates that for the conditions found at this test site, there is no evidence that tire chips tend to increase the levels of these compounds for the 2.5 years that have been monitored to date.

For substances with a secondary drinking water standard, aluminum (Al), iron (Fe), manganese (Mn), and zinc (Zn) are plotted versus date in Figs. 8 through 11. All three substances are naturally present in the soil, however, there is no evidence that tire chips increased the levels of aluminum (Al) or zinc (Zn). In fact, the zinc levels are generally higher in the control section than the two tire chip sections. For most sampling dates, the iron (Fe) levels in the tire chip and control sections are about the same. However, on a few sampling dates the iron levels in the tire chip sections are higher than in the control section and the level exceeds the secondary RAL. The total iron levels were consistently higher in the tire chip sections, indicating that under the right conditions of solubility, tire chips could increase the iron levels present in groundwater. On almost all sampling dates the levels of manganese (Mn) are higher in the tire chip sections than in the control section. The levels in tire chip Section D generally exceed the RAL by more than a factor of 10. On the most recent sampling date (June 1996) a very high level of manganese was found in Section C. The much lower levels found on all previous sampling dates suggests that this may be an anomaly. The levels of chlorine (Cl^-) are plotted in Fig. 12. It is seen that high levels are present in all wells for samples taking in April. This is most likely due to infiltration from road salt. There was no evidence that

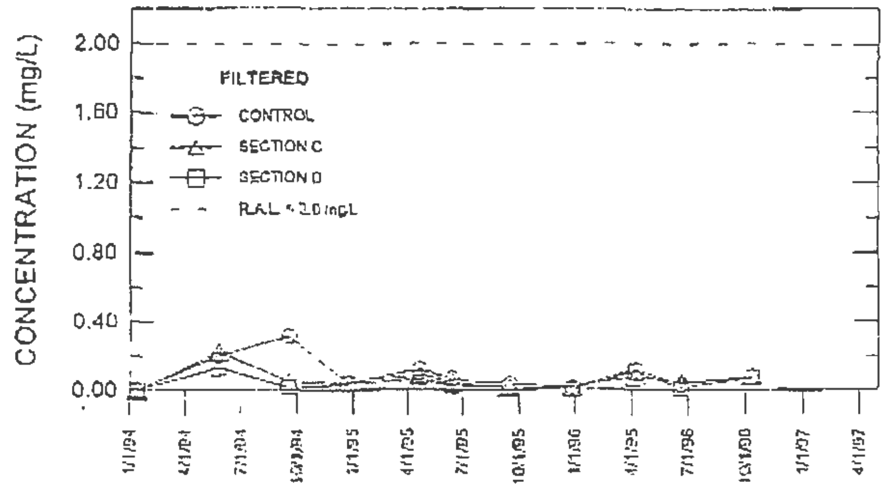

FIG. 5—Filtered barium (Ba) concentrations for North Yarmouth Field Trial.

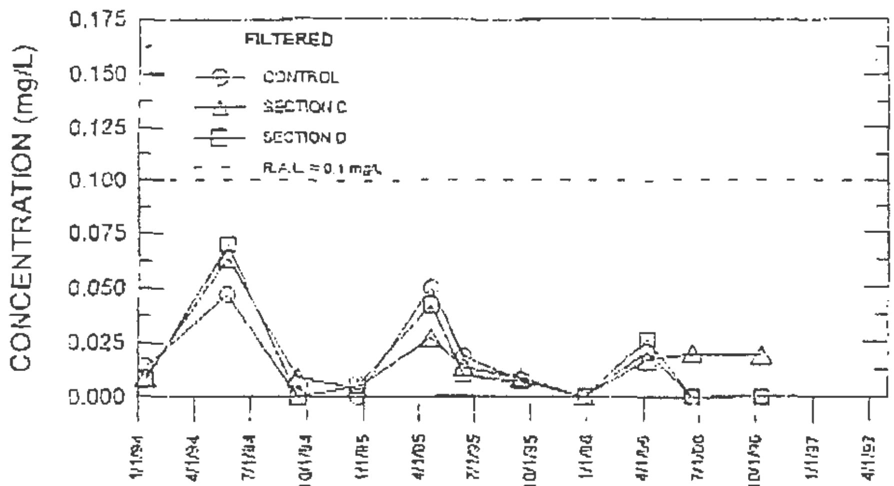

FIG. 6—Filtered chromium (Cr) concentration for North Yarmouth Field Trial.

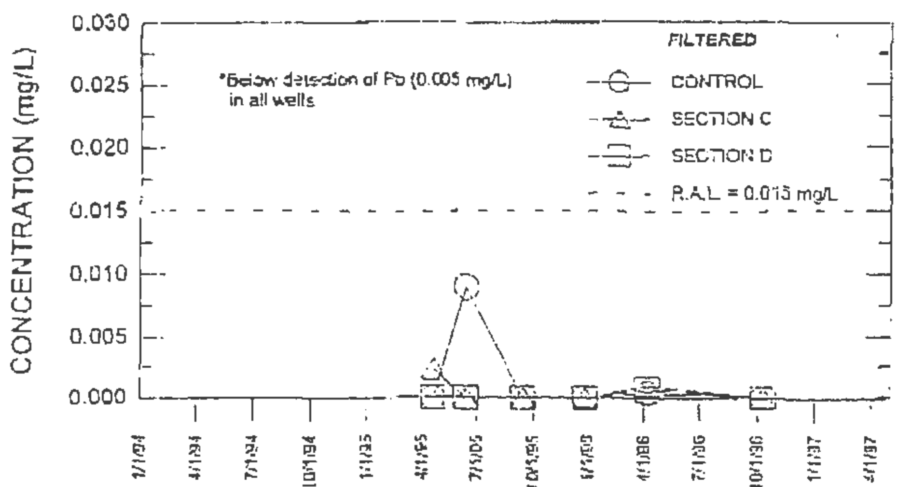

FIG. 7—Filtered lead (Pb) concentrations on North Yarmouth Field Trial.

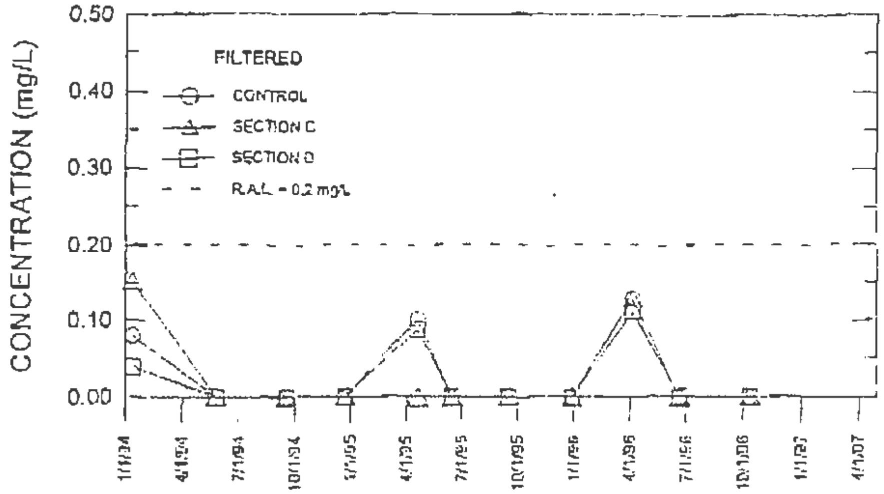

FIG. 8—Filtered aluminum (Al) concentrations for North Yarmouth Field Trial.

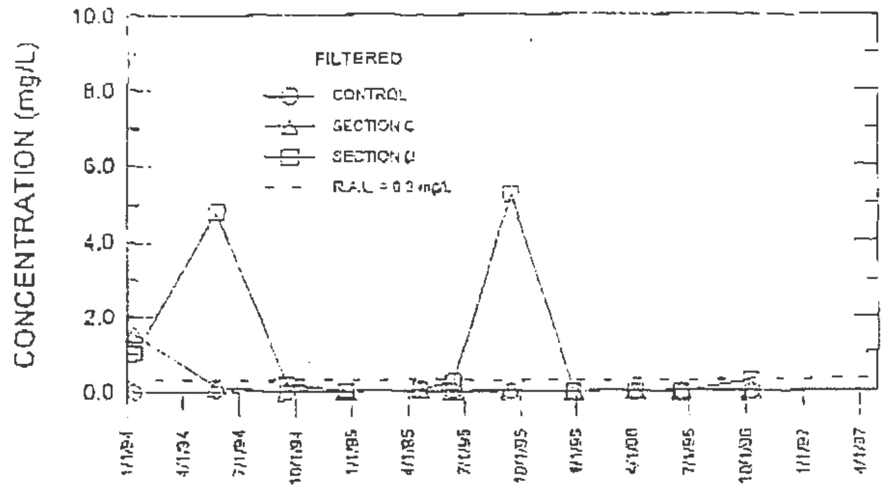

FIG. 9—Filtered iron (Fe) concentration for North Yarmouth Field Trial.

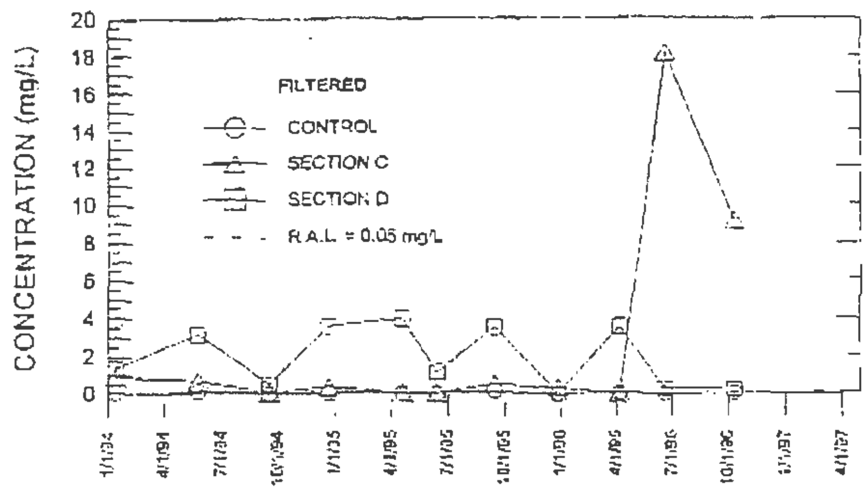

FIG. 10—Filtered manganese (Mn) concentrations on North Yarmouth Field Trial.

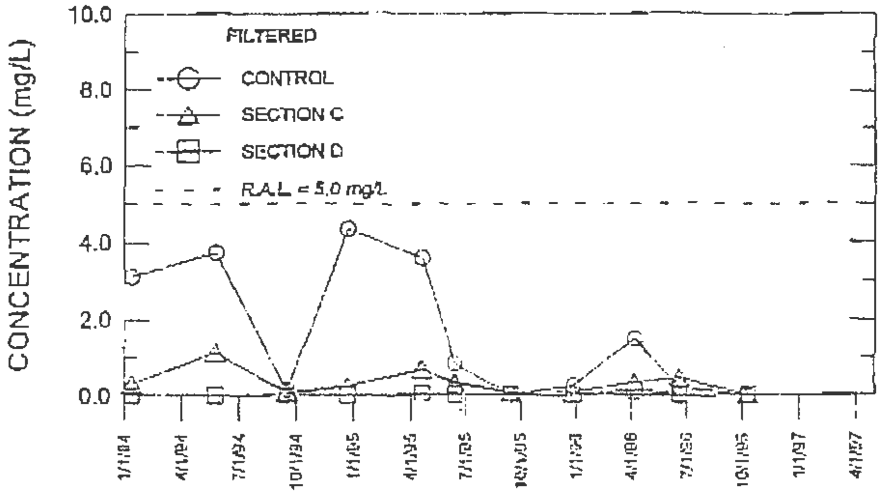

FIG. 11—Filtered zinc (Zn) concentrations on North Yarmouth Field Trial.

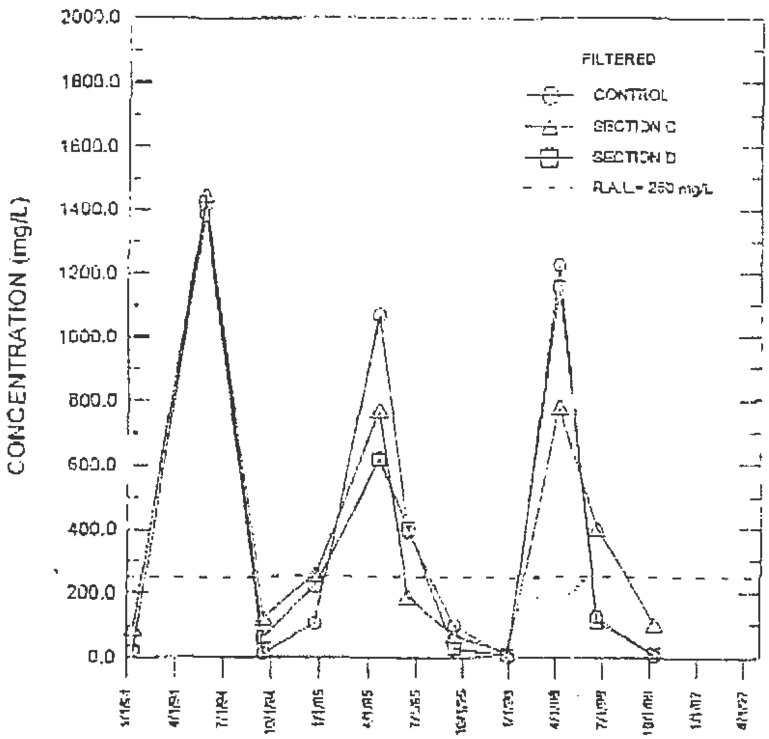

FIG. 12—Filtered chloride (Cl^-) concentrations on North Yarmouth Field Trial.

tire chips increase the concentration of sulfate (SO_4), total solids, calcium (Ca), magnesium (Mg), or sodium (Na). BOD_5 and COD levels have consistently been low and there is no evidence that tire chips increase their levels

<u>Organic Results</u>

Samples taken on December 28, 1995, and April 5, 1996, were tested for volatile and semi-volatile organics. On both sampling dates the levels for all compounds were below the test method detection limits. The negligible levels of VOC's are supported by results of a laboratory leaching study by Downs et al. (1996). In this study, tire chips and tire chip/soil mixtures were placed in a glass reactor, the reactor was filled with water, and then sealed for 10 months. Six VOC's were above the detection limit but the concentrations were less than 5 ppb. This is an important check on the results of the field study since the design of the seepage collection basins and sampling tubes leaves open the possibility that VOC's volatilized from the leachate prior to sampling. Downs et al. (1996) also found one positively identified SVOC (analine), with a concentration ranging from 25 to 48 ppb and five tentatively identified SVOC's with estimated concentrations between 200 and 600 ppb. In contrast, no SVOC's were detected in the samples from the North Yarmouth field site. A separate field study of tire chips placed below the groundwater table is ongoing (Downs et al., 1996).

CONCLUSIONS

1. Most of the inorganic substances that can potentially leach from tires are naturally present at low levels in groundwater. This includes aluminum (Al), barium (Ba), chromium (Cr), iron (Fe), lead (Pb), manganese (Mn), and zinc (Zn) Thus, it is critical that control wells be used to measure the natural background levels of these substances. This would allow any changes in level caused by the tire chips to be separated from background levels.

2. No evidence was found that tire chips increased the concentration of substances that have a primary drinking water standard including, barium (Ba), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), and selenium (Se).

3. No evidence was found that tire chips increased the concentration of the following substances which have a secondary drinking water standard: aluminum (Al), chloride (Cl^-), sulfate (SO_4), and zinc (Zn). There was some evidence that tire chips could increase the levels of iron (Fe) and exceed the secondary drinking water standard under some conditions.

4. Tire chips increase the levels of manganese (Mn) which has a secondary drinking water standard. It is likely that the levels will exceed this standard. However, manganese is of aesthetic concern only and it is naturally present in groundwater in many areas. Further study would be required to determine how far manganese that has leached from tire chips would migrate from a tire chip fill.

5. No detectable levels of organics were measured in two sets of samples taken from the North Yarmouth Field Trial.

Acknowledgements

The authors acknowledge the Maine Department of Transportation, Maine Department of Environmental Protection, and Scrap Tire Management Council who provided the funding for these projects. The U.S. Army Cold Regions Research and Engineering Laboratory is thanked for installing the monitoring wells at the Richmond Field Trial. University of Maine students, William Nickels, Sandi Duchesne, and Aaron Smart, are thanked for their assistance in taking the water quality samples.

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ATTACHMENT 6-B
9 pages

A STUDY FOR THE

MAINE DEPARTMENT OF TRANSPORTATION

WATER QUALITY EFFECTS
OF USING TIRE CHIPS BELOW THE GROUNDWATER TABLE

Technical Services Division
Technical Paper
August 26, 1996

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For Technical Report Standard Title Page (Form DOT F 1700.7)

Abstract:

The purpose of this project was to gather the data necessary to determine the environmental acceptability of placing tire chips below the groundwater table. The study was divided into three parts: (1) laboratory TCLP leaching tests; (2) laboratory reactor simulation of ground conditions; and (3) small scale field trials with 1.5 tons of steel belted tire chips buried below the groundwater table in glacial till, marine clay, and peat.

The TCLP tests showed that tire chips are not a hazardous waste. The levels of TCLP regulated metals and organics were well below their TCLP limits. The reactor study showed that barium, chromium, copper, lead, iron, manganese, and zinc leached from tire chips. Low levels of some volatile and semivolatile compounds also leached from tire chips.

The small scale field trials showed that the levels of metals with a primary drinking water standard were all below their applicable limits. The levels of iron and manganese, which have secondary drinking water standards indicating that they are of aesthetic concern, were increased to well above their applicable standard. Thus, tire chips should be used below the groundwater table only where higher levels of iron and manganese can be tolerated. Zinc was also increased by tire chips, however, the levels were well below its secondary drinking water standard. Low levels of some volatile and semivolatile compounds were detected. However, scatter of the data made it impossible to determine if the levels were high enough to constitute a potential health hazard. Monitoring of organic levels will be continued to clarify the presence or absence of a potential hazard.

Key words: tires, tire chips, tire shreds, waste materials, environmental considerations, groundwater

WATER QUALITY EFFECTS OF USING TIRE CHIPS BELOW THE GROUNDWATER TABLE

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EXECUTIVE SUMMARY

Many of the 240 million scrap tires generated in the United States each year are disposed of in landfills or open piles. This uses valuable landfill space, creates fire hazards, and provides a breading place for disease carrying mosquitoes. Alternate uses of scrap tires have been sought including using tires cut into chips as lightweight and insulating fills in roadways, embankments, and retaining walls. These applications may bring tire chips in direct contact with groundwater, raising concerns of possible contamination. The focus of this research was to evaluate the effects of tire chips placed below the water table on groundwater quality.

This study was divided into three parts: (1) laboratory toxicity characteristics leaching procedure (TCLP) tests; (2) laboratory reactor simulation of ground conditions; and (3) small scale field trials. The TCLP tests were used to evaluate potential pollutants from tire chips. The laboratory simulation of ground conditions was a batch reactor study that compared the long-term leachability of tire chips and soil. Finally, small scale field trials were used to evaluate the long-term effect on groundwater quality of using tire chips as a construction material. In these trials 1.5 tons of tire chips were buried below the water table in each of three Maine soil types: marine clay, glacial till, and peat.

TCLP tests are used to determine if a waste is a significant hazard to human health due to leaching of toxic compounds. In addition, TCLP results can be used to give an indication of potential pollutants that may leach from a waste. In this study, the following four tire chip samples were subjected to TCLP testing: unwashed mixed glass and steel belted chips, washed mixed steel and glass belted chips, unwashed glass belted chips, and washed glass belted chips. Samples were tested washed and unwashed to examine the possibility that pollutants from tire chips could be due to dirt and debris on the surface of the tires rather than the tire itself. Prior to testing, the tire chip size was reduced to passing the 9.5-mm (0.375-in.) sieve as required by the TCLP test protocol.

TCLP results showed that tire chips are not a hazardous waste since concentrations of metals and organics were well below applicable TCLP regulatory limits. Arsenic, mercury, selenium, and silver were below detection limits for all samples. However, low

levels of barium, cadmium, chromium, and lead were detected in leachate extracts from each of the four samples. Thus, tire chips have the potential to leach these compounds. The presence of these compounds was investigated further in subsequent laboratory and field tests. The only TCLP regulated organic compound found in the TCLP extracts was 1,2-dichloroethane with concentrations ranging from ND[1] to 7 µg/L, which is well below the TCLP regulatory limit of 500 µg/L. Several compounds not regulated by TCLP were also found in the extracts. The volatile compound dichloromethane was found at concentrations ranging from 5 to 10 µg/L. In addition, five semivolatile compounds were tentatively identified: 1-(2-butoxyethoxy)-ethanol (ND to 143 µg/L); benzothiazole (200 to 286 µg/L); 1H-isoindole-1,3(2H)-dione (ND to 286 µg/L); 2(3H)-benzothiazolone (100 to 286 µg/L); 2,5-cyclohexadiene-1,4-dione (ND to 114 µg/L); and 4-(2-benzothiazolythio)-morpholine (ND to 143 µg/L). Thus, tire chips have the potential to leach some organic compounds. The presence of these compounds was investigated further in subsequent laboratory batch reactor and field tests.

The laboratory simulation of ground conditions was a batch reactor study. The study was designed to allow direct comparison of the levels of metals and organic compounds that leach from tire chips to the levels that leach from soil. Eight reactors were set up. The reactors were 20 L (5 gal) Pyrex glass jars. Three reactors were controls that contained only soil and water. The three soil types were marine clay, glacial till, and peat. The soil was obtained from each of the three sites chosen for the small scale field trials. Another three reactors were set up with tire chips, soil, and distilled water, one corresponding to each of the control reactors. Two additional reactors contained only tire chips and distilled water. The reactors were stored at ambient temperature in the dark for approximately ten months. The reactors were not mixed or disturbed during that time. At the completion of the storage period, water and soil samples were collected from the reactors. The water samples were analyzed for total and dissolved metal, and volatile and semivolatile organic compounds. The soil samples were digested and analyzed for total metals.

Leaching of metals from tire chips was examined by analyzing soil and water samples taken from the reactors. Results from the soil digestates showed that presence of tire chips increased the concentrations in the clay of manganese, in the till of copper and zinc, and in the peat of barium, chromium, copper, lead, iron, manganese, and zinc. This was evidenced by the concentrations of these metals being higher in digested soil samples taken from reactors with mixtures of soil and chips than for digested soil samples taken from the corresponding control reactors (no tire chips). It appears that peat has a greater tendency to sorb metals released from tire chips than either clay or till.

The water sample results from the laboratory batch reactors showed that the concentration of several metals were increased by leaching from tire chips or leaching from soil due to the environmental conditions created by placing tire chips in contact with soil and water. In some of the tire chip or tire chip/soil mixture reactors, the concentrations of arsenic, barium, chromium, and copper were increased but the levels

[1] ND = not detected

were well below the applicable primary drinking water standards. For all reactors, the levels of cadmium, mercury, and lead were below the test method detection limit. The concentration of iron and manganese were above their secondary, or aesthetic, drinking water standards in reactors containing tire chips or tire chip/soil mixtures. The concentration of zinc was increased, but the levels were well below its secondary drinking water standard. Tire chips also increased the pore water concentrations of calcium, magnesium, and sodium which do not have drinking water standards. The source of the increased levels of chromium, iron, manganese, and zinc appeared to be the tire chips. For barium, calcium, magnesium, and sodium, it could not be determined if the increased levels were due directly to the tire chips or leaching from the soil in response to environmental conditions created by the tire chips. These results suggest that tire chips will not cause primary drinking water standards to be exceeded. However, it is likely that tire chips will cause the secondary drinking water standards for iron and manganese to be exceeded. These laboratory results should be confirmed for field conditions.

The water taken from the reactors was also analyzed for volatile and semivolatile organic compounds. The following volatile compounds and range of concentrations were found in the samples from the tire chip and tire chip/soil mixture reactors but were not found in the reactors containing only soil: benzene (2.5 to 5 μg/L) and cis-1,2-dichloroethene (ND to 3.2 μg/L). The following compounds were below detection limits for all but one sample: bromomethane (one sample had 1.6 μg/L); 1,1-dichloroethane (one sample had 0.6 μg/L); trichloromethane (one sample had 0.8 μg/L); and naphthalene (one sample had 5.3 μg/L). Additional testing would be required to determine if these compounds are leached from tire chips at very low concentrations or if the results could be attributed to testing anomalies. Dichloromethane was found at concentrations ranging from 0.5 to 1.8 μg/L in the soil reactors compared to ND to 1 μg/L in the tire chip and tire chip/soil mixture reactors. Likewise, toluene was found at concentrations ranging from 0.9 to 1.1 μg/L in the soil reactors and the blank, compared to 1.1 to 3.6 μg/L in the tire chip and tire chip/soil mixture reactors. Further testing would be required to determine if dichloromethane and toluene are released from tire chips at low concentrations or if the results could be attributed to testing anomalies. None of the volatile compounds were above drinking water standards (where applicable). Dichloromethane was the only volatile organic compound found in the reactor study that was also found in the TCLP extracts

Some semivolatile compounds were detected in the reactor study. Aniline was detected in water taken from the reactors with tire chips and tire chip/soil mixtures at concentrations ranging from ND to 47.7 μg/L. In addition, the following semivolatile compounds were tentatively identified in some of the water samples taken from reactors with tire chips and tire chip/soil mixtures: 4-acetyl-morpholine, benzoic acid, and 2(3H)-benzothiazolone. The estimated concentration of these compounds ranged from non-detect to 600 μg/L. The compound 2(3H)-benzothiazolone was also found in the TCLP extracts.

Small scale field trials were constructed to examine the effect of tire chips on groundwater quality in three Maine soil types: glacial till, marine clay, and peat. At each site a backhoe was used to excavate a 1.7 m (5.5 ft) to 1.8 m (6 ft) deep trench. The trenches were typically 0.6 m (2 ft) to 0.9 m (3 ft) wide, and 3.3 m (10.8 ft) to 4.6 m (15 ft) long. Approximately 1.4 metric tons (1.5 U.S. short tons) of tire chips were placed in each trench. The tire chips were a mixture of steel and glass belted chips with a majority of the chips having steel wires protruding from the cut edges. About 0.3 m (1 ft) of soil was placed over the tire chips. At the peat site, the tire chips were below the water table for the entire year, however, at the clay and till sites, the water table dropped during the summer resulting in the upper part of the tire chip zone being above the water table for part of the year. At each site, a control well was installed upgradient of the trench, one well was installed directly in the tire chips filling the trench, and wells were installed about 0.6 m (2 ft) and 3 m (10 ft) downgradient of the trench. At the peat site, an additional two wells were installed 0.6 m (2 ft) downgradient of the trench.

Water samples taken from the small scale field trials showed that tire chips increased the levels of some metals with a primary drinking water standard but the concentrations were all below their applicable regulatory limits. Dissolved barium levels as high as 57 μg/L were measured in samples taken from the tire chip filled trenches, however, the drinking water standard for barium is 2000 μg/L, so the measured levels are much too low to be of concern. Dissolved chromium levels ranged from <2 to 7 μg/L in the tire chip filled trenches compared to <2 to 3 μg/L in the control wells. Thus, tire chips may slightly elevate the levels of chromium but the levels are well below the drinking water standard of 100 μg/L. The levels of dissolved arsenic, cadmium, and lead were below the method detection limit for all wells. The levels of dissolved copper were generally below the detection limit or the concentration was higher in the control well that in the well in the tire chips. In summary, for the near neutral pH conditions present in this study, there is no concern that tire chips will release harmful levels of metals with a primary drinking water standard.

The field trials showed that the levels of iron and manganese, which have secondary drinking water standards indicating that they are of aesthetic concern, were increased to levels considerably above their repsective standard. Levels of dissolved iron ranged from 4210 to 71700 μg/L in the tire chip filled trenches, which is well above its secondary drinking water standard of 300 μg/L. For comparison, the iron levels in the control wells ranged from 18 to 3160 μg/L. Levels of dissolved manganese ranged from 724 to 3430 μg/L in the tire chips compared to its drinking water standard of 50 μg/L and levels in the control wells of 27 to 666 μg/L. The elevated levels of manganese showed some tendency to migrate downgradient, however, this was not the case for iron. Thus, tire chips should be used below the groundwater table only where higher levels of iron and manganese can be tolerated. Zinc was also increased by tire chips, however, the levels were well below its secondary drinking water standard. Dissolved zinc levels in the tire chips ranged from 5 to 123 μg/L which is much less than its drinking water standard of 5000 μg/L. For comparison, the zinc levels in the control wells ranged from <2 to 9 μg/L. The levels of silver, aluminum, calcium, magnesium, and sodium were not significantly affected by the presence of the tire chips.

Low levels of some volatile organic compounds were detected. Dichloromethane was detected in all samples, including the control wells and blanks. Additional sampling will be performed to determine if this is a laboratory contamination problem. The following additional volatile compounds were detected in wells located in the tire chip filled trench: 1,1 dichloroethane (ND to 14.3 μg/L); cis-1,2-dichloroethane (6 to 85.5 μg/L); 1,1,1-trichloroethane (ND to 5.6 μg/L); benzene (ND to 1.8 μg/L); trichloroethene (ND to 0.6 μg/L); and toluene (ND to 1.8 μg/L). There is some consistency with the laboratory reactor study which also found low levels of 1,1-dichloroethane, cis-1,2-dichloroethane, benzene, and toluene. For compounds with a drinking water standard, the levels were below the standard except for one sampling date for cis-1,2-dichloroethene when the standard was slightly exceeded. A few other compounds were found in the laboratory blanks at concentrations higher than in the sample wells. These were attributed to laboratory contamination.

Semivolatile organic compounds were also detected at low levels in some wells. The following compounds were present in two or more samples: aniline (ND to 91 μg/L); phenol (ND to 55.2 μg/L); p-cresol (ND to 86 μg/L); benzoic acid (ND to 100 μg/L); and 2(3H)-benzothiazolone (ND to 100 μg/L). This is consistent with the laboratory reactor study which found aniline, benzoic acid, and 2(3H)-benzothiazolone as well as 4-acetylmorpholine which was not found in the field. However, further sampling is required to clarify the level of release of these compounds. In addition, the following compounds were reported in one well on a single sampling date: cyclohexanol (one sample had 40 μg/L); benzothiazole (one sample had 50 μg/L); 2,6-bis-(1,1-dimethylethyl)-2,5-cyclohexadiene-1,4-dione (one sample had 40 μg/L); 1H-isoindole-1,3(2H)-dione (one sample had 40 μg/L); 4-(2-benzothiazolylthio)-morpholine (one sample had 50 μg/L); N-(1,1-dimethylethyl)-formanide (one sample had 30 μg/L); and butanoic acid (one sample had 100 μg/L). Further sampling will be required to determine if these compounds are present in trace amounts or if their presence in a single sample is an experimental anomaly.

In summary, for near neutral pH environments, there is no concern that tire chips will release harmful levels of metals with a primary drinking water standard. However, tire chips placed below the water table do leach iron and manganese at levels that will cause their secondary (aesthetic) drinking water standards to be exceeded. Thus, tire chips should be used below the groundwater table only where higher levels of iron and manganese can be tolerated. Tire chips placed below the water table leach low levels of some volatile and semivolatile organic compounds. However, the short monitoring period and scatter of the data made it impossible to determine if the levels were high enough to constitute a potential health hazard. Monitoring of organic levels will be continued to clarify the presence or absence of a potential hazard.

Appendix F:
Virginia Department of Transportation Final Report on Leachable Metals in Scrap Tires Results

Appendix E:
Scrap Tire Management Council Study Results

ATTACHMENT 6-B.1
10 pages

FIELD STUDY OF WATER QUALITY EFFECTS OF TIRE SHREDS PLACED BELOW THE WATER TABLE

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ABSTRACT

A field trial was constructed to evaluate the water quality effects of tire shreds placed below the water table. The study consisted of three sites, each with 1.4 metric tons of tire shreds buried in a trench below the water table. The tire shreds were made from a mixture of steel and glass belted tires and had a maximum size of about 75 mm. The soil types at the sites were marine clay, glacial till, and peat. At each site, one water sampling well was located upgradient to obtain the background water quality, one well was located in the tire shred filled trench, and two to four wells were located 0.6 m to 3 m downgradient of the trench. Samples were taken over a four-year period and analyzed for a range of metals, volatile organics, and semivolatile organics. The results showed that tire shreds had a negligible effect on the concentration of metals with primary (health based) drinking water standards. For metals with secondary (aesthetic based) drinking water standards, samples from the tire shred filled trench had elevated levels of iron (Fe), manganese (Mn), and zinc (Zn). However, the concentrations of these metals decreased to near background levels for samples taken downgradient of the tire shred filled trench. Trace concentrations of a few organic compounds were found in the tire shred filled trenches, but concentrations were below method detection limits for virtually all the samples taken from the downgradient wells. Tire shreds placed below the water table appear to have a negligible off-site effect on water quality.

INTRODUCTION

Tire shreds are waste tires that have been cut into pieces that are generally 50 to 300 mm in size. They offer the following advantages when used as a fill material: lightweight, low lateral pressure, low thermal conductivity, and free draining[1]. Because of these advantages they have been used on more than 100 road construction projects across the United States. While the potential effect on groundwater quality is thought to be small when used for highway applications, there have been few extended studies of the effects for field conditions. Results from a 5-year field study of the water quality effects of tire shreds placed above the water table showed that tire shreds had a negligible impact on water quality for the near neutral pH conditions[2]. This paper presents the results of a companion study where the tire shreds were placed below the water table and monitored from1993 through 1997. The study included toxicity characteristic leaching procedure (TCLP) tests, a laboratory reactor study, and field installations[3,4]. However, this paper focuses on the field installations.

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FIELD SITES

The field portion of the study consisted of three sites where 1.4 metric tons of tire shreds were buried below the groundwater table in the following three soil types: peat (P), marine clay (C), and glacial till (T). The sites were located near Orono, Maine. The tire shreds had a 75-mm maximum size and were made from a mixture of steel and glass belted tires. Steel belts were exposed at the cut edges of the shreds. At each site, the tire shreds were placed in a 0.7 m to 1.8 m wide trench with its long axis oriented perpendicular to the approximate direction of groundwater flow. At each site, one monitoring well was installed upgradient of the tire shred filled trench to obtain background water quality; one well was installed directly in the tire shred filled trench; one to three wells were installed 0.6 m down gradient of the trench; and one well was installed about 3 m down gradient of the trench. Wells P1, C1, and T1 are located up gradient of the trench, while wells P2, C2, and T2,3 are located in the trench. Wells P3, P4, P5, C3, and T4 are located 0.6 m down gradient of the tire shred filled trench. Wells P6, C4, and T5 are located about 3 m down gradient. Samples were taken for a range of metals, volatile organics, and semivolatile organics.

METHODS

The following sample types were taken from each well: leachate filtered through a 0.3-micron filter and preserved with nitric acid (1.5 ml/L) [5]; unfiltered leachate preserved with nitric acid (1.5 ml/L) for determination of readily extractable total metals; and unfiltered leachate with no acid for water quality index tests such as pH. The unfiltered samples generally contained some fine grained particles. Since wells for drinking water are designed to prevent any significant amount of particulate matter from entering the well, it would not be representative to compare the results from unfiltered samples to drinking water standards. Thus, results from unfiltered samples provide supplementary information only and were not compared to drinking water standards.

Samples for the following metals were prepared in accordance with EPA Method 200.7 (Inductively Coupled Plasma - Atomic Emission Spectrometric Method for Trace Element Analysis)[6]: aluminum, barium, calcium, chromium, copper, iron, magnesium, manganese, silver, sodium, and zinc. Except for silver, measurements were made using a Thermo Jarrell Ash Model 975 Plasma Atomcomp Inductively Coupled Plasma Emission Spectrometer. Silver was measured using a Thermo Jarrell Ash Atomic Absorption Sepctrometer Model Scan-1. Sample perparation for aresenic, cadmium, and lead followed EPA Method 200.9 (Determination of Trace Elements by Stabilized Temperature Graphite Furnace Atomic Absorption Spectrometry)[6]. The tests were carried out using the atomic absorption furnace technique in accordance with EPA Method 7060 Arsenic; EPA Method 7131 Cadmium; and EPA Method 7421 Lead[7].

Samples were taken for volatile organic compounds (VOC's) and semivolatile organic compounds (SVOC's). The containers used for the VOC samples were clear 40 mL borosilicate glass vials with polypropylene closures and Teflon faced silicone septa. The samples were preserved by adding 4 drops of ultrapure hydrochloric (HCl) to each vial before collecting the samples. Leachate from the bailer was placed directly in the vial with no sample preparation. The VOC samples were tested in accordance with EPA

Method 8260 (Determination of Volatile Organics by Purge-and-Trap Capillary Column GC/MS). On most sample dates, 82 VOC's were targeted for analysis. SVOC samples were collected in 1 L amber borosilicate glass bottles with polypropylene closures with Teflon liners. Leachate from the bailer was placed directly in the bottles with no sample preparation. The SVOC samples were tested in accordance with EPA Method 8270 (Determination of Semivolatile Organics by Capillary Column GC/MS). On most sample dates, 69 base neutral extractable, acid extractable, and polyaromatic hydrocarbon SVOC's were targeted for analysis. The compounds for volatile and semivolatile organic analyses were chosen based on the chemical composition of tires and likely breakdown products. Two different laboratories were used for organic analyses.

METALS

Metals with Primary Drinking Water Standards

The following metals with a primary drinking water standard were included in the study: arsenic (As), barium (Ba), cadmium (Cd), chromium (Cr), copper (Cu), and lead (Pb). The concentration of arsenic (As), cadmium (Cd), and lead (Pb) were below the test method detection limit in all samples (15, 5, and 15 μg/L, respectively). The concentration of dissolved copper (Cu) was generally below the test method detection limit of 3 μg/L, however, background levels in a few samples were as high as 11 μg/L compared to levels up to 4 μg/L in the tire shred filled trenches. Thus, tire shreds do not appear to increase the levels of dissolved copper (Cu).

The concentration of dissolved barium (Ba) in the tire shred filled trench ranged from 7 to 57 μg/L compared to background levels of 6 to 33 μg/L. In the wells located 0.6 m downgradient of the tire shred filled trench the concentration of barium (Ba) had returned to background levels (5 to 39 μg/L). Thus, the tire shreds submerged in groundwater slightly increased the level of barium (Ba), but Ba did not show a tendency to migrate downgradient. More importantly, the level of dissolved Ba was less than its primary drinking water standard of 2000 μg/L, even in the tire shred filled trenches.

Metals with Secondary Drinking Water Standard

The following metals with secondary drinking water standards were included in the study: silver (Ag), aluminum (Al), iron (Fe), manganese (Mn), and zinc (Zn). The concentration of dissolved silver (Ag), aluminum (Al), and sodium (Na) in the tire shred filled trenches were generally similar to or less than background levels[4]. However, water in direct contract with submerged tire shreds had elevated levels of dissolved iron (Fe), manganese (Mn), and zinc (Zn) (Table 1). Dissolved iron (Fe) concentrations in the tire shred filled trenches ranged from nondetect to 86,900 μg/L compared to background concentrations of 22 to 3160 μg/L. However, in wells located 0.6 m downgradient of the tire shred filled trench the iron (Fe) concentrations deceased to nondetect to 3660 μg/L, which is comparable to background levels. The concentration of manganese (Mn) in the tire shred filled trench was 376 to 3340 μg/L compared to background levels of 27 to 666 μg/L. There were also increased concentrations of manganese (Mn) in the downgradient wells, however, the concentration appeared to decrease with time and was similar to

Table 1. Concentration of dissolved iron, manganese, and zinc.

Compound	Date	Concentration (µg/l)													
		Peat Site						Clay Site				Till Site			
		P1	P2	P3	P4	P5	P6	C1	C2	C3	C4	T1	T2,T3	T4	T5
		up grad	in shreds	down gradient				up grad	in shreds	down gradient		up grad	in shreds	down gradient	
Fe	6/94	514	22500	279	664	214	155	18.4	17300	21.6	<10	22	4160	2710	33
Fe	9/94	1620	66800	974	1640	1830	1180	53	56300	35	33	*	6530	*	*
Fe	11/94	*	58600	1280	1790	1700	2330	476	56400	300	318	277	71700	352	618
Fe	4/95	3160	86900	2460	2900	2190	2450	<100	#	<100	#	134	47500	<100	<100
Fe	11/96	2950	2080	*	2640	3270	3490	*	ND	*	ND	*	ND	*	28
Fe	6/97	783	49600	*	3660	3320	*	*	ND	2710	ND	*	21800	*	172
Mn	6/94	574	732	726	690	814	1070	120	724	322	157	49	3340	95	288
Mn	9/94	666	1340	954	786	916	845	122	1850	890	653	*	2340	*	*
Mn	11/94	*	1150	900	742	850	584	82	1400	764	44	41	2450	39	662
Mn	4/95	583	1200	1090	812	493	658	49	#	532	#	27	2500	27	773
Mn	11/96	386	514	*	518	293	484	*	502	*	29	*	973	*	40
Mn	6/97	390	619	*	228	391	*	*	376	393	13	*	780	*	56
Zn	6/94	2.8	44.4	5.1	3.3	5.4	3.8	ND	10	2.1	ND	ND	7.6	5.6	2.4
Zn	9/94	3	25	5	ND	2	2	4	123	ND	ND	*	76	*	*
Zn	11/94	*	15	8	5	2	2	7	20	4	ND	4	10	<3	23
Zn	4/95	9	15	8	ND	8	7	4	#	ND	#	4	5	5	ND
Zn	11/96	ND	65	*	8	9	ND	*	ND	*	ND	*	ND	*	ND
Zn	6/97	ND	14	*	7	6	*	*	ND	ND	ND	*	ND	*	ND

Notes: * = no sample on that date; # = compound not included in analysis on that date; ND = below detection limit (DL); see Tables 2 and 3 for detection limits.

background levels in the most recent round of sampling. Zinc (Zn) concentrations were also increased somewhat by tire shreds. The dissolved zinc (Zn) concentration in the tire shred filled trench ranged from below the detection limit to 123 µg/L compared to background levels that varied from below the detection limit to 9 µg/L. However, the zinc (Zn) in the tire shred filled trench decreased with time over the course of the study. The zinc (Zn) in downgradient wells was comparable to background levels.

Concentration of Metals for Unfiltered Samples

Unfiltered concentrations of silver (Ag), aluminum (Al), arsenic (As), barium (Ba), calcium (Ca), cadmium (Cd), copper (Cu), magnesium (Mg), sodium (Na), and lead (Pb) in the tire shred filled trenches were about the same or lower than background levels[4]. However, unfiltered levels of iron (Fe) in the tire shred filled trenches was significantly higher than background levels (Table 2 – note: due to the high Fe concentrations in Table 2, the units are expressed in mg/L whereas µg/L were used for all other concentrations).

This is most likely due to iron oxide precipitate that was visible in water that was in direct contact with the tire shreds. However, there is a general trend of decreasing concentration with time. Moreover, the Fe in wells located 3 m down gradient of the tire shred filled trench was similar to background levels. Unfiltered levels of manganese (Mn), and zinc (Zn) were also elevated in the tire shred filled trench (Table 3) but the levels tended to decrease with time and with distance downgradient from the trench. The unfiltered concentrations of chromium (Cr) in the tire shred filled trench at the peat and till sites tended to be higher than the background levels (Table 4). On some sampling dates, the total chromium concentration was higher in the downgradient wells than either the upgradient well or tire shred filled trench.

Table 2. Unfiltered iron concentration (mg/L).

Compound	Date	DL	Peat Site						Clay Site				Till Site			
			P1	**P2**	**P3**	**P4**	**P5**	**P6**	**C1**	**C2**	**C3**	**C4**	**T1**	**T2,3**	**T4**	**T5**
			up grad	in shred	down gradient				up grad	in shred	down gradient		up grad	in shred	down gradient	
Fe	6/94	0.01	1.8	111	3.2	2.7	1.1	0.1	25	69	33	40	14	155	113	19
Fe	9/94	0.1	0.4	292	4.3	5.9	4.5	3.7	57	209	198	15	*	117	*	*
Fe	11/94	0.1	*	212	8.2	9.2	4.6	9.7	76	195	111	75	64	209	120	70
Fe	4/95	0.1	12	216	12	11	5.7	8.8	78	109	77	78	70	213	817	47
Fe	11/96	0.015	0.7	#	*	0.8	0.9	1.0	*	ND	ND	ND	*	ND	*	ND
Fe	6/97	0.015	4.8	76	*	5.7	8.0	6.9	*	3.4	0.6	3.9	*	39	*	5.8
Fe	6/97	0.015	0.2	52	*	1.9	2.3	4.1	*	0.07	4.6	0.7	*	#	*	#

Table 3. Unfiltered manganese (Mn) and zinc (Zn) concentrations (μg/L).

Compound	Date	DL	Peat Site						Clay Site				Till Site			
			P1	**P2**	**P3**	**P4**	**P5**	**P6**	**C1**	**C2**	**C3**	**C4**	**T1**	**T2,3**	**T4**	**T5**
			up grad	in shred	down gradient				up grad	in shred	down gradient		up grad	in shr.	down gradient	
Mn	6/94	5	1300	1490	1880	1710	1730	1860	503	1570	984	468	365	7000	2620	890
Mn	9/94	5	1440	2830	2220	1930	1850	1830	1610	3880	3590	2530	*	5450	*	*
Mn	11/94	5	*	2300	2410	1770	1720	1490	1900	2830	2690	1360	1010	4990	2710	2260
Mn	4/95	5	1370	2440	2680	2100	1080	1080	1340	1990	1650	1060	1330	5340	13500	2160
Mn	11/96	5	405	#	*	491	473	282	*	ND	499	ND	*	971	*	ND
Mn	6/97	2	381	686	*	250	573	600	*	377	372	37	*	741	*	323
Mn	6/97	2	329	622	*	214	401	504	*	316	408	7	*	#	*	#
Zn	6/94	2	14	2390	25.2	143	66.5	16.3	100	747	198	72.3	42.7	338	307	45.8
Zn	9/94	2	40	561	39	19	18	45	167	675	531	341	*	569	*	*
Zn	11/94	3	*	261	17	8	ND	31	152	95	298	132	103	54	276	99
Zn	4/95	2	28	107	14	ND	ND	10	183	107	171	174	134	205	1540	83
Zn	11/96	7	ND	#	*	ND	ND	10	*	ND	ND	ND	*	15	*	ND
Zn	6/97	5.7	ND	96	*	10	10	10	*	7	ND	11	*	24	*	27
Zn	6/97	5.7	ND	13	*	ND	ND	ND	*	ND	ND	ND	*	#	*	#

Notes for Tables 2 and 3: * = no sample on that date; # = compound not included in analysis on that date; ND = below detection limit; DL = detection limit

Table 4. Unfiltered chromium (Cr) concentration (μg/L).

Compound	Date	DL	Peat Site						Clay Site				Till Site			
			P1	P2	P3	P4	P5	P6	C1	C2	C3	C4	T1	T2,3	T4	T5
			up grad	in shred	down gradient				up grad	in shred	down gradient		up grad	in shred	down gradient	
Cr	6/94	2	3	17	4	2	ND	ND	49	25	60	66	33	62	249	38
Cr	9/94	2	5	22	2	4	2	3	101	26	317	231	*	85	*	*
Cr	11/94	2	*	18	ND	8	4	2	114	16	205	105	93	33	248	92
Cr	4/95	2	10	21	8	5	3	2	128	39	124	118	99	114	1240	68
Cr	11/96	6	ND	#	*	ND	ND	ND	*	ND	ND	ND	*	ND	*	ND
Cr	6/97	6	ND	ND	*	ND	ND	ND	*	8	ND	10	*	7	*	13
Cr	6/97	6	ND	ND	*	ND	ND	ND	*	ND	ND	ND	*	#	*	#

Notes: * = no sample on that date; # = compound not included in analysis on that date;
ND = below detection limit; DL = detection limit

VOLATILE ORGANIC COMPOUNDS

Results for volatile organic compounds with the highest concentrations are summarized in Table 5. Cis-1,2-dichloroethene was found in samples from the tire shred trenches on most sampling dates. Except for one sample, the concentration was below its drinking water standard of 70 μg/L. The exception had a concentration of 85.5 μg/L. The highest concentration found in the wells located down gradient of the trenches was 9.8 μg/L. The results show that tire shreds submerged in groundwater release low concentrations of cis-1,2-dichloroethene, however, the concentration even a short distance (0.6 m) down gradient of tire shreds was well below the compound's drinking water standard.

Benzene appears to be released from tire shreds at trace levels. The measured concentrations were less than the drinking water standard (5 μg/L) except for two samples tested by the University of Connecticut. Duplicate samples tested by Northeast Laboratory found concentrations less than 5 μg/L. The concentration of benzene in wells 0.6 m down gradient of the trench were generally below detection limits except for two samples that had concentrations of 1 and <5 μg/L.

Tire shreds release low levels of 1,1-dichoroethane, 4-methyl-2-prentanone (MIBK), and acetone. The concentration 1,1-dichoroethane in samples taken from the tire shred trenches ranged from nondetect to 19 μg/L. However, the concentrations in the wells down gradient from the trenches were below the detection limit in the most recent round of sampling. Methyl-2-pentanone (MIBK) was found in samples from the tire shred trenches at concentrations ranging from nondetect to 140 μg/L, however the highest concentration in a well located 0.6 m down gradient from the trench was 31 μg/L. The concentration of acetone in the tire shred trenches ranged from nondetect to 54 μg/L for acetone, however, this compound is naturally produced by human metabolism and is not a major health concern at low concentrations. Tire shreds appear to release trace levels of 1,1,1-trichloroethane, 1,1-dichloroethene, xylenes, toluene, trichloroethene, 2-butanone (MEK), and chloroethane. The concentrations are generally less than 10 μg/L. For compounds that have a drinking water standard, the levels were well below the standard[4].

Table 5. Concentration of selected volatile organic compounds.

Concentration are in μg/L				Peat Site						Clay Site				Till Site			
Compound	Lab	Date	DL	P1	P2	P3	P4	P5	P6	C1	C2	C3	C4	T1	T2,3	T4	T5
				up grad	in shred	down gradient				up grad	in shred	down gradient		up grad	in shred	down gradient	
1,1-dichloro-ethane	C	08/94	0.5	ND	2.5	ND	ND	ND	ND	ND	1.9	6.9	ND	*	14.3	*	*
	C	11/94	0.5	*	ND	ND	ND	ND	ND	ND	7	5	ND	ND	19	ND	ND
	N	11/95	5	*	5.9	*	*	*	*	*	*	*	*	*	*	*	*
	C	08/96	0.5	ND	6.4	ND	ND	ND	*	ND	2.5	2.5	0.9	ND	12.7	3.9	ND
	N	09/96	5	*	5.8	*	*	*	*	*	<5	*	*	*	ND	*	*
	C	09/96	0.5	*	5.4	*	*	*	*	*	ND	*	*	*	0.7	*	*
	N	11/96	5	ND	<5	*	ND	ND	ND	*	<5	<5	ND	ND	12	ND	ND
	N	06/97	5	ND	<5	ND	ND	ND	*	*	ND	ND	ND	ND	*	ND	ND
4-methyl-2-pentanone	N	11/95	5	*	140	*	*	*	*	*	*	*	*	*	*	*	*
	N	09/96	5	*	40	*	*	*	*	*	21	*	*	*	ND	*	*
	N	11/96	5	ND	24	*	ND	ND	ND	*	ND	31	ND	ND	100	ND	ND
	N	06/97	5	ND	23	ND	ND	ND	*	*	ND	15	ND	ND	*	ND	ND
acetone	N	11/95	10	*	54	*	*	*	*	*	*	*	*	*	*	*	*
	N	09/96	10	*	21	*	*	*	*	*	10	*	*	*	ND	*	*
	N	11/96	10	ND	ND	*	ND	ND	ND	*	ND	ND	ND	ND	40	ND	10
	N	06/97	10	ND	13	ND	ND	ND	*	*	ND	ND	ND	ND	*	ND	ND
benzene	C	08/94	0.5	ND	0.7	ND	ND	ND	ND	ND	1.4	ND	ND	*	1.8	*	*
	C	11/94	0.5	*	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	N	11/95	5	*	ND	*	*	*	*	*	*	*	*	*	*	*	*
	C	08/96	0.5	ND	1.8	ND	ND	ND	*	ND	2	1	ND	ND	1.5	ND	ND
	N	09/96	5	*	<5	*	*	*	*	*	<5	*	*	*	ND	*	*
	C	09/96	0.5	*	21	*	*	*	*	*	9.5	*	*	*	ND	*	*
	N	11/96	5	ND	<5	*	ND	ND	ND	*	ND	<5	ND	ND	ND	ND	ND
	N	06/97	5	ND	ND	ND	ND	ND	*	*	ND	ND	ND	ND	*	ND	ND
chloroethane	C	08/94	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	*	1.1	*	*
	C	11/94	1	*	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	N	11/95	10	*	ND	*	*	*	*	*	*	*	*	*	*	*	*
	C	08/96	1	ND	ND	ND	ND	ND	*	ND	ND	ND	ND	ND	ND	ND	ND
	N	09/96	10	*	<10	*	*	*	*	*	ND	*	*	*	ND	*	*
	C	09/96	1	*	6.7	*	*	*	*	*	ND	*	*	*	ND	*	*
	N	11/96	10	ND	<5	*	ND	ND	ND	*	ND	ND	ND	ND	ND	ND	ND
	N	06/97	10	ND	ND	ND	ND	ND	*	*	ND	ND	ND	ND	*	ND	ND
cis-1,2-di-chloroethene	C	08/94	0.5	ND	16.1	ND	ND	ND	ND	ND	9.2	ND	ND	*	33.4	*	*
	C	11/94	0.5	*	6	ND	ND	ND	ND	ND	34.5	8.5	ND	ND	85.5	ND	ND
	N	11/95	5	*	25	*	*	*	*	*	*	*	*	*	*	*	*
	C	08/96	0.5	ND	36.9		ND	4.2		ND	9.4	7	0.8	ND	44.7	9.8	ND
	N	09/96	5	*	29	*	*	*	*	*	6.4	*	*	*	ND	*	*
	C	09/96	0.5	*	32.2	*	*	*	*	*	7.9	*	*	*	1	*	*
	N	11/96	5	ND	26	*	ND	ND	ND	*	6	7.9	ND	ND	43	ND	ND
	N	06/97	5	ND	27	<5	ND	ND	*	*	<5	6	ND	ND	*	<5	ND

Notes: * = no sample on that date; ND = below detection limit; DL = method detection limit; C = sample tested by University of Connecticut; N = sample tested by Northeast Laboratory

Table 6. Concentration of selected semivolatile organic compounds.

Concentration in µg/L				Peat Site						Clay Site				Till Site			
Compound	Lab	date	DL	P1	P2	P3	P4	P5	P6	C1	C2	C3	C4	T1	T2,3	T4	T5
				up gr.	in shred	down gradient				up gr.	in shred	down gradient		up gr.	in shred	down gradient	
aniline	C	8/94	10	ND	58	ND	ND	ND	ND	ND	*	ND	*	*	31	*	*
aniline	C	11/94	10	*	20	ND	ND	ND	ND	ND	91	ND	ND	*	64	ND	ND
aniline	C	4/95	--	#	#	#	#	#	#	#	#	#	#	#	(40)	#	*
aniline	N	11/95	10	*	81	*	*	*	*	*	*	*	*	*	*	*	*
aniline	C	11/95	--	*	(30)	*	*	#	*	*	*	*	*	*	*	*	*
aniline	C	7/96	--	#	#	*	#	#	#	#	#	#	#	#	(100)	#	#
aniline	N	10/96	10	*	ND	*	*	*	*	*	ND	*	*	*	ND	*	*
aniline	C	10/96	--	*	(200)	*	*	*	*	*	(65)	*	*	*	#	*	*
aniline	N	11/96	10	ND	ND	*	ND	ND	ND	*	ND	ND	ND	*	ND	ND	ND
aniline	N	6/97	10	ND	ND	*	ND	ND	ND	*	ND	ND	ND	ND	ND	ND	ND
phenol	C	8/94	20	ND	ND	ND	ND	ND	ND	ND	*	ND	*	*	ND	*	*
phenol	C	11/94	20	*	55	ND	ND	ND	ND	ND	16	ND	ND	*	26	ND	ND
phenol	C	4/95	20	ND	27	ND	ND	ND	ND	ND	22	ND	ND	ND	51	ND	*
phenol	N	11/95	10	*	ND	*	*	*	*	*	*	*	*	*	*	*	*
phenol	C	11/95	20	*	ND	*	*	ND	*	*	*	*	*	*	*	*	*
phenol	C	7/96	20	ND	ND	*	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
phenol	N	10/96	10	*	ND	*	*	*	*	*	ND	*	*	*	ND	*	*
phenol	C	10/96	20	*	ND	*	*	*	*	*	ND	*	*	*	ND	*	*
phenol	N	11/96	10	ND	ND	*	ND	ND	ND	*	ND	ND	ND	*	ND	ND	ND
phenol	N	6/97	10	ND	ND	*	ND	ND	ND	*	ND	ND	ND	ND	ND	ND	ND
m&p cresol	C	8/94	20	ND	ND	ND	ND	ND	ND	ND	*	ND	*	*	ND	*	*
m&p cresol	C	11/94	20	*	ND	ND	ND	ND	ND	ND	ND	ND	ND	*	ND	ND	ND
m&p cresol	C	4/95	20	ND	32	ND	ND	ND	ND	ND	42	ND	ND	ND	86	ND	*
m&p cresol	N	11/95	10	*	13	*	*	*	*	*	*	*	*	*	*	*	*
m&p cresol	C	11/95	20	*	20	*	*	ND	*	*	*	*	*	*	*	*	*
m&p cresol	C	7/96	20	ND	29	*	ND	ND	ND	ND	39	ND	ND	ND	82	ND	ND
m&p cresol	N	10/96	10	*	14	*	*	*	*	*	31	*	*	*	ND	*	*
m&p cresol	C	10/96	20	*	42	*	*	*	*	*	24	*	*	*	ND	*	*
m&p cresol	N	11/96	10	ND	ND	*	ND	ND	ND	*	ND	18	ND	*	57	ND	ND
m&p cresol	N	6/97	10	ND	ND	*	ND	ND	ND	*	ND	<10	ND	ND	32	ND	ND
benzothiazole	C	4/95	--	#	#	#	#	#	#	#	(50)	#	#	#	#	#	*
benzothiazole	C	11/95	--	*	(100)	*	*	#	*	*	*	*	*	*	*	*	*
benzothiazole	C	10/96	--	*	(300)	*	*	*	*	*	(300)	*	*	*	#	*	*
2(3H)-benzo-	C	4/95	--	#	(200)	#	#	#	#	#	(100)	(100)	#	#	(100)	#	*
-thiazolone	C	10/96	--	*	(300)	*	*	*	*	*	(300)	*	*	*	#	*	*
Unknown	C	4/95	--	#	(700)	#	#	#	#	#	(40)	(480)	(239)	#	(600)	(150)	#
Unknown	C	4/95	--	#	(200)	#	#	#	#	#	#	#	#	#	#	#	#

Notes: * = no sample on that date; # = compound not included in analysis on that date; ND = below detection limit; ()= tentatively identified compound; DL = method detection limit; C = sample tested by University of Connecticut; N = sample tested by Northeast Laboratory

SEMIVOLATILE ORGANIC COMPOUNDS

For the first few years after placement, tire shreds submerged in groundwater release low levels of aniline and phenol (Table 6). For samples taken through October 1996, aniline was present above the detection limit in most of the samples taken from the tire shred trenches. When detected, the concentrations ranged from 20 to 200 μg/L. However, no detectable levels of aniline were found in the two most recent rounds of samples. Phenol was found in the samples taken from the tire shred trenches at all three sites in November, 1994, and April, 1995. The concentrations ranged from 16 to 55 μg/L. The levels were nondetect in the first round of samples in August, 1994, and in all samples taken on or after November, 1995. More importantly, no detectable levels of either compound were found in the down gradient wells.

m&p cresol was present above the detection limit in slightly more than half of the samples taken from the tire shred trenches. When detected, concentrations ranged from 13 to 86 μg/L. Except for two samples at the clay site, neither compound was found in the down gradient wells. Thus, m&p cresol is released at low concentrations, however, it has a negligible tendency to migrate down gradient.

It is likely that tire shreds release trace levels of benzoic acid and N-nitrosodiphenyl-amine. Benzoic acid was found in about one-quarter of the samples taken from the tire shred trenches at concentrations ranging from <10 to 100 μg/L. N-nitrosodiphenylamine was found in about one-third of the samples taken from the tire shred trenches at concentrations ranging from <10 to 11.2 μg/L. Except for one sample each, these compounds were not found in the down gradient wells.

The following compounds were found above the detection limit in a few samples: benzothiazole, 2(3H)-benzothiazolone, 3-methylbenzenamine, and di-n-butyl-phthate. It is possible that tire shreds sporadically release low levels of these compounds. Several compounds were reported at levels above the detection limit in one well on a single date. This includes: cyclohexanol, 2,6-bis-(1,1-dimethylethyl)-2,5-cyclohexadiene-1,4-dione, 1H-isoindole-1,3(2H)-dione, 4-(2-benzothiazolythio)-morpholine, N-(1,1-dimethlyethyl)-formamide, butanoic acid, and isothiocyanato cyxlohexane. It is possible that tire shreds sporadically release low levels of these compounds. However, it is more likely that these are spurious data points and that tire shreds do not release detectable levels of these compounds.

Nine semi-volatile compounds were tentatively identified on a single date in the tests performed by the University of Connecticut. The compounds are: cyclohexanol, 2,6-bis-(1,1-dimethylethyl)-2, 1H-isoindole-1,3(2H)-dione, 4-(2-benzothiazolythio)-morpholine, N-(1,1-dimethlyethyl)-formamide, butanoic acid, diethytoluamide (DEET), 3-methylbenzenamine, and isothiocyanato cyxlohexane. In addition, benzothiazole was tentatively identified on three sampling dates and 2(3H)-benzothiazolone was tentatively identified on two sampling dates. There were also unidentified compounds on two dates. The estimated concentrations of these compounds are given in Table 6. It is possible that tire shreds release low concentrations of these compounds.

CONCLUSIONS

The results showed that tire shreds had a negligible effect on the concentration of metals with primary (health based) drinking water standards. For metals with secondary (aesthetic based) drinking water standards, samples from the tire shred filled trench had elevated levels of iron (Fe), manganese (Mn), and zinc (Zn). However, the concentrations of these metals decreased to near background levels for samples taken 0.6 to 3 m downgradient of the tire shred filled trench. Trace concentrations of a few organic compounds were found in the tire shred filled trenches, but concentrations were below method detection limits for virtually all the samples taken from the downgradient wells. Tire shreds placed below the water table appear to have a negligible off-site effect on water quality.

Acknowledgments and Corresponding Author

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ATTACHMENT 6-C
6 pages

WATER QUALITY RESULTS FOR WHITTER FARM ROAD TIRE SHRED FIELD TRIAL

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INTRODUCTION

The Whitter Farm Road tire shred field trial was constructed in the Fall, 1996. The purpose of the field trial was to evaluate the insulation and drainage properties of tire shreds beneath a paved road. A secondary purpose was to obtain data on the effects of tire shreds on water quality. The field trial consists of six 12.2-m (40-ft) long paved sections. Three sections are underlain by 154 mm (6 in.) to 305 mm (12 in.) of tire shreds, two sections are underlain by 305 mm (12 in.) of a mixture of tire shreds and granular subbase aggregate (gravel), and one section is a control underlain by granular subbase aggregate. A typical cross section is shown in Figure 1. The tire shreds had a maximum size of 76 mm (3 in.) and were made from a mixture of steel and glass belted tires. There was a significant amount of steel belt and bead wire exposed at the cut edges of the shreds. Additional information on the design of the project is given in Lawrence, et al. (1998).

A drainage trench runs parallel to one side of the road. The trench width varies from 0.66 to 1.07 m (2.2 to 3.5 ft). It was filled with the same material as the adjacent test section, i.e., tire shreds, tire shred/gravel mixture, or gravel. About 76 m (250 ft) of 102-mm (4-in.) diameter perforated ADS pipe was embedded in the trench backfill at a

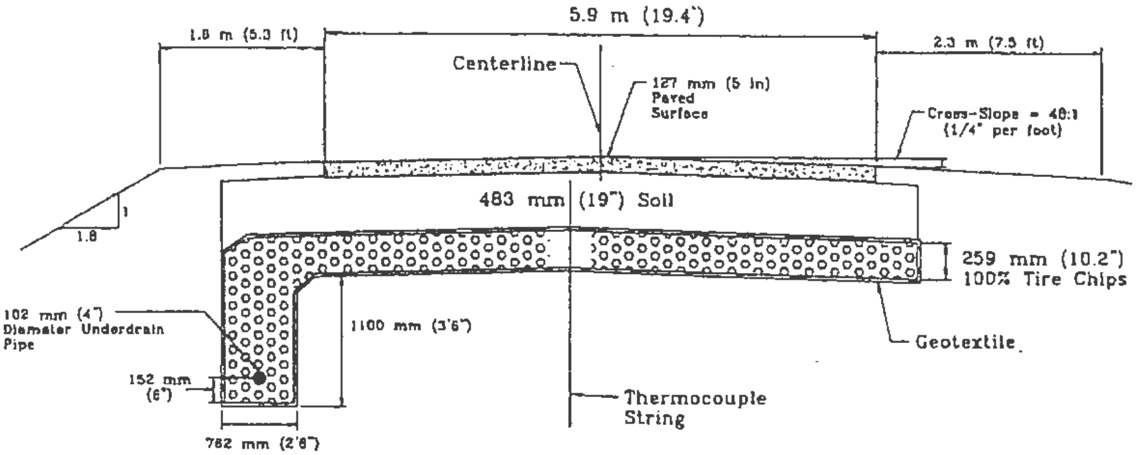

Figure 1. Typical cross section of Whitter Farm tire shred field trial.

depth of about 1.7 m (5.6 ft) below the road surface. Approximately 100 mm (4 in.) of backfill was placed under the pipe as bedding. The trench and perforated pipe intercepted groundwater flowing from higher ground adjacent to the project and surface infiltration. Thus, the water would come into direct contact with the tire shreds. It is likely that the tire shreds used as bedding beneath the pipe are saturated. The trench and perforated pipe conveyed the water to a 67-m (220-ft) length of solid 102-mm (4-in.) diameter ADS pipe. The solid pipe discharged in a field adjacent to the project. On June 27, 1997 water discharging from the pipe was collected for analysis.

WATER SAMPLING AND ANALYSIS PROCEDURES

Water sampling and analysis procedures were adapted from those described in Downs, et al. (1996) and Humphrey, et al. (1996). The sample containers used for collecting samples to be analyzed for volatile organics were clear 40 mL borosilicate glass vials with polypropylene closures and Teflon faced silicone septa. The samples were preserved by adding 4 drops of hydrochloric acid (HCl) to each vial before collecting the samples. Samples to be analyzed for semivolatile organics were collected in 1 L amber borosilicate glass bottles with polypropylene closures and Teflon liners. No sample preservation is required for semivolatile samples. Samples to be analyzed for metals and other compounds were collected in 1 L or 0.5 L high-density polyethylene (HDPE) bottles with HDPE closures. Samples to be analyzed for dissolved metals were filtered through Corning disposable sterile filters with 0.45 μm cellulose acetate filters. Filtered and unfiltered samples were preserved with 1.5 mL nitric acid (HNO_3) per liter of sample. All samples were stored at 4°C prior to analysis.

Samples for metals analysis except for lead were prepared in accordance with EPA Method 200.7 (Inductively Coupled Plasma - Atomic Emission Spectrometric Method for Trace Element Analysis) (EPA, 1991). The metals were then measured with a Thermo Jarrell Ash Model 975 Plasma Atomcomp Inductively Coupled Plasma Emission Spectrometer. Samples for lead were prepared in accordance with EPA Method 200.9 (Determination of Trace Elements by Stabilized Temperature Graphite Furnace Atomic Absorption Spectrometry) (EPA, 1991) and tested in accordance with EPA Method 7421 Lead (Atomic Absorption, Furnace Technique) (EPA, 1987). Chloride and sulfate were measured in accordance with EPA Method 300.0 (Determination of Inorganic Anions by Ion Chromatography) (EPA, 1983). Volatile organics were analyzed in accordance with EPA Method 8260 (Determination of Volatile Organics by Purge-and-Trap Capillary Column GC/MS). Semivolatile organics were analyzed in accordance with EPA method 8270 (Determination of Semivolatile Organics by Capillary Column GC/MS).

WATER QUALITY RESULTS

The results for metals and other inorganic compounds are summarized in Table 1. For metals with a primary drinking water standard, the dissolved and total concentrations were all below their corresponding regulatory limit. In fact, the concentrations were below the test method detection limit for cadmium (Cd), chromium (Cr), copper (Cu),

Table 1. Inorganic test results.

Compound	Test method detection limit (mg/L)	Drinking water standard type	Regulatory Limit (mg/L)	Concentration (mg/L)		
				Sample 1 (Disolved)	Sample 2 (Total)	Sample 3 (Total)
Ba	0.005	Primary	2.0	0.017	0.021	0.020
Cd	0.0005	Primary	0.005	< 0.0005	< 0.0005	< 0.0005
Cr	0.006	Primary	0.1	< 0.006	< 0.006	< 0.006
Cu	0.009	Primary	1.3	< 0.009	< 0.009	< 0.009
Pb	0.002	Primary	0.015	< 0.002	< 0.002	< 0.002
Al	0.07	Secondary	0.05 - 0.2	< 0.07	< 0.07	< 0.07
Cl	0.4	Secondary	250	111	100	103
Fe	0.015	Secondary	0.3	0.158	22.3	19.1
Mn	0.002	Secondary	0.05	2.53	2.51	2.51
SO4	0.5	Secondary	500	3.51	5.19	4.79
Zn	0.0057	Secondary	5.0	0.082	0.144	0.142
Ca	0.5	None	N/A	33.0	32.3	32.4
Mg	0.1	None	N/A	12.7	12.4	12.4
Na	0.5	None	N/A	79.5	75.3	75.1

and lead (Pb). Moreover, the measured concentration of barium (Ba) was a factor of 100 less than its regulatory limit.

For metals and other compounds with a secondary drinking water standard, the dissolved concentrations of aluminum (Al), chloride (Cl), iron (Fe), sulfate (SO_4), and zinc (Zn) were below their corresponding regulatory limit. Although it is most appropriate to compare dissolved concentrations to drinking water standards, it is noteworthy that the total concentrations of aluminum (Al), chloride (Cl), sulfate (SO_4), and zinc (Zn) were also below the standard. The total concentration of iron was elevated due to the presence of relatively insoluble iron oxide in particulate form. The level of dissolved manganese (Mn) was above its secondary drinking water standard. The dissolved and total concentrations of manganese were essentially the same.

Tests were also conducted for calcium (Ca), magnesium (Mg), and sodium (Na). The results are shown in Table 1. These are commonly found in groundwater and do not have drinking water standards. The dissolved solids concentration in Sample 1 was 320 mg/L. The total solids concentration in Samples 2 and 3 were 660 mg/L and 559 mg/L, respectively.

The results for volatile and semivolatile organic compounds were all below the test method detection limit. The test results are included as Attachment A. The results indicate that there were no detectable levels of organic compounds.

DISCUSSION and CONCLUSIONS

In this sampling event, tire shreds did not cause the levels of metals to exceed their primary drinking water standard. Moreover, the levels of volatile and semivolatile organic compounds were all below their test method detection limit. The same results were obtained at the North Yarmouth field trial where tire shreds were used as subgrade fill above the water table (Humphrey, et al., 1996). The level of manganese (Mn) was above its secondary drinking water standard. Steel belts are 2 to 3% manganese by weight so this is the likely source of the compound. Water in direct contact with tire shreds causes higher levels of particulate iron (Fe) due to oxidation of the exposed steel belts. Since manganese (Mn) and iron (Fe) have secondary (aesthetic based) drinking water standards these do not pose a health concern. The levels of aluminum (Al), chloride (Cl), sulfate (SO_4), and zinc (Zn) were all below their respective secondary drinking water standard. It is not possible to draw definitive conclusions from the single sampling event covered by this report. However, these results agree with the ongoing study in North Yarmouth, Maine (Humphrey, et al., 1996), namely, that tire shreds placed above the water table have a negligible impact on ground water quality.

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ATTACHMENT A

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NORTHEAST LABORATORY

ANALYSIS REPORT

University of Maine-Orono/Aaron Smart

DATE SAMPLED:	06/27/97	LABORATORY NUMBER:	9733527
DATE RECEIVED:	07/01/97	SAMPLE MATRIX:	Water
DATE ANALYZED:	07/15/97*	ANALYST:	VAM
DATE REPORTED:	07/15/97		
SAMPLE DESCRIPTION:	WF Road		

VOLATILE ORGANICS

8260 COMPOUNDS	PQL ug/L	Result ug/L	8260 COMPOUNDS	PQL ug/L	Result ug/L
Dichlorodifluoromethane	5	ND	1,2-Dibromoethane	5	ND
Chloromethane	5	ND	Chlorobenzene	5	ND
Vinyl chloride	5	ND	1,1,1,2-Tetrachloroethane	5	ND
Bromomethane	10	ND	Ethylbenzene	5	ND
Chloroethane	10	ND	m,p-Xylene	5	ND
Trichlorofluoromethane	5	ND	o-Xylene	5	ND
1,1-Dichloroethene	5	ND	Styrene	5	ND
Methylene Chloride	5	ND	Bromoform	5	ND
trans-1,2-Dichloroethene	5	ND	Isopropylbenzene	5	ND
1,1-Dichloroethane	5	ND	1,1,2,2-Tetrachloroethane	5	ND
2,2-Dichloropropane	5	ND	1,2,3-Trichloropropane	5	ND
cis-1,2-Dichloroethene	5	ND	n-Propylbenzene	5	ND
Chloroform	5	ND	Bromobenzene	5	ND
Bromochloromethane	5	ND	1,3,5-Trimethylbenzene	5	ND
1,1,1-Trichloroethane	5	ND	2-Chlorotoluene	5	ND
1,1-Dichloropropene	5	ND	4-Chlorotoluene	5	ND
Carbon Tetrachloride	5	ND	tert-Butylbenzene	5	ND
1,2-Dichloroethane	5	ND	1,2,4-Trimethylbenzene	5	ND
Benzene	5	ND	sec-Butylbenzene	5	ND
Trichloroethene	5	ND	4-Isopropyltoluene	5	ND
1,2-Dichloropropane	5	ND	1,3-Dichlorobenzene	5	ND
Bromodichloromethane	5	ND	1,4-Dichlorobenzene	5	ND
Dibromomethane	5	ND	n-Butylbenzene	5	ND
Toluene	5	ND	1,2-Dichlorobenzene	5	ND
1,1,2-Trichloroethane	5	ND	1,2-Dibromo-3-chloropropane	5	ND
1,3-Dichloropropane	5	ND	1,2,4-Trichlorobenzene	5	ND
Tetrachloroethene	5	ND	Hexachlorobutadiene	5	ND
Dibromochloromethane	5	ND	Naphthalene	5	ND
			1,2,3-Trichlorobenzene	5	ND
ADDITIONAL VOC'S			**ADDITIONAL VOC'S**		
Diethyl Ether	10	ND	Methyl Methacrylate	5	ND
Acetone	10	ND	2-Nitropropane	10	ND
Iodomethane	5	ND	4-Methyl-2-pentanone (MIBK)	5	ND
Allyl Chloride	5	ND	cis-1,3-Dichloropropene	5	ND
Carbon Disulfide	5	ND	2-Chloroethylvinyl ether	15	ND
Acrylonitrile	10	ND	trans-1,3-Dichloropropene	5	ND
Methyl t-Butyl Ether (MTBE)	5	ND	Ethyl Methacrylate	5	ND
2-Butanone (MEK)	10	ND	2-Hexanone	5	ND
Propionitrile	50	ND	trans-1,4-Dichloro-2-butene	5	ND
Methacrylonitrile	5	ND	Pentachloroethane	5	ND
Tetrahydrofuran	10	ND	Hexachloroethane	5	ND
1-Chlorobutane	5	ND	Nitrobenzene	15	ND
			Vinyl Acetate	15	ND

Surrogate	% Recovery
1,2-Dichloroethane-d4	103
Toluene-d8	91
4-Bromofluorobenzene	99

*Analysis performed outside of the recommended holding time for EPA Method 8260 due to instrumentation problems with the mass spec.
Analysis was conducted according to EPA Method 8260, "SW-846," 3rd Ed., July 1992.

< = Less than PQL = Practical Quantitation Limit ND = None Detected

Reviewed by: James E. Curlett [signature] Date: 7.15.97

James E. Curlett, Laboratory Manager

ATTACHMENT A (continued)

NORTHEAST LABORATORY

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ANALYSIS REPORT

TO:
University of Maine-Orono/Aaron Smart

DATE SAMPLED:	06/27/97	LABORATORY NUMBER:	9733527
DATE RECEIVED:	07/01/97	SAMPLE MATRIX:	Water
DATE EXTRACTED:	07/03/97	ANALYST:	VAM
DATE ANALYZED:	07/10/97		
DATE REPORTED:	07/14/97		

SAMPLE DESCRIPTION: WF Road

SEMI-VOLATILE ORGANICS

Base/Neutral Extractables	PQL, ug/L	Result, ug/L	Acid Extractables	PQL, ug/L	Result, ug/L
N-Nitrosodimethylamine	10	ND	Phenol	10	ND
Aniline	10	ND	2-Chlorophenol	10	ND
Bis(2-chloroethyl) ether	10	ND	2-Methylphenol (o-cresol)	10	ND
1-3-Dichlorobenzene	10	ND	3&4-Methylphenol (m&p-cresol)	10	ND
1,4-Dichlorobenzene	10	ND	2-Nitrophenol	10	ND
1,2-Dichlorobenzene	10	ND	2,4-Dimethylphenol	10	ND
Benzyl alcohol	10	ND	Benzoic acid	10	ND
Bis(2-chloroisopropyl) ether	10	ND	2,4-Dichlorophenol	10	ND
Hexachloroethane	10	ND	4-Chloro-3-methylphenol	20	ND
Nitrobenzene	10	ND	2,4,5-Trichlorophenol	10	ND
Isophorone	10	ND	2,4,6-Trichlorophenol	10	ND
Bis(2-chloroethoxy)methane	10	ND	2,4-Dinitrophenol	50	ND
N-Nitrosodi-n-propylamine	10	ND	4-Nitrophenol	50	ND
1,2,4-Trichlorobenzene	10	ND	2-Methyl-4,6-dinitrophenol	50	ND
4-Chloroaniline	10	ND	Pentachlorophenol	50	ND
Hexachlorobutadiene	10	ND			
Hexachlorocyclopentadiene	10	ND			
2-Nitroaniline	10	ND	**Polyaromatic Hydrocarbons**		
Dimethyl phthalate	10	ND	Naphthalene	10	ND
2,6-Dinitrotoluene	10	ND	2-Methylnaphthalene	10	ND
3-Nitroaniline	50	ND	2-Chloronaphthalene	10	ND
Dibenzofuran	10	ND	Acenaphthylene	10	ND
2,4-Dinitrotoluene	10	ND	Acenaphthene	10	ND
Diethyl phthalate	10	ND	Fluorene	10	ND
4-Chlorophenyl phenyl ether	10	ND	Phenanthrene	10	ND
4-Nitroaniline	50	ND	Anthracene	10	ND
N-Nitrosodiphenylamine	10	ND	Fluoranthene	10	ND
Azobenzene	50	ND	Pyrene	10	ND
4-Bromophenyl phenyl ether	10	ND	Benzo(a)anthracene	10	ND
Hexachlorobenzene	10	ND	Chrysene	10	ND
Di-n-butyl phthalate	10	ND	Benzo(b)fluoranthene	10	ND
Benzidine	20	ND	Benzo(k)fluoranthene	10	ND
Butyl benzyl phthalate	10	ND	Benzo(a)pyrene	10	ND
3,3'-Dichlorobenzidine	20	ND	Indeno(1,2,3-cd)pyrene	10	ND
Bis(2-ethylhexyl) phthalate	10	ND	Dibenzo(a,h)anthracene	10	ND
Di-n-octyl phthalate	10	ND	Benzo(g,h,i)perylene	10	ND

Surrogate	% Recovery	Surrogate	% Recovery
Nitrobenzene-d5	116*	2-Fluorophenol	7.1*
2-Fluorobiphenyl	124*	Phenol-d5	26
Terphenyl-d14	103	2,4,6-Tribromophenol	7.6*

*Recoveries are outside the expected control limits for Nitrobenzene-d5 (35-114%), 2-Fluorobiphenyl (43-116%), 2-Fluorophenol (21-100%) and 2,4,6-Tribromophenol (10-123%) as expressed in EPA Method 8270.
Analysis was conducted according to EPA Method 8270, "SW-846," 3rd Ed., 1986.

< = Less than PQL = Practical Quantitation Limit ND = None Detected

Reviewed by: James E. Curlett Date: 7-14-97
James E. Curlett, Laboratory Manager

ATTACHMENT 6-D
8 pgs

Review of the Human Health & Ecological Safety of Exposure to Recycled Tire Rubber found at Playgrounds and Synthetic Turf Fields

Prepared for:
Rubber Manufacturers Association
Washington, DC

Prepared by:
Cardno ChemRisk
Pittsburgh, PA

August 1, 2013

Executive Summary

Increasingly, tires that reach the end of their serviceable life are processed for beneficial reuse in novel applications. Some of these include soil and surface amendments at athletic fields, playground and garden mulch, and bound surfaces at playgrounds and athletic facilities. These modern artificial surfaces reduce the likelihood of personal injury, provide uniform recreational playing surfaces, promote energy conservation, eliminate pesticide and fertilizer usage, and support waste recycling. Tires are manufactured with a variety of materials and additives to ensure optimum product safety, reliability and performance. Some tire ingredients are considered to be human health hazards at exposure levels several orders of magnitude greater than possible from contact with finished consumer products. Accordingly, athletes, parents and other stakeholders have expressed questions and concerns about the potential for adverse human health or ecological effects from the use of recycled tires in sport surface or playground materials.

The purpose of this report is to evaluate the health and ecological risks associated with the use of recycled tire rubber in consumer applications, particularly playgrounds and athletic fields. In doing so, a thorough review of available literature was conducted including studies from both advocates and opponents to the use of recycled tire materials.

An examination of the weight of evidence across all of the available studies was conducted to enable a comprehensive assessment of potential risk. As is true of all such studies, uncertainties and limitations to the health assessments that have been completed to date are recognized. However even recognizing such limitations, a review of available studies concludes that adverse health effects are not likely for children or athletes exposed to recycled tire materials found at playgrounds or athletic fields (Table 1). Similarly, no adverse ecological or environmental outcomes from field leachate are likely.

The reviewed studies considered the quantitative and qualitative aspects of exposure to classes of chemicals most likely to be inhaled, ingested or directly contacted during athletic or recreational use. While some of the ingredients used in tire manufacturing are considered potentially hazardous to human health at high doses, the potential for athlete or child exposure to these chemicals is very low. During tire manufacturing, tires are subjected to high temperature and pressure for a specified period. In this process the raw materials undergo multiple physical transformations and chemical reactions that change the initial mix from a plastic compound into an elastic rubber composite. The materials present in this composite are permanently linked, either chemically or physically. The process is designed so the release of chemicals into the environment is inhibited. Studies which assessed exposure from breathing in indoor sporting environments where tire materials are used did not find appreciable adverse health effects. The same conclusion is applicable to outdoor settings, where particulate and gaseous phase air concentrations are expected to be 10 to 100 times lower, due to air dispersion and turbulence.

Uncertainties in the existing literature have been cited as areas of concern, resulting in confusion regarding the safety of recycled tire products, especially for children or other sensitive individuals. While these uncertainties, such as the lack of a temperature-emission rate relationship for outdoor ground rubber field installations or the lack of an extensive peer reviewed toxicology database for some compounds released from ground rubber from recycled tires, represent data gaps, the weight of the evidence indicates that these data gaps are not urgent or short term data needs. Although unique or significant health risks are unlikely from use of recycled tires in sports or playing fields, research to affirm the continued safety of these products is planned and ongoing.

Based on a review of the currently available data, there is one reasonable long term research goals: assessment of fine particulate exposure at indoor and outdoor fields. Completion of this goal is not considered to be a short term or urgent data need, but would be useful in enhancing the quality of risk communication regarding play surfaces that use recycled tires. Of the exposure pathways and chemicals reviewed in this report, inhalation of respirable fine particulates, particularly at indoor fields, was identified as a candidate for additional characterization. Although ground rubber used in playing fields are typically 1-mm or larger in diameter, they were identified in one study as an appreciable fraction of the respirable fine particulate matter ($PM_{2.5}$) using a tracer molecule. Fine particulate load is expected to be low for most applications due to the processing and washing of the product which occurs during recycling. However, since adverse health outcomes are associated with fine particles, further characterization of $PM_{2.5}$ in the raw material, as well as at indoor and outdoor fields, using a reliable tracer is recommended as a long term research objective. Although on-field outdoor $PM_{2.5}$ levels and composition are not likely to differ from local background levels or pose a health risk, as suggested by the preliminary studies by the NYDEC, additional assessment of these levels is important for risk communication given the scientific consensus on adverse health outcomes associated with fine particles. If indoor spaces adhere to building codes and best practices defined by American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), no adverse health concern is expected due to $PM_{2.5}$ levels.

Concerns have been expressed about ecological toxicity from zinc and the possibility of natural rubber allergy. Zinc is ubiquitous in the urban environment, and zinc compounds leaching from artificial turf fields are not likely to pose unacceptable ecological risk. Surface water samples may easily be collected to address this issue if there are specific concerns about sensitive local species. Surface water sampling, effluent monitoring and lysimeter tests suggest that zinc in field leachate is unlikely to result in exceedance of aquatic toxicity criteria particularly when a sand or mineral underlayment system is used. The existing literature indicates that natural rubber sensitization or adverse allergic reactions are not likely from recycled tire materials, since liquid latex is not used in making tires. Tires are made from natural rubber in bale form, which does not contain the same level of active proteins which may trigger allergenic responses, as found in liquid latex.

In conclusion:

- The health and ecological risks associated with the use of ground rubber in consumer applications, particularly playgrounds and athletic fields, were evaluated through a thorough review of the literature;
- This review included studies from both advocates and opponents to the use of ground rubber;
- No adverse human health or ecological health effects are likely to result from these beneficial reuses of tire materials; and

- While these conclusions are supported by existing studies or screening risk assessments, additional research would provide useful supplemental and/or confirmatory data regarding the safety of recycled tire products and enhance the weight of evidence used in risk communication.

Table 1: Summary of Selected Human Health Assessments of Recycled Tire Rubber

Scenario	Classes of chemicals considered	Routes considered: Oral Ingestion or Hand-to-mouth transfer	Routes considered: Inhalation	Routes considered: Dermal	Study Conclusions	Study Year and Citation
Outdoor child playground usage	Metals, PAHs, VOCs, allergen	Literature data; simulated gastric digestion; wipe sampling of tile	--	Allergic skin sensitization based on standard guinea pig model	Acute ingestion of shreds unlikely to produce health effects; low chronic risk for hand-to-surface-to-mouth transfer; skin sensitization or reaction unlikely.	United States 2007[1]
Indoor professional athlete use of artificial turf	PAHs	Literature review	Literature Review	Leaching studies; urine biomarker	No significant health risk for professional athletes; sufficient indoor ventilation recommended to control fine dust.	Nether-lands 2007[2]
Artificial turf use	Nitrosamines	--	Air quality sampling and headspace analysis	--	Small quantities of nitrosamines emitted but not detectable in air; nitrosamine related health effects not likely.	Nether-lands 2007[3]
Indoor artificial turf installation and amateur/ professional athletic use	VOCs formaldehyde	--	Emission chamber test results paired with model small indoor gymnasium	--	Worst case indoor VOC and aldehyde concentrations do not pose a health concern for adult or child athletes; during field installation, an air exchange rate of at least 2 per hour is recommended for protection of worker health.	France 2007[4]
Indoor adult and child use of artificial turf	PAHs, PCBs, VOCs, phthalates, alkyl phenols	Ground rubber phthalate and alkyl phenol content	Indoor air quality sampling of gaseous and particulate phase compounds	Leaching studies	Chemical substances are released in very low quantities; based on worst case assumptions, use of artificial turf halls does not pose elevated risk; more information needed on natural rubber allergens.	Norway 2006[5]
Child use of public playgrounds	Organic extract of tire rubber	Genotoxicity testing			Extracts were not genotoxic and exposure potential in children deemed minimal; tire rubber at playgrounds does not pose a health hazard to children.	Canada 2003[6]
Outdoor use of artificial turf fields	VOCs, SVOCs, metals, PM	--	Measurement of VOCs and PM above field	--	Concentrations of VOCs and PM above field did not exceed background, even with high field temperatures; Not likely to pose risk from inhalation	United States, 2009, 2010 [7, 8]

1.0 INTRODUCTION

A portion of tires that have reached the end of their serviceable life are processed for beneficial reuse in athletic fields, playgrounds, and gardens. These include loose 1 to 3-mm particles used as soil and surface amendments, larger shreds for use as garden mulch, and bound surfaces at playgrounds and athletic fields. These modern artificial surfaces reduce the likelihood of personal injury, provide uniform recreational playing surfaces, promote energy conservation, eliminate pesticide and fertilizer usage and support waste recycling. Tires are manufactured with a variety of materials and additives to ensure optimum product safety, reliability and performance. Some tire ingredients are considered occupational hazards at high exposure levels. Accordingly, athletes, parents and other stakeholders have expressed questions and concerns about the potential for adverse human health or ecological effects from the use of recycled tires in sport surface or playground materials.

The purpose of this report is to evaluate the health and ecological risks associated with the use of ground rubber[1] from recycled tires in consumer applications, particularly playgrounds and athletic fields. In doing so, a thorough review of available literature was conducted including studies from both advocates and opponents to the use of recycled tire materials.

This report discusses the findings and limitations of key human health and ecological studies of ground rubber from recycled tires that have been completed to date. However even recognizing the limitations, the review of available studies concludes that adverse health effects are not likely for children or athletes exposed to recycled tire materials found at playgrounds or athletic fields (Table 1). Similarly, no adverse ecological or environmental outcomes from field leachate are likely.

The reviewed studies considered the quantitative and qualitative aspects of exposure to classes of chemicals most likely to be inhaled, ingested or directly contacted during athletic or recreational use. While some of the ingredients used in tire manufacturing are considered potentially hazardous to human health at high doses, the potential for athlete or child exposure to these chemicals is very low. Tires are heated during manufacturing to generate physical and chemical reactions which bind the individual chemicals together such that they are inhibited from release into the environment.

Various stakeholders have identified uncertainties in the existing literature as areas of concern, resulting in confusion regarding the safety of recycled tire products, especially for children or other sensitive individuals. While these uncertainties, such as the lack of a temperature-emission rate relationship for outdoor ground rubber field installations and the lack of an extensive peer reviewed toxicology database for some compounds from ground rubber from recycled tires represent data gaps, the weight of the evidence indicates that these data gaps are not urgent or short term data needs. Although unique or significant health risks are not likely from use of recycled tires in sports or playing fields, research to affirm the continued safety of these products is planned and ongoing, and may enable better communications on this topic.

[1] While synthetically produced ground rubber is available, for the purposes of this report, unless otherwise noted, reference to ground rubber implies ground rubber derived from recycled tires.

2.0 DISPOSAL AND RECYCLING OF TIRES

The focus of this report is the use of ground rubber from ground scrap tires in sports field, running track and playground applications.[9] A number of methods are used to dispose of the tires discarded in the United States each year including recycling approximately 75% of the total disposed into useful products such as tire derived fuel (TDF), tire derived aggregate for civil engineering applications, infill for artificial turfs and as a cushioning ground cover in playgrounds.[10-12] Landfilling and tire piles have been discouraged by state and federal agencies because landfill caps can be compromised by tires rising to the surface and tire piles pose pest and fire risks, potentially requiring costly cleanups.[12, 13] Many states have implemented incentives for useful applications of scrap tires including public reporting of waste tire fate in Arizona and a scrap tire recycling trust fund in Kentucky.[10, 14-16] The marketing of recycled ground rubber based products has been highly ranked in a list of environmental and economic preference for tire disposal, second only to using the tire for as long as possible before disposal.[9]

2.1 GROUND RUBBER PROCESSING

The recycling of used tires into ground rubber is a mature technology which requires complex machinery using either ambient - temperature or cryogenic processes. These multi-step processes result in a uniform product free of fiber or steel impurities.[9, 17, 18] For most applications, typical finished ground rubber diameters range from ½ to 10 mm.[9] Either process can be used to generate ground rubber for use as athletic field infill, with typical diameters between 1 to 3 mm.[19] In addition to inter-technology variation, there is likely to be variation in product characteristics within the same technology across various suppliers.[20]

In the ambient process, tire chips are ground by a sequence of consecutive granulators to produce ground rubber of varying size specifications with a yield of approximately 70% ground rubber and 30% steel and fiber.[9, 21] Steel and textiles are recovered using magnetic and vibration density separators. A spray or mist may be used for lubrication and to control particle generation rates. Respirable fine particles are generated during the mechanical shredding process, but are recovered to some degree in the latter stages by air pollution control devices such as cyclones or washing.[1, 17] In some applications, such as playground mats bound with polyurethane, roller mills are used to produce longer and rougher granulates which facilitate bonding.[22]

In cryogenic recycling, liquid nitrogen is used to cool whole tires or chips to a temperature below -112 °F.[9, 21] At this temperature, the rubber is brittle like glass and size reduction is accomplished by crushing or breaking. Cryogenic recycling has been historically considered to result in a cleaner, less porous, and more uniform end product in fewer steps than ambient grinding, but the expense of liquid nitrogen is a consideration when comparing the two processes. As with the ambient process, steel and fibrous byproducts are recovered in the process. Because smaller size particles are more cost effective to produce than larger particles sizes, ground rubber products from cryogenic technology may have smaller nominal sizes than ground rubber products from ambient technology.

2.2 USES OF GROUND RUBBER

Ground rubber from recycled tires has a variety of uses including: rubber modified asphalt, molded products, athletic surfaces such as fields and tracks, reuse in tires/automotive products, construction, landscaping, and playgrounds.[9, 10] The benefits of ground rubber use in these applications are cost savings, improved performance, and increased safety and durability.[10] Ground rubber does not promote microbial growth. When used as a surface cover in playgrounds, it was shown to be more protective in preventing serious brain injury compared to pea gravel, sand and wood chips, saving an estimated $6.6 billion per year in injury related costs.[10, 23-25] In landscaping uses, ground rubber resists compaction or decomposition over time when compared to wood mulch. Rubber modified asphalt is used on roads, highways, and bike, walking, and golf cart paths.[10]

Ground rubber is frequently used as infill for artificial turf athletic fields and the New York City Department of Parks and Recreation reports that artificial turf athletic fields are used 28% more often than a conventional sports field.[26] Although the cost to install artificial turf fields can be more than conventional fields, artificial fields are estimated to have lower maintenance costs than grass fields.[26] While frequency of injury does not differ between artificial and natural grass fields, the types of injuries that occur on each are very different. One study found that natural grass fields are associated with head and neural injuries, and ligament injuries whereas artificial turf fields were associated with noncontact injuries, surface and epidermal injuries, muscle trauma, and injuries at high temperature. Furthermore, natural grass field injuries generally require longer recovery times than do artificial turf field injuries.[27] A separate study evaluated rotational and translational traction in rubber in-filled artificial versus natural turf fields and determined that natural grass has an increased rotational traction (often associate with more serious ligament injuries) when compared to artificial turf fields.[25]

Some applications consist of ground rubber bound in a poured substrate, which is used at playground surfaces and running tracks.[9] As compared to loose rubber, it is easier to maintain and keep clean. The material is not moved or displaced during play but can have less shock absorbing potential than loose ground rubber.[24]

Wastes - Resource Conservation - Common Wastes & Materials - Scrap Tires

Science/Technology

Background | Innovative Uses for Scrap Tires | Other Innovative Uses in the News

Background

In recent years, research on uses for scrap tires and advances in technology have created many new markets and innovative applications. New uses for ground rubber and advances in civil engineering keep millions of tires out of landfills and stockpiles every year.

EPA performs research and development to identify, understand, and solve current and future environmental problems. EPA's Office of Research and Development has conducted research projects on scrap tires through EPA's National Center for Environmental Research. Research topics have included rubberized asphalt, bridge erosion protection, air emissions from scrap tire combustion, and pyrolysis.

The Army Corps of Engineers used tires to protect marshland on Gaillard Island, Alabama from wave action, enabling plant root systems to establish.

One EPA funded project investigated the use of scrap tires to form a protective system for mitigating local scour around bridge piers. Local scour is the erosion of the riverbed around bridge piers. Bridge failure caused by this phenomenon has long been an important issue with respect to both public safety and maintenance costs. Nearly half a million bridgesnationwide are potentially affected by local scour. A honeycomb structure of scrap tires can mitigate local scour by modifying the water flow in the vicinity of a bridge pier and adjacent riverbed (more information on this project).

The US Department of Energy (DOE) also conducts research on innovative scrap tire uses. One project, sponsored by DOE's Office of Energy Efficiency and Renewable Energy, investigated the development of a method for treating rubber from scrap tires so that it can be used in various applications such as carpet underlay, automotive seals and gaskets, caulks, sealants, and adhesives. The treated rubber requires much less energy to produce than the polymers it replaces. More information on scrap tire research at DOE.

Innovative Uses for Scrap Tires

Scrap Tire Promotional Video

Tire-Derived Aggregate in Civil Engineering Applications

Highway Sound Barriers – Many states are turning to absorptive sound barriers—structures that soak up sound—to reduce highway noise. The "Whisper Wall" used in Northern Virginia, starts as a mixture of concrete aggregate, cement, water, and small pieces of shredded rubber from scrap tires. The wall deflects sound waves among its nooks and crannies until they lose energy.

Athletic and Recreational Applications – Several brands of resilient playground rubber surfacing material are being made from recycled tires and sold at major retailers across the US. The material can absorb much of the impact from falls providing added safety to children. This material can also be used as a mulch replacement in medians or decorative areas. Athletic and recreational applications are a fast growing market for ground rubber. An estimated 80 million pounds of scrap tire rubber were used in

2001 for athletic/field turf applications (50 million pounds)—above or below the ground—and as loose cover (30 million pounds).

Railroad Ties – Highly durable, rubber-encased railroad ties are being produced using scrap tires. These railroad ties have a steel-beam core filled with concrete that is then encased in 80 pounds of ground-up scrap tires and discarded plastic bottles, held together with a special binder or glue. These railroad ties are over 200% stronger than creosote-soaked wooden ties, enabling railroads to use fewer ties per mile. Moreover, rubber-encased railroad ties could last 60 to 90 years versus 5 to 30 years for wood.

Other Innovative Uses in the News

- Scrap Tire News: news and information about the scrap tire industry EXIT Disclaimer
- Road Management Journal, "Tires: A New Source for Culvert Pipe", August 1997 EXIT Disclaimer
- NewsFactor Network, "Scientists Tweak Old Recycling Technique To Attack Tire Problem", March 2002 EXIT Disclaimer
- Other Related Links

ATTACHMENT 6-F
3 pgs

Civil Engineering Applications

The civil engineering market encompasses a wide range of uses for scrap tires. In almost all applications, scrap tire material replaces some other material currently used in construction such as lightweight fill materials like expanded shale or polystyrene insulation blocks, drainage aggregate, or even soil or clean fill.


Road embankment constructed with shredded tires in El Paso, Texas.

A considerable amount of tire shreds for civil engineering applications come from stockpile abatement projects. Tires that are reclaimed from stockpiles are usually dirtier than other sources of scrap tires and are typically rough shredded. Rough tire shreds can be used as embankment fill and in landfill projects.

U.S.Scrap Tire Management Summary 2005-2009, October 2011, Civil Engineering Markets p.9 Rubber Manufacturers Association. EXIT Disclaimer

Civil Engineering Applications

Scrap Tire Promotional Video

- Tire-Derived Aggregate in Civil Engineering Applications

Subgrade Fill and Embankments

Tire shreds can be used to construct embankments on weak, compressible foundation soils. Tire shreds are viable in this application due to their light weight. For most projects, using tire shreds as a lightweight fill material is significantly cheaper than alternatives.

Examples of projects using scrap tires as subgrade fill and/or embankments include:

- Two highway embankments on weak clay in Portland, Maine.
- An interstate ramp across a closed landfill in Colorado.
- Mine access roads across bogs in Minnesota.
- Stabilization of a highway embankment in Topsham, Maine.
- Reconstruction of a highway shoulder in a slide prone area in Oregon.

Other uses of tire shreds: subgrade fill and embankments include retaining forest roads, protecting coastal roads from erosion, enhancing the stability of steep slopes along highways, and reinforcing shoulder areas.

For additional information, see:

- US DOT Federal Highway Research Center, User Guidelines for Tires Shreds as Embankment or Fill
- Texas DOT Specifications for the Use of Recycled Materials EXIT Disclaimer

Backfill for Walls and Bridge Abutments

Tire shreds can be useful as backfill for walls and bridge abutments. The weight of the tire shreds reduces horizontal pressures and allows for construction of thinner, less expensive walls. Tire shreds can also reduce problems with water and frost build up behind walls because tire shreds are free draining and provide good thermal insulation.

Recent research has demonstrated the benefits of using tire shreds in backfill for walls and bridge abutments.

Subgrade Insulation for Roads

In northern climates, excess water is released when subgrade soils thaw in the spring. Placing a 6 to 12-inch thick tire shred layer under the road can prevent the subgrade soils from freezing in the first place. In addition, the high permeability of tire shreds allows water to drain from beneath the roads, preventing damage to road surfaces.


Shredded scrap tires used as road base in Odessa, Texas.

For more information on civil engineering applications, consult:

- ASTM specifications for use of tire shreds in civil engineering applications, specifically ASTM D6270-98 - available on the ASTM Web site EXIT Disclaimer [Note: users must pay to download/view a copy of the ASTM specifications]
- State DOT engineering reports;
- Leachate data; and
- Training courses on highway and landfill applications.

Landfills

Landfill construction and operation is a growing market application for tire shreds. Scrap tire shreds can replace other construction materials that would have to be purchased. Scrap tires may be used as a lightweight backfill in gas venting systems, in leachate collection systems, and in operational liners. They may also be used in landfill capping and closures, and as a material for daily cover.

Septic System Drain Fields

Some states—Alabama, Florida, Georgia, South Carolina, and Virginia—allow tire shreds to be used in construction of drain fields for septic systems. Tire-derived material replaces traditional stone backfill material, but reduces the expense and labor to build the drain fields. Tire chips can also hold more water than stone and can be transported more easily due to their light weight.

Challenges to using tire shreds in drain fields include tire chip quality (tire chips must be clean cut and be of uniform size) and economics—in some areas, stone is abundant and cheap; tire shreds must be cheaper than stone to be used readily.

Other Uses

- Playground surface material
- Gravel substitute
- Drainage around building foundations and building foundation insulation
- Erosion control/rainwater runoff barriers (whole tires)
- Wetlands/marsh establishment (whole tires)

- Crash barriers around race tracks (whole tires)
- Boat bumpers at marinas (whole tires)

Environmental Studies on Using Scrap Tires in Civil Engineering Applications

A literature review was done by the University of Maine on the water quality and environmental toxicology effects of tire-derived aggregate (TDA). The review found that: "TDA has a limited effect on drinking water quality and fresh water aquatic toxicity for a range of applications including lightweight backfill for walls and bridge abutments, insulation and drainage layers beneath roads, free-draining and insulating backfill for residential foundations, vibration damping layers beneath rail lines, landfill leachate collections systems, drainage layers in landfill caps, landfill gas collection systems, and drainage aggregate for drain fields for on-site waste water treatment systems. TDA is unlikely to increase the concentration of substances with primary drinking water standards above those naturally occurring in the groundwater. It is likely that TDA will increase the concentration of iron and manganese, but the data indicates that these elements have limited ability to migrate away from the TDA installation." This literature review compiled by Dr. Dana Humphrey and Michael Swett of the University of Maine.

- Literature Review of the Water Quality Effects of Tire Derived Aggregate and Rubber Modified Asphalt Pavement (PDF) (58 pp, 332K, about PDF)

Several environmental studies have been performed to assess the potential for toxics to leach from tires when placed in wet soils. The impact of scrap tires on the environment varies according to the local water and soil conditions, especially pH value.

- Chelsea Center's Technical Report on Environmental Impacts of Rubber In Light Fill Applications (PDF) (20 pp, 153K, about PDF) EXIT Disclaimer

Two studies by the University of Maine's Department of Civil Engineering on water quality of tire leachate below the ground water table showed that if the groundwater pH is near neutral (not too acidic or basic), tire shreds have only a small impact on groundwater quality.

Minnesota began using shredded tires as a lightweight fill material in 1985 on logging roads through areas with weak soils. This report documents seven sites in Minnesota that used shredded waste tires as lightweight fill. Shredded tires were proven to be a viable form of lightweight fill because they are relatively lightweight, inexpensive and non-biodegradable. (Please note that this report mentions pyrolysis as a potential market for scrap tires, but after many attempts, pyrolysis has never been proven to be economically viable in the US.)

- Using Shredded Tires as Lightweight Fill Material for Road Subgrades (PDF) (38 pp, 327K, about PDF) EXIT Disclaimer

ATTACHMENT 6-G

EPA United States Environmental Protection Agency

Extramural Research

Using Scrap Tires to Save up to 100 Million Dollars Per Year by Mitigating Bridge Flood Damage

Research Project Search

NCER Research Project Search

EPA Contract Number: 68D70026
Title: Using Scrap Tires to Save up to 100 Million Dollars Per Year by Mitigating Bridge Flood Damage
Investigators: Bilanin, Alan J.
Small Business: Continuum Dynamics Inc.
EPA Contact: Manager, SBIR Program
Phase: I
Project Period: September 1, 1997 through March 1, 1998
Project Amount: $69,931
RFA: Small Business Innovation Research (SBIR) - Phase I (1997)
Research Category: SBIR - Pollution Prevention , Pollution Prevention/Sustainable Development

Description:

This Phase I project will investigate using scrap tires to form a protective system for mitigating local scour around bridge piers. Local scour is the erosion of the riverbed around bridge piers, which is induced by the recirculating juncture flow at the intersection of the pier and the riverbed. Bridge failure caused by this phenomenon has long been an important issue with respect to both public safety and maintenance costs. Average total losses from the resulting damage can run up to $100 million annually. Nearly half a million bridges nationwide are potentially affected by local scour. A honeycomb structure of scrap tires can mitigate local scour by modifying the vortical flow in the vicinity of the pier and riverbed. Moreover, this design is judged to be a highly desirable supplement to traditional methods of recycling scrap tires with the potential of recycling billions of tires. A complete scaling analysis will be conducted to determine the important parameters for experimental investigation. Subscale scouring experiments will be run and results will be used to compile a general design model for the implementation of the honeycomb device.

Supplemental Keywords:

small business, SBIR, engineering, recycling., Waste, Sustainable Industry/Business, Scientific Discipline, RFA, Technology for Sustainable Environment, Sustainable Environment, Civil/Environmental Engineering, Environmental Engineering, cleaner production/pollution prevention, Municipal, Chemistry and Materials Science, Civil Engineering, tires, scrap tires, mitigating bridge flood damage

Region 2 Water

You are here: EPA Home Region 2 Water > Oceans > Artificial Reefs

http://www.epa.gov/region02/water/oceans/artfishreefs.htm
Last updated on Tuesday, October 05, 2010

Artificial Reefs

Artificial reefs can create valuable habitat for fish and other aquatic wildlife. These reefs are created by sinking objects ranging from old tires to decommisioned ships in offshore waters. The role of the EPA is to assure that only acceptable material is used as artificial reef material and that the placement of these materials on the ocean floor will not violate federal laws or regulations that protect the environment. EPA works with federal (i.e. U.S. EPA Wetlands Division, U.S. Army Corps of Engineers, EXIT Disclaimer U.S. Coast Guard) EXIT Disclaimer and local government agencies (i.e. New Jersey Department of Environmental Protection, EXIT Disclaimer and New York State Department of Environmental Conservation) EXIT Disclaimer to address the delivery, placement, ownership and liability of the proposed artificial reef materials. *(Photo courtesy of NOAA)*

It is the responsibility of the U.S. Army Corps of Engineers (USACE) to regulate the construction and maintenance of fishing reefs and fishing attractors in waters of the United States including the waters that overlay the outer continental shelf. Permits for such structures are required from USACE pursuant to Section 10 of the Rivers and Harbors Act of 1899 and/or Section 404 of the Clean Water Act (CWA). Under Clean Water Act (CWA) § 404, EPA may prohibit, restrict, or withdraw use of a site for the discharge of dredged or fill material which would have unacceptable effects on fish, wildlife, shellfish, recreation, or municipal water supplies.

The states of New York and New Jersey each have valid USACE permits for artificial reefs in the Atlantic Ocean. EPA is consulted for all requests of permits, for artificial reefs, from USACE and confirms authorization of sites to receive certain materials for the purpose of enhancing the aquatic environment.

Several informative publications concerning coastal artificial reef planning and guidelines for marine artificial reef materials may be found at Gulf States Marine Fisheries Commission EXIT Disclaimer , under Publications and Sport Fish Restoration.

ATTACHMENT 6-H

ATTACHMENT 7-A

OCTAGON Consulting Engineers

CIVIL • LAND DEVELOPMENT
STRUCTURAL • MECHANICAL

May 16, 2011

Dan Babcock, Chief
Park County Rural Fire District #1
304 East Park Street
Livingston, MT 59047

Re: Request Confirmation of Fire Coverage for Proposed Waste Tire Landfill
Located within NE $^1/_4$ Section 18 T5S R9E MPM, Park County

Dear Dan:

The ~14 acre property southwest of the intersection and between Chicory Road and East River Road with rural address 19 Chicory Road is occupied by an old gravel pit which dates back to the late 1940's, and serves as the base of operations for Adkins Construction Company. We are preparing a proposal to seek approval from the State of Montana Solid Waste Program to license this property as a Class III mono-fill waste tire landfill. This proposal calls for the entire property to be excavated over the life of the landfill to the depth of the existing old gravel pit and backfilled with rubber pieces from shredded tires. Plans call for the surface of the pit to be progressively reclaimed, seeded and replanted with bushes, shrubs and trees as the pit is filled to ground level. Copy of map showing the location of this property is attached.

Fire protection is an important consideration to the licensing and operation of a facility of this nature. As you know, a Rural #1 fire station shares a common boundary with this proposed landfill. In addition, the Paradise Valley Volunteer Fire Department station is within 5 miles of this property located on East River Road toward the southwest from this site.

I am requesting that you address in a return letter to me your department's ability to provide fire protection to this proposed waste tire landfill. I will be happy to stop by the station to pick up your response letter at your earliest convenience. Thank you for your cooperation and assistance in this matter.

Sincerely,
OCTAGON CONSULTING ENGINEERS, LLC

William E. Smith, P.E.
Consulting Engineer

WES:
Attachments
Cc: Mike Adkins, Property Owner

Wastes - Resource Conservation - Common Wastes & Materials - Scrap Tires

Tire Fires

Photo of Burning Tires

Tire fires, although infrequent, are serious situations that are difficult to extinguish and expensive to clean-up.

Tire fires often become major hazardous incidents affecting entire communities —frequently requiring neighborhood evacuations and long, drawn-out fire extinguishing operations. These fires threaten pollution of the air, soil, and water. EPA, states, municipalities, and private companies have spent millions of dollars cleaning up tire fires across the country.

EPA does not consider scrap tires a hazardous waste. However, if a tire fire occurs, tires break down into hazardous compounds including gases, heavy metals, and oil. The average passenger car tire is estimated to produce over two gallons of oil when burned. (Source: Rubber Manufacturers Association, April 2003)

Oil that exudes into ground and surface water as a result of tire fires is a significant environment pollutant. In some cases, this may trigger Superfund cleanup status. For every million tires consumed by fire, about 55,000 gallons of runoff oil can pollute the environment unless contained and collected. This oily material is also highly flammable.

Air pollution is also produced by tire fires. Air emissions may include polycyclic aromatic hydrocarbons (PAHs), benzene, styrene, phenols, and butadiene. For more information on toxic air pollutants generated by tire fires, go to EPA's Toxics Air Pollution website.

Notable Tire Fires

- In 1983, a 7-million tire fire in Rhinehart, Virginia issued a plum of smoke 3,000 feet high and nearly 50 miles long with air pollution emissions deposited in three states. The fire burned for nine months, polluting nearby water sources with lead and arsenic. The tire storage facility where the fire occurred is now being cleaned-up as a Superfund site.
- In 1999, a lightning strike ignited a tire fire in Westley, California. The tire dump contained millions of scrap tires located in a canyon in a coastal mountain range. The large smoke plume from the fire impacted nearby farming communities and caused widespread concern of potential health affects from exposure to the smoke emissions. The tire fire also produced large volumes of pyrolitic oil that flowed off the slope and into the drainage of an intermittent stream. This oil was ignited too and the oil fire significantly increased the smoke emissions close to ground level. A response to the oil and tire fires was beyond the capabilities of local and state agencies. The EPA regional coordinator immediately responded using Oil Pollution Act of 1990 authority. It took 30 days to extinguish the fire. Total EPA response costs were $3.5 million.

Extinguishing Tire Fires

Waste tires are difficult to ignite, but once a tire fire starts, it is generally very hard to control and extinguish. Using water and/or foam to extinguish a tire fire is often futile. Water is best used to keep adjacent, unburned tires from igniting.

Smothering a tire fire with dirt or sand is usually the best option for extinguishing fires. Typically, the sand or dirt is moved with heavy equipment to cover the burning tires.

Putting out a tire fire can also be facilitated by removing unburned tires from the pile to lessen the fuel load.

Additional Information

Through EPA's Superfund website, users can search for National Priority List sites throughout the US, including those that have resulted from tire fires—such as the Rhinehart Tire Fire Dump Site in Virginia.

Adkins Waste Tire Monofill Landfill

Landfill Operations Plan

1. This landfill will receive waste tires at an operational maximum rate of 5000 carcasses per day from three sources: 1) whole carcasses delivered to the landfill by trucks from shops, retail businesses and many other sources that generate waste tires; 2) cut, chopped and shredded waste tire pieces that have been processed by company trucks at source locations and hauled to landfill; and 3) whole carcasses dropped off at landfill one to four-at-a-time by private individuals. Upon arriving at the landfill, whole tire carcasses and rubber pieces will be delivered directly into the pit. Whole tires will be cut into at least 4 pieces prior to being placed into lifts. If and when the chopping machine is installed, whole tire carcasses delivered to the landfill will be off-loaded into the processing building located within the licensed landfill boundary, chopped, cut or shredded and then conveyed into the pit.
2. The upper edge of the excavated pit will set at least 12 ft inside the property boundary on all sides, and occupy an area of approximately 11 acres at full build-out. As a part of routine landfill operation, the pit will be excavated to a nominal depth of 60 ft below natural ground surface, and perimeter excavation into native soils will be laid back to maintain stable soil conditions in the surrounding terrain. The total volume of the landfill will be approximately 700,000 cubic yards. Tire carcasses will be cut, chopped and shredded to reduce void volume and increase the number of carcasses that can be placed into each cubic yard of pit volume. At the outset of pit operations, consideration will also be paid to future retrieval of these rubber pieces, when technology enables economically viable processes for their use. It is estimated that cut or chopped rubber pieces produced from between 23 and 62 average size car tires can be disposed per cubic yard. A total of an estimated 25 million tires can be disposed over the life of this landfill. At the estimated rate of 5000 tires per day, this landfill will have a useful life of at least 20 years.
3. Rubber pieces will be placed into the pit in lifts approximately 5 ft thick; backfilled with native sand and gravel excavated from the pit; and mechanically compacted to fill voids and stabilize each lift. The compacted lift will then be covered with a 6" layer of sand/gravel. The lift will grow in surface area at the rate of approximately 3000 sq. ft per week. Lifts will be routinely backfilled, compacted and covered every 2 to 3 weeks as the fill operation proceeds across the open pit, so that no more than 6 to 9 thousand sq. ft of rubber pieces remain exposed at any one time. When the eleventh lift finally reaches ground surface, an 18" thick finish layer of sand/gravel excavated from the pit and a 6" cover of loamy topsoil retrieved from on-site stockpiles will be placed to cap the pit. This finished layer will be

contoured to an average slope of 2% toward the perimeter of the pit to enhance stormwater runoff. A stormwater control berm approximately 2 ft high will be constructed within not more than 10 ft of the edge of the open pit (as shown in schematic Section A-A on the attached drawing sheet C) to protect from stormwater running into the pit.

4. All rubber pieces will be placed into the pit as carcasses cut or chopped. Carcasses will be processed at a rate that will control and minimize the number of waste tires stockpiled and the time they remain in standby. In the initial stage of operation, whole tire carcasses will be cut in the pit. At later stages, hydraulic shredders or cutters may be installed in the building on site to cut carcasses. In addition, heavy excavation equipment, such as rubber tired front loader, track excavator, track bulldozer, vibratory sheep-foot compactor, and material handling conveyors adequately sized to efficiently handle the volume of rubber pieces and earthen backfill material will be operated within the designated perimeter of the landfill. Tire pieces will be compacted into lifts as described in Section 7.12 of this report.

5. One adequately sized building existing or constructed on-site will be used to provide for indoor staging and processing of waste tire carcasses. Processing activities will occur inside the buildings and not be visible to surrounding neighbors and passersby.

6. The licensed area of the proposed landfill is approximately 11.7 acres. A large pit already exists on the property from previous commercial mining of gravel and sand. This pit has set a gauge for depth of excavation at a nominal dimension of 60 ft below surrounding ground surface. The pit will be excavated, expanded and shaped in order to landfill waste tire pieces. The pit has established the west area of the licensed landfill as where the excavation and landfilling operations will commence.

7. The west area is designated as Phase 1. Phase 1area is shown on the attached aerial photo labeled "Existing Conditions" (sheet 2 of 4), Site Layout (sheet 3 of 4) and Plan Schematic (sheet B). Additional activities also conducted within Phase 1 area will include: staging and processing whole tire carcasses in the processing building planned to be constructed immediately to the north of the existing shop building; and maintaining equipment in the existing shop building.

8. As the surface area of the pit is enlarged, topsoil on the natural ground surface shall be stripped and stockpiled on-site for use in future reclamation of landfill surface. In addition, erosion control measures shall be implemented in accordance with Section 11 of the Engineer's report. Excavated soil will be screened on-site as required and used to provide sand, gravel and cobble material adequate for backfilling lifts of rubber pieces. Dust abatement measures, which may include use of water sprinklers in the

screening equipment, shall be implemented as required. Larger dimension reject cobbles, rocks and boulders will be hauled off site.

9. The line separating Phase 1 from Phase 2 will be fenced with a durable steel chain link fencing material 10 ft in height, and maintained as long as landfill operations are limited to the Phase 1 area. The location of this fenced line between Phase 1 and Phase 2 is shown on the attached Site Layout.

10. The landfill area designated as Phase 2 is presently occupied by: a small storage building; one small vacant house; four small residential dwellings; one well; and two active drainfield septic systems. The storage building will remain for use by landfill operations, the vacant house is intended to be used as an office until excavation of the pit encroaches upon it, and the residential buildings will be removed to locations off-site prior to commencing landfill operations. Without the residences, the existing water supply well will be used to supply potable water to buildings; for monitoring groundwater; and supplying water for irrigation of the reclaimed and seeded finished surface of the pit. The drainfields will be removed as the pit is excavated for the landfill.

11. As the pit fills up with waste tire pieces from the southwest corner of the property in Phase 1, and the surface is reclaimed to form natural ground, excavation and landfill will proceed to the north and east. As the pit encroaches upon the gravel screening operation, this operation will be relocated from the northern area to the southern area of Phase 1 made available by reclaiming the pit. Landfill operations will continue uninterrupted throughout Phase 1. As the pit in Phase 1 nears completion, excavation will continue east along the south boundary of the licensed landfill property into the south portion of Phase 2 area. Then pit excavation will continue north until the processing building, maintenance shop and storage building are encroached upon. These buildings may then be temporarily relocated onto the reclaimed Phase 1 area or removed from site. Because this scenario is at least 15 years off into the future, exact details of this transition are not clear at this writing.

12. The number of tires used per unit volume, the rate at which a lift of compacted rubber pieces will grow, and area of each lift required to be covered in each 2 to 3 week interval is discussed as follows:

    Completed lifts will be backfilled and covered with native pit run and screened earthen material consisting of sand and gravel with varying content of loam and fines at intervals not to exceed 13 weeks. This is the maximum interval set by the laws and rules of the State of Montana. However, the operational standard will be to keep the lifts covered within three weeks of placement in order to reduce the visual impact and the danger from fire. A total of eleven lifts of compacted rubber pieces will be placed in the full depth of the pit.

According to the Operation Plan, waste tires will be received at a maximum rate of 5000 carcasses per day. Carcasses will be chopped, cut and shredded prior to being placed into the landfill. Density of rubber shreds averages between 24 and 33 lb/cu. ft (pcf) for loose material and between 40 and 52 lb/cu. ft once compacted into place. (Refer to NEWMOA Fact Sheet, "Beneficial Use of Tire Shreds As Lightweight Fill", dated April 6, 2001 prepared by Northeast Waste Management Officials' Association, and "Source Users Guidelines for Waste and By-Product Materials in Pavement Construction" Federal Highway Administration, FHWA-RD-97-148, April 1998.) At 25 pcf each cubic yard (cy) averages 675 lbs, and at 46 pcf each cubic yard weighs 1242 lbs. Given that an average tire weights 20 lbs, each cubic yard of quartered tire carcasses contains approximately 23 tires; each cubic yard of loose rubber shreds contains 34 tires; and each compacted cubic yard contains a maximum of 62 tires. Since many tires received may be larger than average and the vibratory sheep-foot compactor is expected to deliver near maximum compaction, we will assume 35 to 50 tires per cy. Rubber pieces will be placed and compacted into the landfill at a nominal rate of 110 cu. yds per day. Each lift will be nominal 5 ft in depth and will be backfilled and compacted in several passes to ensure stability as the lift is brought up. Each lift will grow at a rate of 3000 sq. ft per week, and a completed open face of lift measuring 9,000 sq. ft in area will be covered with 6 inches of sand and gravel soil at least every 3 weeks.

13. The relationship between the: 1) total volume of the landfill; 2) volume of soil excavated to form the existing pit; and 3) volume of soil backfill required to fill and cover each lift and provide a soil cap (not including topsoil which has been and will be stripped and stockpiled on-site) is calculated as follows:
1) Estimated volume of existing pit = 40% of total landfill
Therefore, volume of soil remaining to be excavated = 60% of total landfill
2) Fill voids in waste rubber: compacted rubber density @ 46 pcf = 1242 pcy
assumed density of rubber @ 70 pcf = 1900 pcy
Therefore, void ratio = 1.0 – (1242/1900)*100% = 35.0%
3) 6" soil cover over each lift of rubber pieces to lift thickness = 10%
18" soil cover over top of pit compared to total depth of pit = 2.5%
4) Total volume to backfill required = 47.5%
Round total soil backfill required to 50%
Conclusion: The difference between remaining soil volume of landfill to be excavated and calculated volume of soil backfill is 10%. This 10% represents a reasonable estimate in volume of oversize cobbles and rocks that could be rejected and hauled from site. Therefore, the presence of the existing pit results in a balanced cut and fill over the life of the landfill. Due to the soil volume that must be excavated in order to shape the existing pit to begin to receive waste rubber, the balanced cut and fill will take effect immediately.

14. When the final lift of waste rubber pieces brings a portion of the landfill's surface at least 6000 sq. ft in area to within +/-1 ft of surrounding ground level, an 18" thick layer of sand/gravel covered by a 6" minimum thick layer of loam and clayey loam topsoil shall be placed over top of the lift. The final topsoil layer spread over the sand/gravel layer shall be capable of sustaining a healthy stand of surface vegetation. Prior to placing the topsoil layer, the final layer of sand/gravel spread over the finished lift shall be contoured to a gentle crown across the finished surface of the landfill pit and slightly compacted. Weather permitting, the topsoil shall be planted with a mix of grass seeds. If hot summer weather is present, seeded areas should be gently irrigated to establish a durable, erosion resistant stand of surface vegetation.

    As each lift is brought to ground surface, covered with the required layer of sand/gravel, contoured to finish shape and planted, measures shall be taken to prevent stormwater runoff from flowing into the open pit and causing erosion and transport of sediment into the pit. The edges of the open pit shall be protected with a small berm of compacted topsoil or silt fence and the surface crowned toward the perimeter of the pit to cause stormwater collected on the finished surface to be drained toward the outside edges.

    During the growing season, application of irrigation water to the freshly reclaimed and seeded areas should be a consideration. Water can be pumped from the existing monitoring well located near the north boundary of Phase I area, or the well located within Phase 2 for use in irrigating the reclaimed and seeded areas of finished pit surface. Irrigation water should be applied at a rate of 1 inch to 1.5 inches per week during the growing season for at least two consecutive growing seasons to establish and maintain a durable stand of grass and surface vegetation.

15. Reclamation will be completed on areas of the pit surface approximately 7000 to 9000 sq. ft in size (approximately every two to three weeks) as top lift is brought to ground level. Finish topsoil will be spread to the required thickness, graded to a gentle slope toward the property boundary and planted with a mix of native and drought resistant grass seeds. Stormwater received on the finished surface during a rainfall event will drain toward the perimeter of the landfill but most will soak in to the root zone of the plants. The exterior perimeter between the edge of the pit and the licensed boundary of the landfill shall be protected with an earth swale approximately 2 ft deep by 5 ft wide contoured into the natural ground surface and planted with grass. The swale is dimensioned to provide adequate capacity to convey flows generated by the 100 year storm event without over topping it banks, thereby ensuring that stormwater is not diverted onto the reclaimed pit surface. This swale fits into the natural topography of the ground and serves as the path of least resistance to convey stormwater runoff around the landfill. Stormwater runoff from the surface of the landfill, and from

surrounding land will be intercepted by the swale and channeled around the perimeter of the licensed landfill and off the property.

Steps must be taken to contact neighboring land owners to remind them that trespass irrigation water from Mill Creek pipeline and/or other sources must not cross the boundary onto this landfill property. Allowing trespass water to flow off your property and onto the neighbor without permission is a violation of state law and will not be tolerated.

16. Stormwater landing inside the open pit shall be channeled into a lined stormwater detention basin from which it can be pumped. The lined basin should be excavated into the bottom of the pit at its lowest point. A pumping sump must be provided in the lowest end of the lined basin to accommodate a pump intake. A basin 10 ft wide x 15 ft long x 2 ft average depth will contain the total volume of runoff generated by design storm event. Water discharged from the pump outlet must be spread and dispersed onto ground surface outside pit in such a manner to prevent soil scour and erosion.

17. The Owner's business plan estimates receiving, processing and landfilling 1.26 million tires per year at full operation. This is a rate of 105,000 per month or 5,000 tires per business day (assuming 21 business days per month). The processing and landfilling of tire carcasses would occur eight hours per day with business hours assumed to be between 7:30 am to 4:00 pm Monday through Friday.
An average 40 ft long tractor trailer load of whole tires could bring 800 carcasses to the landfill, however the labor to properly stack waste tires into the van may increase costs excessively. An open bobtail truck can bring at least 170 average size carcasses per load if stacked properly in a laced pattern. The same bobtail truck could bring 400 carcasses after those carcasses had been chopped into pieces. A 30 cu yd side dump trailer could deliver approximately 300 whole carcasses. On an average business day, this landfill is expected to receive approximately 20 truckloads of whole waste tire carcasses and processed pieces. Because this pit will encourage local residents, businesses, Park County government and Yellowstone National Park to bring waste tires for disposal, approximately 10 additional deliveries per day by individual cars and small trucks are expected during regular business hours. At this rate, the pit would fill up at the rate of approximately 200 cu yds per business day, and have a usable life of over 20 years.

18. The Owner's business plan also contemplates the possibility of unearthing and retrieving the rubber pieces at some future date, provided there becomes viable economic value based on future developments in technology and regulations. In this scenario, the landfilled rubber pieces would be excavated from the pit and removed from the sand and gravel

backfill by screening. The salvaged rubber would be hauled from the site in truck loads that meet DOT highway requirements. Sand and gravel soil material rejected from the screened tire pieces would be returned and compacted into the pit along with adequate volume of imported pit run sand and gravel soil to replace salvaged rubber pieces. As the pit would be emptied of rubber pieces and backfilled the new surface could be lower than surrounding ground level, the surface shall be reclaimed with topsoil, planted with grass seed mix and protected from stormwater erosion in accordance with the closure plan for this licensed landfill.

ATTACHMENT 8-C
3 pages

Adkins Class III Monofill Waste Tire Landfill
Fire Plan to Guide Physical Plant Infrastructure and Day to Day Operations

Introduction

This fire plan is provided to establish infrastructure setup and operational parameters for the licensed monofill waste tire landfill. Another component of fire preparedness involving emergency response and incident command has been addressed by the plan entitled "Fire Plan: Emergency Response and Incident Command" prepared by fire chiefs of Paradise Valley Volunteer Fire Department and Park County Rural #1 Fire District. A personnel training plan is in discussion and will be added. These plans taken together effectively address public health, safety and welfare, and the environment regarding a threat of fire from this landfill facility. Routine annual inspection of the landfill facility and review of these three plans will be conducted by the landfill owners with local fire authorities to help improve all aspects of preparedness.

Technical and Regulatory Basis for Infrastructure Layout and Facility Operations

Requirements and guidelines set forth in this plan were taken from several sources including: Chapter 25, "Tire Rebuilding and Tire Storage" of the International Fire Code, 2009 Edition as applicable to a Class III waste tire monofill landfill; input from the local fire chiefs and other fire authorities; and Site Specific License Conditions set forth by the DEQ Solid Waste Program for Solid Waste License No. 517.

These guidelines and requirements address: separating sources of ignition and heat from tire carcasses; eliminating potential of ignition in tire staging areas located within the licensed landfill facility; mitigating flame spread by providing adequate setback distances; and enhancing fire fighters' ability to control and rapidly suppress fire should one start.
IFC states: "Tire fires, although infrequent, are serious situations that are difficult to extinguish…"[1]; "Scrap tires are not generally considered a hazardous waste; however, if a tire fire occurs, tires break down into hazardous compounds including gases, heavy metals and oil."[1]; and "Waste tires are difficult to ignite, but once a tire fire starts, it is generally very hard to control and extinguish."[1]

Purpose of this Setup and Operations Plan

The purpose of this plan is to regulate design and layout of infrastructure, and present requirements and guidelines which when implemented as part of infrastructure set up and day-to-day operations will: heighten employees' awareness of the seriousness of fire; reduce sources of ignition throughout the landfill facility; minimize exposure of tires and rubber pieces to sources of heat and ignition; limit quantity and volume of waste tire carcasses staged for processing; routinely cover quartered tire carcasses and chopped rubber pieces with sandy gravel soil within the pit in order to eliminate exposure to oxygen; prepare, update and maintain an accurate site layout site plan of the landfill property which identifies locations of utilities; designate access routes through the facility for emergency fire vehicles and apparatus; and enhance fire fighters' ability to control and suppress a fire in this facility.

General Description of Operation

In the initial phase of operation, all tire carcasses will be unloaded directly into the pit upon delivery to the landfill facility. Once in the pit, carcasses will be sorted, select few tires placed into a sealed storage container for removal from the site, and remaining carcasses sheared into at least four pieces and placed into the landfill in lifts. No tire carcasses will be processed outside of the pit. In subsequent phases when carcasses are chopped, shredded or processed inside a building, rubber pieces will be transported by conveyor directly into the pit (in order to eliminate double handling) and placed in lifts. Exposed lifts of rubber pieces will be routinely backfilled, compacted and covered with sand and gravel soil every two to three weeks using vibratory compacting equipment. IFC states: "Smothering a tire fire with dirt or sand is usually the best option for extinguishing fires."[1] In the landfill operation, this is our method for preventing fires, by encapsulating rubber tire pieces in sand and gravel soil to eliminate oxygen and minimize exposure to ignition.

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[1] International Fire Code Commentary, 2009 Edition General Comments page 25-1.

Precautions Against Fire

1. Install a 10 ft high chain link fence and locking swing gates of equal height to restrict unauthorized access to the property. Gates will be closed, secured with heavy-weight chains and locked when the facility is closed.
2. 'No Trespassing' signs will be installed and maintained on the perimeter fence.
3. Establish and at all times maintain clear ingress and egress points for emergency vehicles. Multiple locks (keyed and combination) provided by the facility and fire departments will be daisy-chained together to secure gates while facility is closed.
4. An adequate stockpile of fine-medium grain soil (approximately 1000 cu. yds) will be staged on-site for use in smothering burning materials in the event of fire. In addition, provide heavy earth moving equipment at the ready to excavate in-situ soil during fire suppression operations.
5. Open burning or open flame is prohibited within 1000 ft of the tire pile anywhere within the landfill facility.
6. Sources of ignition and heat, such as welding, gas flame cutting or heating devices including portable heaters, shall only be used inside designated enclosure erected for this purpose within the licensed landfill facility. This enclosure must be located more than 200 ft from the tire pile.
7. Smoking within the licensed landfill facility is permitted only in a specifically designated area adjacent to the office or lunch/break room. "No Smoking" signs shall be posted prominently and maintained around the facility, and this prohibition shall be rigorously enforced.
8. Whole waste tire carcasses shall not be staged or stored near or under electrical power lines which cross the property.
9. Lightning rods conforming to applicable state codes shall be installed. Materials specified and furnished by a company experienced in protection from lightning. Lightning rods shall be placed on the facility, but away from any waste tire pile.
10. Fire suppression systems shall be installed inside all tire processing buildings with specific emphasis on protecting the tire chopping/cutting machine.

On-Site Fire Response Measures

Fire extinguishers (2A10BC-rated or higher) shall be prominently placed within buildings, structures and vehicles so as to be readily available to any employee in the area for incipient fire control. Every fuel-fired vehicle operated by the landfill shall be equipped with a minimum 2-A:20-B:C rated portable fire extinguisher. All fire extinguishers shall be inspected and tagged annually. All employees of the landfill shall be trained in emergency response and use of hand held fire extinguishers.

In addition, some members of the staff will receive training from the local volunteer fire department in the use of personal protective equipment (PPE), SCBA, radios and heavy earth moving equipment during fire suppression operations.

Water storage will be maintained in underground storage tanks located immediately behind the fire station on contiguous lot and at other places on the property. Additional water volume will be stored in Adkins Construction's water tender truck parked at the facility.

Emergency Response Notification

Location of nearest land-line telephone shall be posted conspicuously in attended locations, and instructions to dial 911 in case of any emergency including fire shall be stated on every sign.

Piled Storage and Staging

Piled storage of tire carcasses within the licensed landfill facility is expressly prohibited. Tires received by the landfill shall be processed and placed into the pit in a timely manner in accordance with the operating plan. A residual backlog of tire carcasses staged for processing equivalent to 1/2 day of processing (a total of 2500 tires) may be kept, and the gross volume of whole tires piled shall not exceed 6750 cubic feet (250 cu. yds) at a maximum height of 10 feet. At a nominal pile height of 6 ft to 8 ft, average footprint area would not exceed 1000 sq. ft. Piled tires must be fully covered with fire resistant tarps for fire protection or placed in an enclosed structure by the end of every working day. In order to eliminate unsightliness and increase access for material handling, this staging pile may be placed immediately adjacent to the processing building and covered with a roof. A clear space of at least 40 ft shall be maintained around three sides of this pile to provide for material handling, fire break and access by fire fighters.

Tire carcasses and pieces placed in the pit are part of the active disposal unit, and do not fall under this restriction. These carcasses and pieces are restricted to not exceed 9,000 sq. ft in exposed surface area and to be covered with at least 6-inches of soil every 3 weeks.

Fire Department Vehicles Access

Fire access lanes not less than 20 wide must be maintained within the licensed landfill facility to provide for access by fire department apparatus to within 150 ft of any point within the landfill boundary. Turn-arounds and turning radii of at least 50 ft must be provided to enable fire apparatus to maneuver to protect fire fighters as well as exposures. Any access lane longer than 150 ft must end in an adequately sized turnaround, dead-ends are not allowed. Fire lanes must be kept a minimum clear distance of 20 ft from the staging pile. The 40 ft minimum clearance required to be maintained around the staging pile provides this 20 ft clearance for fire apparatus to maneuver. Fire apparatus access lanes must be unobstructed at all times.

A fire apparatus access lane shall be provided along the west boundary of the landfill property between the perimeter chain link fence and edge of pit. This lane can be used by fire fighters to obtain favorable position on the windward side of the pit under certain wind directions. This lane will end in an adequately sized turnaround to enable safe turning for fire response apparatus.

Perimeter Fencing

A firmly anchored 10 ft high chain link fence and locking swing gates of equal height to restrict unauthorized access to the property shall be erected around the facility. Two 10 ft wide access gates shall provide a clear opening width of at least 20 ft. Gateways shall be kept clear of obstructions so as to be fully openable at all times. All gates shall be locked when the facility is not staffed. Pad locks and chains which can be cut and removed with bolt cutters should be used.

ATTACHMENT B-D
5 pages

PARK COUNTY RURAL
FIRE DISTRICT #1

02-14-2014

TO: Judge Gilbert

FROM: Dann T. Babcox Fire Chief

RE: Tire Fires and Adkins Tire Collection Site

Your Honor,

As the Chief of the largest Fire District in Park County I have seen many tires burn. Some are single tires and some are in piles that have ignited due to structural or wild land fires that have produced enough heat for a long enough period of time to get the tires burning. There is a lot of speculation about this issue so I would like to explain it from the fire side.

Most all tire fires are a result of arson. It takes several minutes at 700 degrees for a tire to ignite and stay lit to continue burning. Many things can accelerate this process but usually if a tire is just sitting there it will not ignite. The Pablo Fire in Ronan in 2001 should have been extinguished sooner by better pre planning and quicker response by the IC. The tires were burning for an unknown time from an unknown source. Tires are hard to ignite. If left unattended the fire will spread but that is not realistic with the location of the proposed tire pit on Chickory Road.

The proximity of homes and businesses to the pit make it impossible for a fire to spread quickly in a tire fire scenario. A fire station is on the property. Trained firefighters are generally on hand for suppression at the time of the call. PCRFD#1 station#1 is 20 minutes away at the most.

Pyrolysis is a thermo chemical decomposition of organic material at elevated temperatures in the absence of oxygen (or any halogen). It involves the simultaneous change of chemical composition and physical phase, and is irreversible. Once the chemical reaction takes place you need oxygen and a fire can happen when an ignition source is introduced. These components are commonly known as the fire triangle. OXYGEN, HEAT, and FUEL all have to be present or you will not have a fire. If you take any one of these components away a fire cannot happen. So when fighting fire we look to take away one or more of the Triangle components to defeat the blaze.

The simplest way to extinguish any tire fire is with dirt. The very smartest and easiest way to manage a tire fire is to not let it get big in the first place. The proposed location of the Adkins tire pit is surrounded by homes on the property. This would make it nearly impossible for a fire to spread at all unless an accelerant was used. Even in that case the amount of time it would take for Fire Officials to get on scene and control the issue with dirt or water is not long enough to create a hazardous issue that isn't common place in any field or open space in the rest of the county.

I have fought many tire fires. None of the fires I have fought have come close to being a haz-mat situation because we do not let them get that big. Fast aggressive methods can be used to limit the spread. In the fire plan and the site set up of the Adkins Monofill all of these considerations have been mitigated. For example:

The tires will be buried in lifts in small increments of time to limit the exposure. Dirt will be deposited on each lift to keep oxygen from getting to the fuel. Take the oxygen away and you have no fire. The lifts themselves will not consist of millions of tires so the impact of a fire is minimal at best. In addition the lifts the owner will have plenty of dirt on hand above the lifts on the edge of the pit for quick access to bury anything that has caught on fire. PCRFD#1 will train each of the employees on the fire equipment located at the tire monofill site. Some of the potential employees have already joined the fire department. Nevertheless, all employees working at the monofill will be trained to operate equipment and respond to a fire in the area. In review, the following safety measures are or will be put in place.

1. A Fire Station and equipment within yards of the site.
2. Employees trained on the equipment and tactics for preventing and fighting any fire in the area.
3. Tires will be buried in lifts with dirt eliminating heat and oxygen to the fuel source.
4. Employees of the company live on site for 24 hours surveillance of the area.

5. The location of the monofill is at a lower elevation and any emergency issue can be seen immediately so authorities will be contacted right away to ensure prompt response.
6. Fire preplans and operational tactics will be monitored by the Fire Authority to ensure ongoing safety.
7. Dirt will be piled up on the top off the pit for quick access to bury existing exposed tires.

The polycyclic aromatic hydrocarbons would not be any more than a typical vehicle fire. Any water used would be used to keep other tires from igniting and dirt or other appropriate material would be used to smother the fire instead of having water in the mix to possibly pollute the ground water.

All of the aspects of fire have been considered for this site and have been mitigated or are just not realistic. PCRFD#1 will be working with the owner during all phases of operation to ensure fires never become a reality. If for any reason a fire does break out in the area of the tires it will not have the time or ability to spread into a large haz-mat situation. Again the tires will be buried in lifts so at least one of the components of the fire triangle will be gone. Also by burying the tires in lifts you almost completely eliminate the Heat component as well as the OXYGEN component. In this scenario a fire cannot happen.

I do understand that people are concerned about the idea of a tire fire. The reality is that a tire fire at that location with all the preplanning in place is virtually nonexistent. And if a fire did breakout the response time would sufficient to keep the fire from becoming anything larger than a few tires. The proposed plan of burying the tires in lifts makes the chances even more remote.

I am concerned that other people are talking for the Fire Authority that has jurisdiction. I am the only spokesman for PCRFD#1 and I am not worried about tire fires at this facility. It is also very troubling to me that opponents to this project are attempting to use the Fire Department as a pawn in order to make the claim of a possible disaster. PCRFD#1 is the authority having Jurisdiction at the proposed tire collection facility. The current plans submitted to me by Mike Adkins are acceptable to me.

Very Respectfully Yours,

Dann T. Babcox Sr.

Fire Chief PCRFD

ATTACHMENT 7-A
7 pages

Scrap Tires: Handbook on Recycling Applications and Management for the U.S. and Mexico

December 2010

United States Environmental Protection Agency

Office of Resource Conservation and Recovery
1200 Pennsylvania Avenue NW
Mail Code: 5304P
Washington DC 20460
www.epa.gov/waste

EPA530-R-10-010

CHAPTER 6

Transportation and Processing Economics

The preceding chapters focused on major applications, or specialized uses, for scrap tire resources because markets define the required collection and processing methods. Collection can be local for small, nearby markets, or regional, for large markets and centralized processing facilities. Scrap tires can be used whole or processed into pieces ranging from large civil engineering chips to fine crumb rubber, with differing processing requirements for each size. Collection and processing systems naturally evolve with markets, but the probability of succeeding with limited resources is maximized by targeting defined initial market needs. The following section provides a brief discussion of basic collection, transportation, and processing (including methods, equipment, processes, and economics) to assist in evaluating alternatives. The discussion is based on historical experience in the United States, but U.S. economics have been converted into comparable Mexican economics to make them more applicable to the projected market and economic structure in Mexico and increase their usefulness in Mexico. This section is based on 2008 costs and may vary depending on present market values.

COLLECTION AND TRANSPORTATION

Scrap tire collecting and hauling are critical components in effective use of the tire resource. The impact of efficient collection on the economic viability of scrap tire management alternatives is often underestimated. Hauling, on the other hand, will evolve with the management program. If no regulations or enforcement exist to govern tire disposal, transportation costs will encourage discarding them at the closest site, especially for small collection vehicles such as pickup trucks. Small vehicles generally represent the highest risk for illegal tire disposal in the United States. However, once regulations are in place and enforced, competitive pressure will force the use of efficient collection methods and vehicles. Inefficient haulers will fail.

Methods

Scrap tires are normally generated where replacement tires are installed, such as at tire stores, car dealerships, and repair shops. Tires are a naturally segregated waste stream unless they are mixed with other wastes intentionally. In the United States, they are generally collected separately, without contamination from other materials, by people or companies that specialize in tire collection. Reusable casings are removed for resale, and the rest are properly disposed of at processing facilities or landfills if appropriate regulations, penalties, and enforcement are in place. Otherwise, the remaining tires are too often dumped or stockpiled because these disposal options are the lowest cost.

Tires can be collected on scheduled intervals or an as-needed basis. Route collection generally involves trucks travelling scheduled routes at designated frequency, with tires loaded by the driver, an assistant, or store personnel. Tires are counted during loading for invoicing. Collection can be requested as needed rather than on a regular schedule for stores with small or variable generation. Charges for this type of pickup are generally based on the number of tires, distance, and other factors.

Trailers are often parked at stores with high volumes and adequate space. The trailers are loaded by store employees and locked to prevent vandalism, dumping, and arson. When the trailer is full, the store notifies the collector and an empty trailer is delivered at the same time that the full trailer is removed. The store is generally charged a fixed fee per trailer based on distance, turnover frequency, gradable casings, and other cost-sensitive factors. Dumpsters and bins have also been used, but limited capacity and inefficient hauling make these alternatives expensive. In all cases, the hauler is paid by the store or by the government to haul the tires to an acceptable disposal site based on the requirements of the waste tire program that is used in the area.

Equipment

A wide variety of vehicles have been used to haul tires, anything from wheelbarrows to diesel tractors. The following is a brief discussion of some commonly used vehicle types.

Pickup Truck

Pickup trucks are a common vehicle capable of hauling many materials, including scrap tires. Carrying capacity for full-size pickups ranges from

Box truck for tire transportation
Photo courtesy of Tire Recycling and Disposal, Inc.

about 450 to 900 kg (1,000 to 2,000 pounds), depending on model and condition. The bed can hold the equivalent of up to 50 passenger tires (10 medium truck tires) if properly laced or stacked. These tires weigh approximately 1,000 pounds, the normal carrying capacity of basic half-ton (sometimes called 150-class) pickups in good condition. A metal cage can be added to increase the containment volume if the pickup has sufficient load carrying capacity. Some 0.7 metric ton and 0.9 metric ton (called 250- and 350-Class) pickups can carry 900 kg (2,000 pounds) or more. A caged trailer can be used to optimize hauling capacity because most pickups can tow more weight than they can carry within the truck itself. Towing capacity generally ranges from 2,250 to 4,550 kg (5,000 to 10,000 pounds), representing 250 to 500 passenger tires. Since most manageable trailers cannot hold that number of tires, trailer volume generally controls towing capacity.

Box Truck

Box trucks are commonly used for local waste tire collections. They can hold up to 400 passenger tires if tightly laced. Examples of a box truck and proper lacing techniques are shown in the photos to the right.

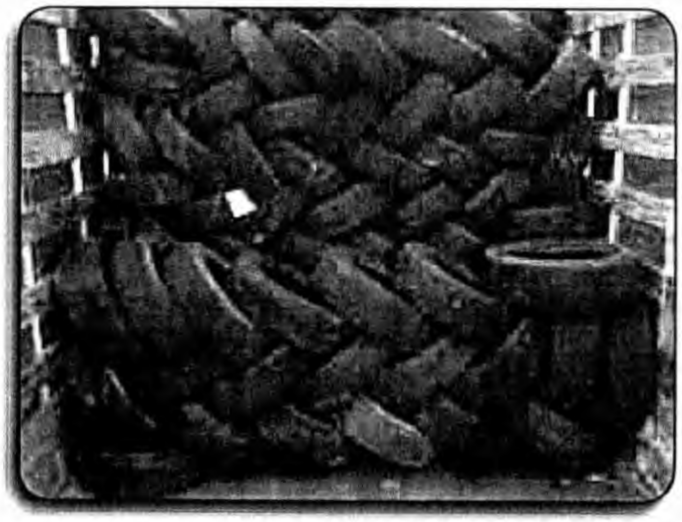
The driver typically travels a designated route, stopping to load tires from regular customers or those requesting service from a dispatcher. Infrequently, cargo vans or an open cage welded onto a flatbed truck have been used as alternatives.

Tractor Trailer

Traditional tractor trailer rigs are commonly used for collection and transport of large volumes of tires. Capacity for whole tires is limited by volume and depends on the trailer size, tire types, loading methods, and contamination. It ranges from 500 to 750 tires in a 27-foot tandem trailer to more than 1,500 stacked in laced fashion in a 52-foot trailer. Processing reduces the tire volume by a factor of two to five, so processed tire loads are normally limited by maximum weight allowances, and not volume. Normal payload limits are 22 to 26 U.S. tons (2,200 to 2,600 passenger tire equivalents) in the United States, based on total weight limits minus the weight of the tractor and empty trailer. Tandem trailers further increase tire capacity for long hauls when local regulations allow them.

Collection/Hauling Economics

Tires can be collected and hauled by whatever vehicle is available, but experience and the competitive nature of the business have led good operators to carefully evaluate optimum equipment for specific purposes. To illustrate the differences, capital and operating costs associated with collecting and hauling tires about 30,000 miles a year were calculated for each major type of equipment. Since all of these costs vary significantly with time and location, this information should be used only for comparison or as a basis for recalculation using local economic conditions. The example assumes the purchase of used equipment in good condition with estimated labor, maintenance, and fuel costs based on some areas in the United States. Estimated insurance, depreciation, and a 20-percent annual return on investment have been included in the fixed cost calculations, but interest was not included for any funds borrowed. The initial U.S.-based economics are included in Appendix H for reference by those in border areas. In addition, a Spanish version of these



Proper lacing technique for tire transportation
Photo courtesy of Tire Recycling and Disposal, Inc.

economics adjusted to reflect economics within Mexico is also included in Appendix H.

The capital and operating costs were estimated for a pickup truck, a pickup with a caged trailer, a box truck, and a diesel tractor with a 48-foot trailer. For simplicity, it was assumed that the vehicle averages 48.28 km/hour (30 mph), allowing time for tire loading along the way. The costs were calculated on a cost/km basis, and then reduced to cost/km/tire to more accurately reflect volume economics. The data is provided in Appendix F at the end of this chapter.

Exhibit 6-1 summarizes the capital and operating costs ($/mile) for each of these alternatives. As expected, both costs increase with size of the vehicle. However, cost/km/tire is a better indicator of hauling efficiency than is cost/mile. Exhibit 6-2 provides the cost/tire for hauls of 25, 100, and 500 miles for comparison, again based on the data shown in Appendix F. Pickup trucks are expensive on a cost/tire basis even on short hauls, but become prohibitive on longer trips. A caged trailer improves capacity and efficiency, but practical service range is generally 100 to 150 miles. Box trucks are slightly more efficient, but are normally used for total travel distances of less than 200 miles. Tractor trailers are the most efficient choice for longer distances. Longer trailers (52 feet) or tandem 27-foot trailers are most efficient if roads and regulations allow them.

These calculations also assume that the vehicle is filled up during the trip. The cost/tire will increase if it is not filled, so a smaller vehicle may be better in these cases. In some cases, it may be most efficient to establish a collection point in a town or area where tires can be accumulated and then be hauled in larger vehicles to regional processing facilities or markets.

PROCESSING

Tires must withstand impact and high speeds while on vehicles, and they have to do so at temperatures ranging from subzero to desert heat. The flexibility of rubber, combined with the strength and abrasiveness of reinforcing steel, makes tires a challenge to process for product applications. The following section discusses basic tire processing and economics as a generic framework for individual evaluations.

Scrap tire processing covers a broad range of methods and equipment. This discussion focuses on large markets that can use whole tires and shredded tires ranging from large Type B TDA (See Chapter 3 for discussion of Type B TDA) to nominal 2.5-cm (1-inch) TDF (discussed in the Energy Utilization Section) and the equipment commonly used to produce these products. Additional equipment that can be added to further reduce product size for ground rubber applications is also discussed. Capital and operating costs associated with this additional equipment are substantial.

Critical Issues

Many U.S. scrap tire processors, and especially ground rubber producers, have historically failed within 1 to 5 years after they enter the business. Many of the failures may have been avoided by considering the following issues before any investment decisions were made:

Product Markets

The rate of market development for scrap tire products has historically limited the growth of tire processing. Elapsed time and costs associated with market development are generally underestimated and have a major impact on the economic viability of processors. The time required to develop markets can be years, not weeks, and may require customer identification and acceptance, regulatory approval, product testing, market introduction, and distribution development. Accumulating product inventory while markets develop is doubly expensive because it decreases revenue anticipated from product sales while increasing working capital requirements. The combined result can lead to failure of an otherwise well-conceived operation because, sooner or later, either financial resources or regulatory agencies will limit the inventory of products and tires at a processing site.

Product Specifications

Time spent defining product specifications and processing requirements before investment decisions generally saves money in implementation and minimizes subsequent, expensive changes. Equipment that may be appropriate for one application can be technically or economically unsuitable for another. Considering the evolutionary stages for markets and products can improve the probability that initial equipment purchases will have the flexibility to serve future needs. Properly evaluating product volumes, specifications, and timing are probably the most critical, and commonly ignored, steps in establishing a successful processing operation.

Product Pricing

Apparent scrap tire product pricing may be lower in practice for these important reasons:

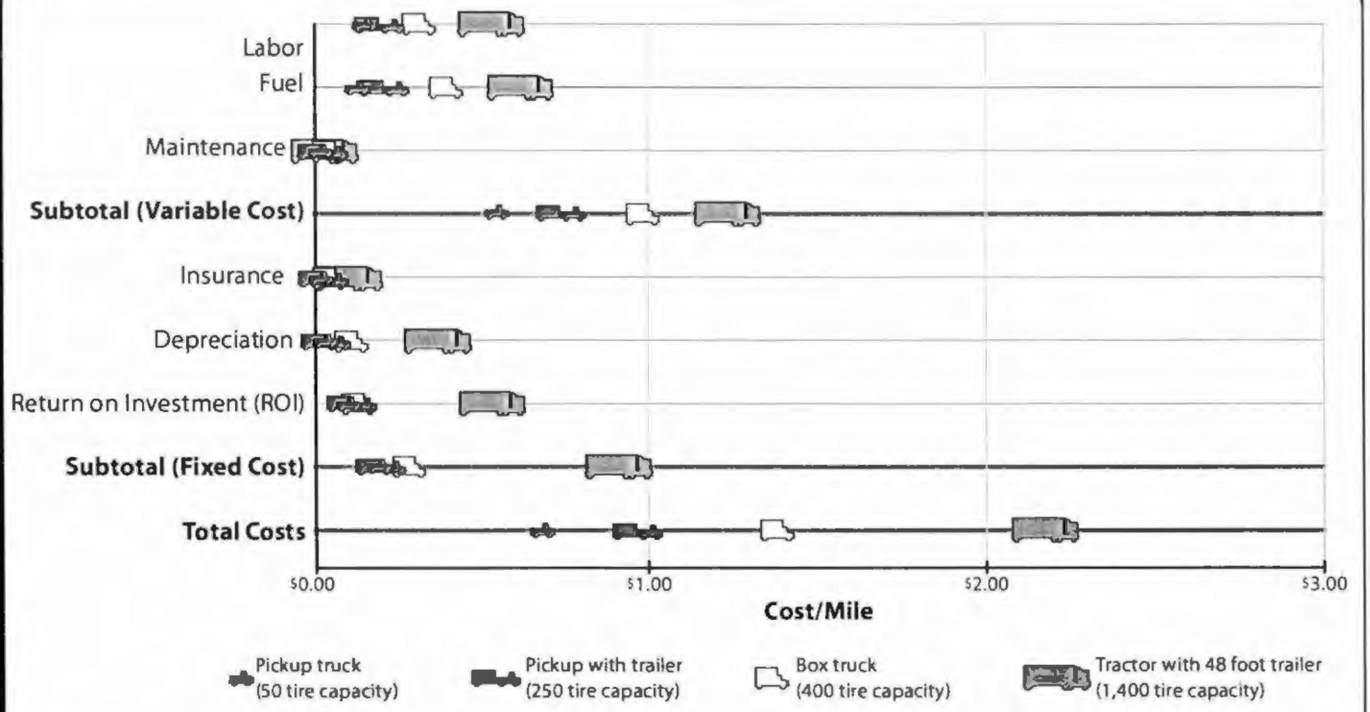


Exhibit 6-1. Capital and Operating Cost Comparison (Cost/Mile)
(See Appendix F for specific data)

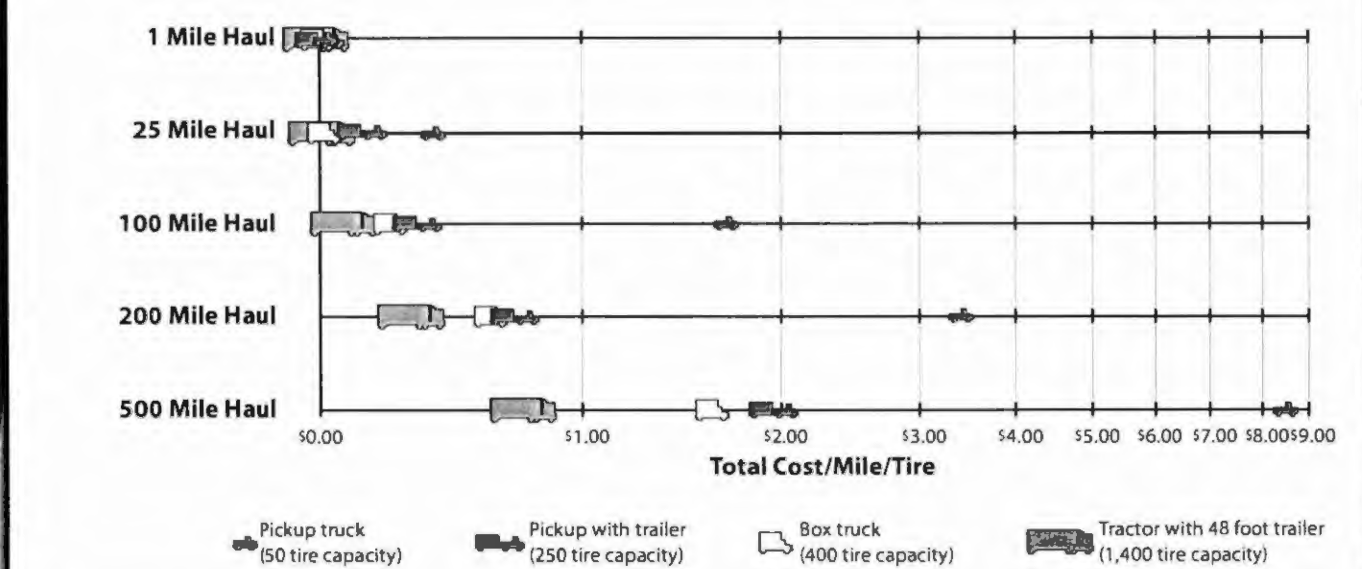


Exhibit 6-2. Hauling Efficiency (Cost/Mile/Tire)
(See Appendix F for specific data)

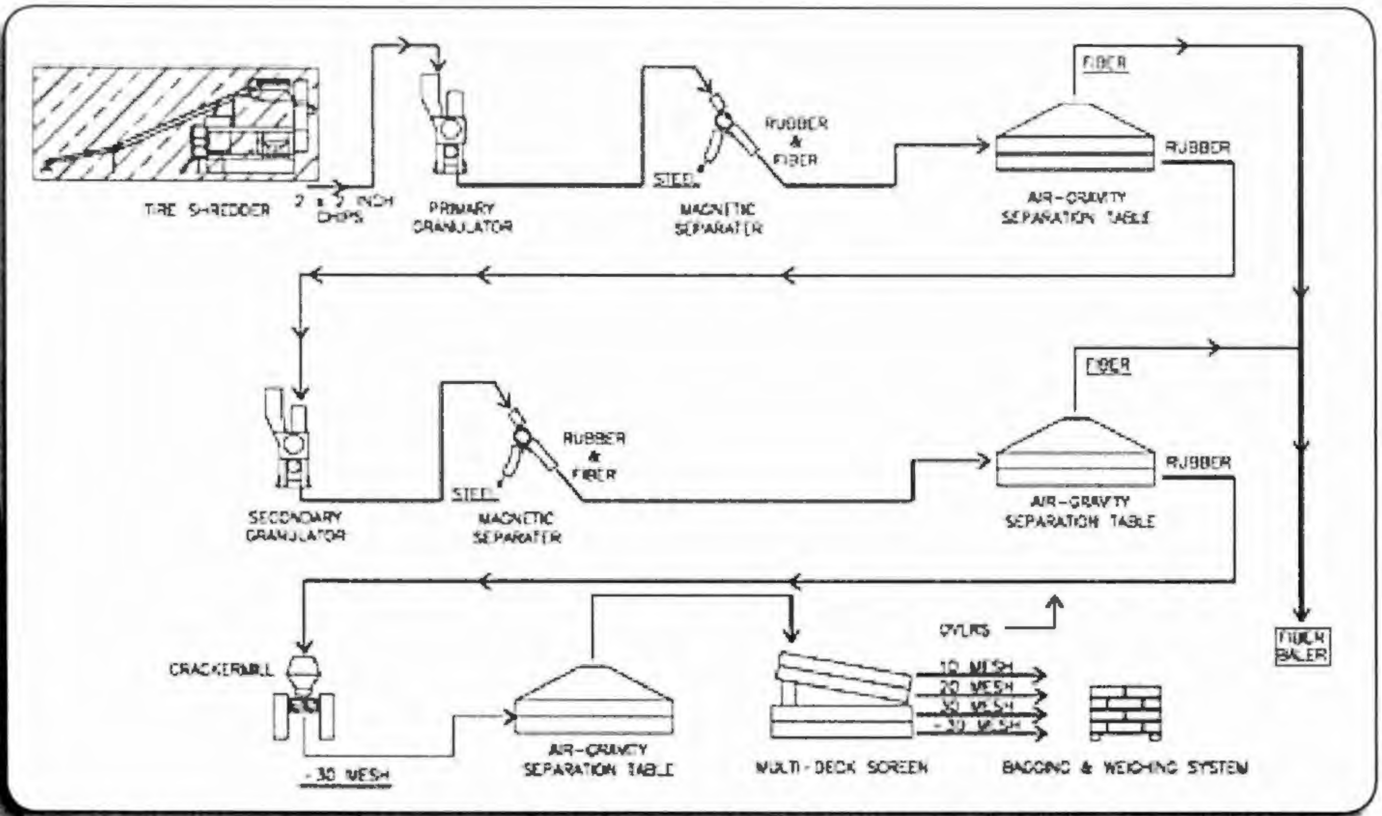


Exhibit 6-4. Schematic representation
Source: Columbus McKinnon Corporation

with other feedstock or additional processing to reduce rubber contamination or increase its density. The fabric has limited use as a fuel in cement kilns.

SUMMARY

There are many critical components to the successful implementation of a scrap tire management program. Transportation, tire processing, and market potential are three key factors to consider before implementation. Attention to travel distance, volume and frequency of tire collection, loading techniques, and other aspects can help lead to optimal equipment usage and ultimately achieving an economically sound transportation and tire collection program. Additional thorough understanding of the markets, specifications, pricing, and raw material availability for scrap tire processing can prevent letdowns similar to those seen by prior U.S. processors. The success or failure of new and established programs may also be affected by variables such maintenance, personnel, and administrative duties. Experiences of attempted and established programs in the U.S. can serve as valuable lessons learned for potential programs in Mexico.

APPENDIX F

Comparative Transportation Cost Example

	Vehicle Type			
	Pickup Truck		**Pickup with Trailer**	
	Basis	**Cost/mile**	**Basis**	**Cost/mile**
Labor ($/hr)	$10/hour, 30 miles/hour	$0.33	$10/hour, 30 miles/hour	$0.33
Fuel ($/mile)	$4.00/gallon, 15 miles/gallon	$0.27	$4.00/gallon, 12 miles/gallon	$0.33
Maintenance($/mile)	$1000/yr, 30,000 miles/yr	$0.03	$2000/yr, 30,000 miles/yr	$0.07
Subtotal-Variable Cost		$0.63		$0.73
Insurance	$1000/yr, 30,000 miles/yr	$0.03	$1000/yr, 30,000 miles/yr	$0.03
Depreciation	$2500/yr, 30,000 miles/yr	$0.08	$2500/yr, 30,000 miles/yr	$0.08
ROI	$15,000x20%= $3,000/yr	$0.10	$18000x20%= $3600/yr	$0.12
Subtotal-Fixed Cost		$0.22		$0.24
Total costs		$0.85		$0.97
Tires/load		50		250
Cost/mile/tire	for 1 mile	$0.02	for 1 mile	$0.004
	for 25 miles	$0.43	for 25 miles	$0.10
	for 100 miles	$1.70	for 100 miles	$0.39
	for 200 miles	$3.40	for 200 miles	$0.78
	for 500 miles	$8.50	for 500 miles	$1.94
	Box Truck		**Tractor with 48 foot trailer**	
	Basis	**Cost/mile**	**Basis**	**Cost/mile**
Labor ($/hr)	$12/hour, 30 miles/hour	$0.40	$15/hour, 30 miles/hour	$0.50
Fuel ($/mile)	$4.00/gallon, 8 miles/gallon	$0.50	$4.00/gallon, 6 miles/gallon	$0.67
Maintenance($/mile)	$2500/yr, 30,000 miles/yr	$0.08	$3500/yr, 30,000 miles/yr	$0.12
Subtotal-Variable Cost		$0.98		$1.28
Insurance	$2000/yr, 30,000 miles/yr	$0.07	$3000/yr, 30,000 miles/yr	$0.07
Depreciation	$3500/yr, 30,000 miles/yr	$0.12	$10000/yr, 30,000 miles/yr	$0.33
ROI	$25000x20%= $5000/yr	$0.17	$80000x20%= $16000/yr	$0.53
Subtotal-Fixed Cost		$0.35		$0.93
Total costs		$1.33		$2.22
Tires/load		400		1,400
Cost/mile/tire	for 1 mile	$0.003	for 1 mile	$0.002
	for 25 miles	$0.08	for 25 miles	$0.04
	for 100 miles	$0.33	for 100 miles	$0.16
	for 200 miles	$0.67	for 200 miles	$0.32
	for 500 miles	$1.67	for 500 miles	$0.79

EAST RIVER ROAD OR SECONDARY 540 IN PARK COUNTY

CRASH NUMBER	DATE	LOCATION	
50049663	6/8/2013	East River Road & Chico Road	SUV
50050935	9/5/2013	1755 East River Road	Passenger Car
50047464	7/20/2013	2654 East River Road	SUV
50053519	10/12/2013	East River Road & Chico Road	SUV
50056726	10/18/2013	East River Road-mile marker 17 –	Single SUV, daylight, road was ice/frost, vehicle overturned
50039917	6/29/2012	2099 East River Road	Motorcycle
50039127	6/28/2012	2364 East River Road	Pickup
50044061	8/28/2012	2504 East River Road	Pickup
50039118	4/12/2012	2912 East River Road	SUV
50037651	3/6/2012	3095 East River Road	Passenger Car
50043575	8/8/2012	425 East River Road	Motorcycle
50038216	5/13/2012	East River Road- mile marker 10	Pickup
50045385	12/24/2012	East River Road – mile marker 32	SUV
50042330	8/11/2012	East River Road – mile marker 1	Pickup
50042999	10/14/2012	East River Road – mile marker 18.1	SUV
50042992	8/15/2012	East River Road – mile marker 30	Passenger Car & SUV
50038208	2/3/2012	East River Road – mile marker 6	Pickup
50042240	8/29/2012	East River Road – mile marker 22.9	Freightliner CMV
50031175	9/9/2011	1903 East River Road	ATV
50034157	11/21/2011	2063 East River Road	Pickup
50029228	9/7/2011	2681 East River Road	Pickup
50026804	2/20/2011	2911 Secondary Route 540	Passenger Car
50035228	11/17/2011	3013 East River Road	SUV
50026243	2/5/2011	East River Road & Pray Road	SUV
50027681	1/29/2011	East River Road – mile marker 28	Passenger Car
50035348	12/14/2011	East River Road – mile marker 13	SUV

ATTACHMENT 9-B

ATTACHMENT 10-A
3 pages

United States
Environmental Protection
Agency

Solid Waste and
Emergency Response
(5305W)

EPA-530-B-99-002
August 1999
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EPA

State Scrap Tire Programs

A Quick Reference Guide: 1999 Update





Printed on paper that contains at least 30 percent postconsumer fiber

INTRODUCTION

Scrap tire management has been a serious concern over the past decade. Although great strides have been made in reducing the size and quantity of scrap tire stockpiles, at least 800 million scrap tires remain in stockpiles across the country. Many of the stockpiles continue to receive more scrap tires each year. (See Tables 1 and 2, p. ii, for further information on scrap tire generation.) In addition, in 1996, approximately 266 million scrap tires were generated in the United States. Since the first scrap tire law was passed in 1985, 49 out of 50 States have addressed scrap tire management through specific scrap tire laws and regulations or through State solid waste or transportation legislation.

The Scrap Tire Management Council estimates that, in 1996, of the 266 million scrap tires generated in the United States, approximately 24.5 million were recycled for purposes such as ground rubber in products and asphalt highways, stamped products, and agricultural and miscellaneous uses. An additional 10 million were beneficially used in civil engineering projects. These civil engineering uses are presented separately from the recycling figure because, although some are recycled into products such as artificial reefs or septic system drain fields, many are used in landfill construction and operation. In addition, 152.5 million were combusted for energy recovery, and 15 million were exported. The remaining 64 million were landfilled or disposed of in either legal or illegal stockpiles.

The following information summarizes each State's scrap tire management legislation and programs in a matrix for each State program. It is intended to provide State regulators, as well as members of industry, with a quick reference on State scrap tire programs across the country.

The matrix for each State program contains eight sections. The "State Contact" section provides the name, address, phone number, and fax number of the scrap tire program manager for the State; websites and e-mail information are given when available. The "Legislation and Regulations" section briefly outlines the history of scrap tire legislation for the State. The "Funding Sources/Fees" section addresses the State funds and collection fees authorized by the State. The "Collector, Seller, and Hauler Regulations" section summarizes the regulations that apply to these entities. Similarly, the "Storage and Processor Regulations" and the "Disposal Restrictions" sections outline relevant regulatory requirements. The "Financial/Market Incentives" section discusses grants and other programs that foster better scrap tire disposal/recycling waste management and reduction. The "Additional Information" section provides information about activities of interest related to scrap tires in a particular State, such as special field tests or studies, and innovative uses for scrap tires.

For the information contained in this publication, *State Scrap Tire Programs: A Quick Reference Guide*, the U.S. Environmental Protection Agency (EPA) contacted all States for the latest information (as of April 1998) on their programs. Overall figures for the information in this "Introduction" are based on estimates in the Scrap Tire Management Council's *Scrap Tire Use/Disposal Study, 1996 Update*, April 1997.

For further information on scrap tire management, contact the EPA Resource Conservation and Recovery Act (RCRA)/Superfund Hotline, Monday through Friday, 9:00 a.m. to 6:00 p.m.

Eastern Standard Time (EST). The national toll-free number is 800-424-9346. For the hearing-impaired, the number is TDD 800-553-7672. A document on scrap tire management, *Summary of Markets for Scrap Tires*, (Document No.: EPA/530-SW-90-074B, published October 1991), is available through the hotline or by writing: RCRA Information Center, U.S. Environmental Protection Agency, Office of Solid Waste (5305W), 401 M Street SW, Washington, DC 20460. The full report, *Markets for Scrap Tires* (PB92115252), is available for $31.50 (subject to change) from the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161, 703-487-4600.

Table 1
Scrap Tire Generation: 1996

Passenger replacement[a]	175,328,000
Light truck replacement[a]	27,605,000
Medium, wide base, heavy & large off-the-road[a]	11,139,000
Farm[a]	2,460,000
Tires from scrapped vehicles[b]	49,476,000
Total Scrapped Tires	**266,008,000**
U.S. Population	265,100,000
Rate of Scrappage	1.00 per person

[a] Figures from *Tire Industry Facts 1996*, Rubber Manufacturers Association (in preparation).
[b] Estimates based on four tires per scrapped vehicle. Vehicle estimates for 1994 from the *Statistical Abstract of the United States*, U.S. Department of Commerce.

Source: Scrap Tire Management Council. 1997. *Scrap Tire Use/Disposal Study, 1996 Update*, Washington, DC

Table 2
Estimated Destination for Scrap Tires in 1996

Destination		Percent of Generation
Recycled		
Crumb Rubber	12.5	
Cut/Stamped/Punched Products	8.0	
Agricultural Uses	2.5	
Miscellaneous Uses	1.5	
Total Recycled	24.5 million	9%[a]
Beneficially Used in Civil Engineering	10 million	4%[a]
Combusted for Energy Recovery	152.5 million	57%[a]
Exported	15 million	6%[a]
Landfilled, stockpiled, or illegally dumped	64 million	24%
TOTAL GENERATED	266 million scrap tires	100%

[a] 202 million scrap tires, or 76% of the scrap tires generated in 1996, had markets. Adapted from Scrap Tire Management Council, 1997. *Scrap Tire Use/Disposal Study, 1996 Update*, Washington, DC.

ATTACHMENT 10-A.1
2 pages

Wastes - Resource Conservation - Common Wastes & Materials - Scrap Tires

Basic Information

Markets and Uses for Scrap Tires | Landfill Disposal | Stockpiles and Illegal Dumping | Scrap Tire Cleanup Guide | State and Local Governments | Health and Environmental Concerns

At the end of 2003, the US generated approximately 290 million scrap tires. Historically, these scrap tires took up space in landfills or provided breeding grounds for mosquitoes and rodents when stockpiled or illegally dumped. Fortunately, markets now exist for 80.4% of these scrap tires-up from 17% in 1990. These markets—both recycling and beneficial use—continue to grow. The remaining scrap tires are still stockpiled or landfilled, however.

In 2003, markets for scrap tires were consuming 233 million, or 80.4%, of the 290 million annually generated scrap tires:

- 130 million (44.7%) are used as fuel
- 56 million (19.4%) are recycled or used in civil engineering projects
- 18 million (7.8%) are converted into ground rubber and recycled into products
- 12 million (4.3%) are converted into ground rubber and used in rubber-modified asphalt
- 9 million (3.1%) are exported*
- 6.5 million (2.0 %) are recycled into cut/stamped/punched products
- 3 million (1.7%) are used in agricultural and miscellaneous uses

Another 16.5 million scrap tires are retreaded. After any retreading has been performed, 290 million scrap tires are generated. About 27 million scrap tires (9.3%) are estimated to be disposed of in landfills or monofills. *(Source: Rubber Manufacturers Association, 2004.)*

Scrap Tire Promotional Video

- Tire-Derived Aggregate in Civil Engineering Applications (MP4) (5.45 min, 81MB) | en Español
- Video plays on the QuickTime Player and requires you to have the QuickTime Player Plug-in EXIT Disclaimer
- **NOTE:** Download time for the video may vary depending on the speed of your web connection and other factors.
- To request a DVD of the full-length, 45-minute video, contact Mark Schuknecht, 703-308-7294

*Many scrap tires are exported to foreign countries to be reused as retreads, especially in countries with growing populations of automobile drivers such as Japan and Mexico. According to Mexico's National Association of Tire Distributors, as many as 20% of tires sold in Mexico are imported as used tires from the US and then retreaded for reuse. Some foreign countries also import tires to be shredded and used as crumb rubber, or to be used as fuel. Unfortunately, not all exported tires are reused or recycled. The downside of exporting scrap tires is that the receiving countries may end up with a disproportionate amount of tires, in addition to their own internally-generated scrap tires.

Markets and Uses for Scrap Tires

Scrap tires are used in a number of productive and environmentally safe applications. From 1990 through 2003, the total number of scrap tires going to market increased from 11 million (24.5%) of the 223 million generated to 233 million (80.4%) of the 290 million generated.

"Over 75% of scrap tires are recycled or are beneficially used for fuel or other applications." **- Rubber**

The three largest scrap tire markets are:

- Tire-derived fuel
- Civil engineering applications
- Ground rubber applications/rubberized asphalt

Manufacturers Association, 2003

Many uses have been found for recycled tires including whole tires, tires chips, shredded tires, and ground rubber. Retreading also saves millions of scrap tires from being disposed of as scrap each year.

More information on scrap tire markets and uses.

Landfill Disposal

Even with all of the reuse and recycling efforts, almost one quarter of scrap tires end up in landfills each year. Landfilling scrap tires can cause problems due to their uneven settlement and tendency to rise to the surface, which can harm landfill covers. To minimize these problems, many states require chipping or grinding of tires prior to disposal. Sometimes scrap tires are also incorporated into the landfill itself as part of daily cover, or in a landfill cap.

In recent years, the placement of shredded scrap tires in monofills—a landfill, or portion of a landfill, that is dedicated to one type of material—has become more common. Monofills may be used where no other markets are available and municipal solid waste landfills do not accept tires. Monofills are preferable to above ground storage of tires in piles, due to fire hazards and human health hazards.

State landfill regulations:

- 38 states ban whole tires from landfills.
- 35 states allow shredded tires to be placed in landfills.
- 11 states ban all tires from landfills.
- 17 states allow processed tires to be placed into monofills.
- 8 states have no restrictions on placing scrap tires in landfills.

Source: Rubber Manufacturers Association, 2003

Stockpiles and Illegal Dumping

In 1994, the estimated number of scrap tires in stockpiles in the US was 700 to 800 million. Since that time, millions of tires have been removed from stockpiles primarily due to aggressive cleanup through state scrap tire management programs. 275 million tires were estimated to be in stockpiles *(Source: Rubber Manufacturers Association, 2004.)*

Tire Stockpiles

- A tire's physical structure, durability, and heat-retaining characteristics make these stockpiles a potential threat to human health and the environment. The curved shape of a tire allows rainwater to collect and creates an ideal habitat for rodents and mosquitoes.
- Prone to heat retention, tires in stockpiles also can ignite, creating tire fires that are difficult to extinguish and can burn for months, generating unhealthy smoke and toxic oils. Illegal tire dumping pollutes ravines, woods, deserts, and empty lots. For these reasons, most states have passed scrap tire regulations requiring proper management.

Scrap Tire Cleanup Guidebook

To help state and local governments reduce the economic burdens and environmental risks associated with scrap tire piles on their landscapes, US EPA Region 5 and Illinois EPA, with input from members of the national Scrap Tire Workgroup, have collaborated to create the Scrap Tire Cleanup Guidebook. The guidebook brings together the experience of dozens of professionals in one resource designed to provide state and local officials with the information needed to effectively clean up scrap tire piles. The

ATTACHMENT 10-B
25 pages

APPENDIX A

TDA Material Specifications

TDA, GENERAL

The material shall be made from scrap tires which shall be shredded into the sizes specified herein. They shall be produced by a shearing process. TDA produced by a hammer mill will not be allowed. The TDA shall be free of all contaminants such as oil, grease, gasoline, diesel fuel, etc., that could leach into the groundwater or create a fire hazard. In no case shall the TDA contain the remains of tires that have been subjected to a fire because the heat of a fire may liberate liquid petroleum products from the tire that could create a fire hazard when the shreds are placed in a fill. The TDA shall be free from fragments of wood, wood chips, and other fibrous organic matter. The TDA shall have less than 1 percent (by weight) of metal fragments that are not at least partially encased in rubber. Metal fragments that are partially encased in rubber shall protrude no more than 25 mm (1 inch) from the cut edge of the TDA on 75 percent of the pieces (by weight) and no more than 50 mm (2 inch) on 90 percent of the pieces (by weight). The gradation shall be measured in accordance with C136-05 (also designated AASHTO T-27), "Standard Method for Sieve Analysis of Fine and Coarse Aggregate," except that the minimum sample size shall be 6 to 12 kg (15 to 25 lbs) for Type A TDA and 16 to 23 kg (35 to 50 pounds) for Type B TDA.

TDA, TYPE A

Type A TDA shall have a maximum dimension, measured in any direction, of 203 mm (8 inch). In addition, Type A TDA shall have 100 percent passing the 102 mm (4 inch) square mesh sieve, a minimum of 95 percent passing (by weight) the 75 mm (3 inch) square mesh sieve, a maximum of 50 percent passing (by weight) the 38 mm (1.5 inch) square mesh sieve, and a maximum of 5 percent passing (by weight) the No. 4 sieve.

TDA, TYPE B

A minimum of 90 percent (by weight) shall have a maximum dimension, measured in any direction, of 300 mm (12 inch) and 100 percent shall have a maximum dimension, measured in any direction, of 450 mm (18 inch). At least one side wall shall be severed from the tread of each tire. A minimum of 75 percent (by weight) shall pass the 203 mm (8 inch) square mesh sieve, a maximum of 50 percent (by weight) shall pass the 76 mm (3-inch) square mesh sieve, a maximum of 25 percent (by weight) shall pass the 38 mm (1.5-inch) square mesh sieve, and a maximum of 1 percent (by weight) shall pass the No. 4 sieve (4.75 mm; 0.187 inch).

APPENDIX B

Design Guidelines to Minimize Internal Heating of Tire Shred Fills

(JULY 1997; REVISED 2003)

BACKGROUND

Since 1988 more than 70 tire shred fills with a thickness less than 1 m and an additional ten fills less than 4 m thick have been constructed. In 1995 three tire shred fills with a thickness greater than 8 m experienced a catastrophic internal heating reaction. These unfavorable experiences have curtailed the use of all tire shred fills on highway projects.

Possible causes of the reaction are oxidation of the exposed steel belts and oxidation of the rubber. Microbes may have played a role in both reactions. Although details of the reaction are under study, the following factors are thought to create conditions favorable for oxidation of exposed steel and/or rubber: free access to air; free access to water; retention of heat caused by the high insulating value of tire shreds in combination with a large fill thickness; large amounts of exposed steel belts; smaller tire shred sizes and excessive amounts of granulated rubber particles; and the presence of inorganic and organic nutrients that would enhance microbial action.

The design guidelines given in the following sections were developed to minimize the possibility for heating of tire shred fills by minimizing the conditions favorable for this reaction. As more is learned about the causes of the reaction, it may be possible to ease some of the guidelines. In developing these guidelines, the insulating effect caused by increasing fill thickness and the favorable performance of projects with tire shred fills less than 4 m thick were considered. Thus, design guidelines are less stringent for projects with thinner tire shred layers. The guidelines are divided into two classes: Class I Fills with tire shred layers less than 1 m thick and Class II Fills with tire shred layers in the range of 1 m to 3 m thick. Although there have been no projects with less than 4 m of tire shred fill that have experienced a catastrophic heating reaction, to be conser¬vative, tire shred layers greater than 3 m thick are not recommended.

In addition to the guidelines given below, the designer must choose the maximum tire shred size, thickness of overlying soil cover to address pavement structural concerns, etc., to meet the requirements imposed by the engineering performance of the project. The guidelines are for use in designing tire shred monofills. Design of fills that are mixtures or alternating layers of tire shreds and mineral soil that is free from organic matter should be handled on a case by case basis.

GENERAL GUIDELINES FOR ALL TIRE SHRED FILLS

All tires shall be shredded such that the largest shred is either: (1) no greater than 0.6 m in any direction measured, or (2) no more than one-quarter of the circumference of the tire, whichever is less. At least one sidewall shall be severed from the tire shred.

The tire shreds shall be free of all contaminates such as oil, grease, gasoline, diesel fuel, etc., that could create a fire hazard. In no case shall the tire shreds contain the remains of tires that have been subjected to a fire because the heat of a fire may liberate liquid petroleum products from the tire that could create a fire hazard when the shreds are placed in a fill.

CLASS I FILLS

Material Guidelines

The tire shreds shall have a maximum of 50 percent (by weight) passing the 38-mm sieve and a maximum of 5 percent (by weight) passing the 4.75-mm sieve.

Design Guidelines

No design features are required to minimize heating of Class I Fills.

CLASS II FILLS

Material Guidelines

The tire shreds shall have a maximum of 25 percent (by weight) passing the 38-mm sieve and a maximum of 1 percent (by weight) passing the 4.75-mm sieve.

The tire shreds shall be free from fragments of wood, wood chips, and other fibrous organic matter. The tire shreds shall have less than 1 percent (by weight) of metal fragments which are not at least partially encased in rubber. Metal fragments that are partially encased in rubber shall protrude no more than 25 mm from the cut edge of the tire shred on 75 percent of the pieces and no more than 50 mm on 100 percent of the pieces.

Design guidelines. The tire shred fill shall be constructed in such a way that infiltration of water and air is minimized. Moreover, there shall be no direct contact between tire shreds and soil containing organic matter, such as topsoil. One possible way to accomplish this is to cover the top and sides of the fill with a 0.5 m thick layer of compacted mineral soil with a minimum of 30 percent fines. The mineral soil should be free from organic matter and should be separated from the tire shreds with a geotextile. The top of the mineral soil layer should be sloped so that water will drain away from the tire shred fill. Additional fill may be placed on top of the mineral soil layer as needed to meet the overall design of the project. If the project will be paved, it is recommended that the pavement extend to the shoulder of the embankment or that other measures be taken to minimize infiltration at the edge of the pavement.

Use of drainage features located at the bottom of the fill that could provide free access to air should be avoided. This includes, but is not limited to, open graded drainage layers daylighting on the side of the fill and drainage holes in walls. Under some conditions, it may be possible to use a well graded granular soil as a drainage layer. The thickness of the drainage layer at the point where it daylights on the side of the fill should be minimized. For tire shred fills placed against walls, it is recommended that the drainage holes in the wall be covered with well graded granular soil. The granular soil should be separated from the tire shreds with geotextile.

GENERAL GUIDELINES FOR ALL TIRE SHRED FILLS (July 1997; revised 2003)

All tires shall be shredded such that the largest shred is either: (1) no greater than 0.6 m in any direction measured, or (2) no more than one-quarter of the circumference of the tire, whichever is less. At least one sidewall shall be severed from the tire shred.
Tire shreds shall be free of contaminates such as oil, grease, gasoline, diesel fuel, etc., that could create a fire hazard
In no case shall the tire shreds contain the remains of tires that have been subjected to a fire

CLASS I FILLS (< 1 m thick)
Maximum of 50 percent (by weight) passing 38-mm sieve
Maximum of 5 percent (by weight) passing 4.75-mm sieve

CLASS II FILLS (1-3 m thick)
Maximum of 25 percent (by weight) passing 38-mm sieve
Maximum of 50 percent (by weight) passing 50-mm sieve
Maximum of 1 percent (by weight) passing 4.75-mm sieve
Tire shreds shall be free from fragments of wood, wood chips, and other fibrous organic matter
The tire shreds shall have less than 1 percent (by weight) of metal fragments that are not at least partially encased in rubber
Metal fragments that are partially encased in rubber shall protrude no more than 25 mm from the cut edge of the tire shred on 75 percent of the pieces by weight and no more than 50 mm on 90 percent of the pieces by weight
Infiltration of water and air into the tire shred fill shall be minimized
No direct contact between tire shreds and soil containing organic matter, such as topsoil
Tire shreds should be separated from the surrounding soil with a geotextile
Use of drainage features located at the bottom of the fill that could provide free access to air should be avoided

APPENDIX C
Engineering Properties of TDA

Selected engineering properties of tire derived aggregate (TDA) are presented in this appendix. This information includes gradation, compacted unit weight, compressibility, time-dependent settlement, and shear strength.

GRADATION

Large pieces are desirable when the TDA zone is more than 1 m (3.3 feet) thick because they are less susceptible to self-heating (as discussed in Appendix B). However, when the TDA contain a significant number of pieces larger than 300 mm (12 inches), they tend to be difficult to spread in a uniform lift thickness. Thus, a typical specification requires that a minimum of 90 percent (by weight) of the TDA have a maximum dimension, measured in any direction, of less than 300 mm (12 inches) and that 100 percent of the TDA have a maximum dimension less than 450 mm (18 inches). Moreover, at least 75 percent (by weight) must pass a 200-mm (8-inch) sieve and at least one sidewall must be severed from the tread of each tire. To minimize the quantity of small pieces, which can be susceptible to self-heating, the specifications require that no more than 50 percent (by weight) pass the 75-mm (3-inch) sieve, 25 percent (by weight) pass the 38-mm (1.5-inch) sieve, and no more than 1 percent (by weight) pass the No. 4 (4.75-mm) sieve. Pieces of this size are commonly referred to as Type B TDA. When samples are collected for gradation analysis, they should be collected directly from the discharge conveyor of the processing machine. This procedure ensures that the minus No. 4 fraction will be representative, which is not the case when samples are collected by shoveling pieces from a stockpile. TDA that meets the size requirements given above generally have a uniform gradation. Typical results are shown in Exhibit C-1.

COMPACTED UNIT WEIGHT

The compacted unit weight of TDA has been investigated in the laboratory for pieces up to 75 mm (3 inches). These tests were generally done with 254-mm (10-inches) or 305-mm (12-inches) inside

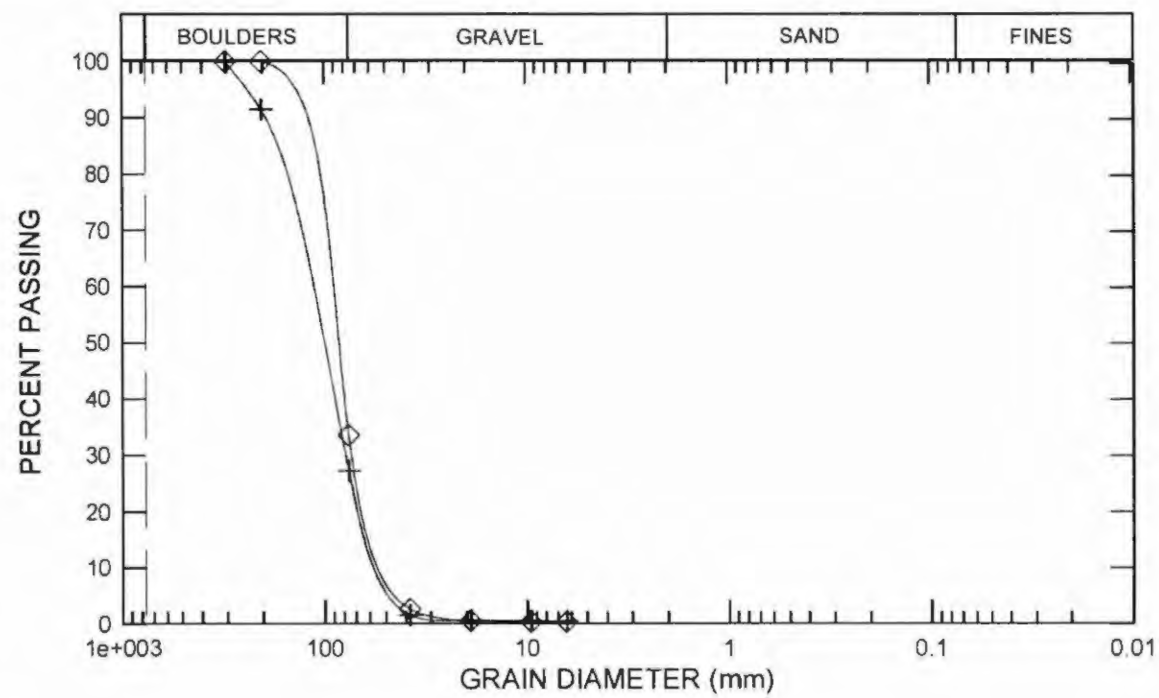

Exhibit C-1. Gradation of Type B TDA used as lightweight fill for Partland Jetport Interchange

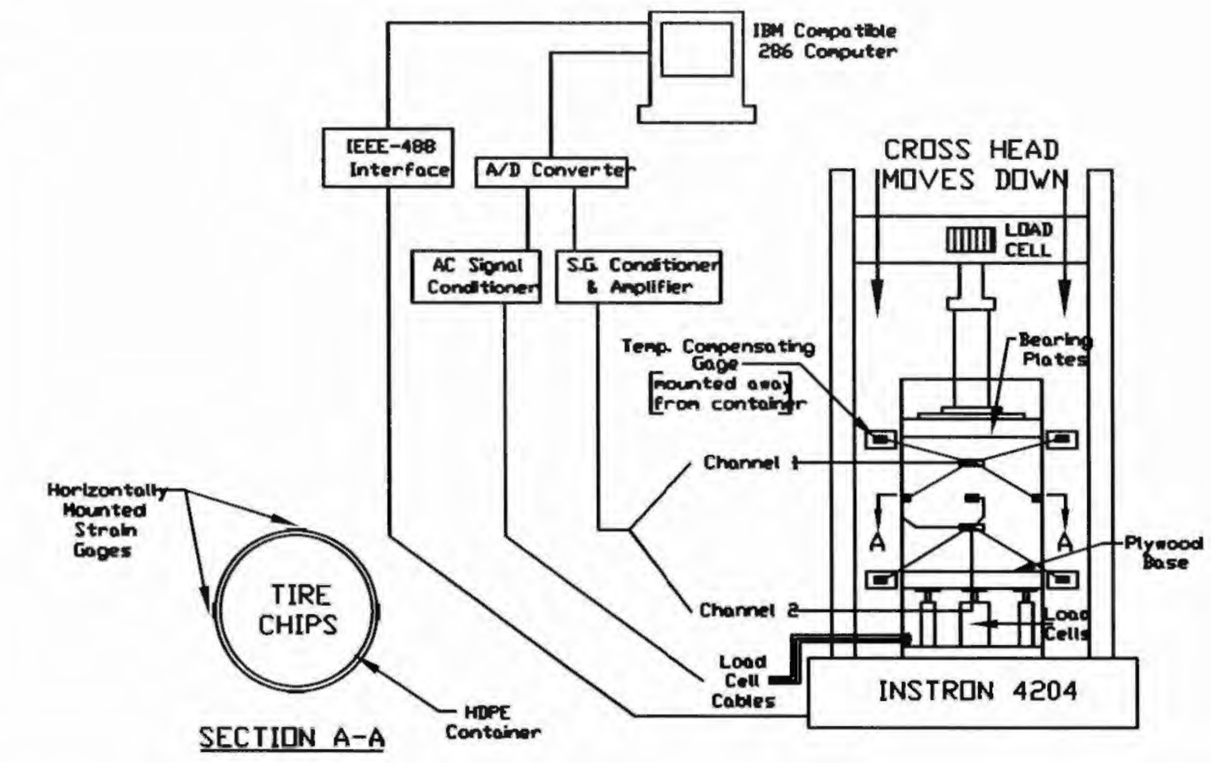

Exhibit C-2. Compressibility apparatus used by Nickels (Ref. 12)

meter compaction molds and impact compaction. Compacted dry unit weights ranged from 0.61 to 0.69 Mg/m3 (38 to 43 pcf) (Ref.1).

The effect of compaction energy and compaction water content was investigated. Increasing the compaction energy from 60 percent of standard Proctor to 100 percent of modified Proctor increased the compacted unit weight by only 0.02 Mg/m3 (1.2 pcf), showing that compaction energy has only a small effect on the resulting unit weight. Unit weights were about the same for air-dried samples and samples at saturated surface dry conditions (about 4 percent water content), indicating that water content has a negligible effect on unit weight (Refs. 7, 11). One significance of this finding is that there is no need to control moisture content of TDA during field placement.

Measuring the compacted unit weight of TDA with a 300-mm (12-inches) maximum size is impractical in the laboratory. However, results from a highway embankment constructed with large TDA suggest that the unit weight of 300-mm (12-inches) maximum size TDA is less than for 75-mm (3-inches) maximum size TDA (Ref. 10).

COMPRESSIBILITY

The compressibility of TDA with a 75 mm (3 inches) maximum size has been measured in the laboratory. An apparatus used by Nickels (Ref. 12) had a 356-mm (14-inches) inside diameter and could accommodate a sample up to 356-mm (14-inches) thick. One challenge to measuring the compressibility of TDA is friction between the TDA and the inside wall of the test container. The apparatus used by Nickels (Ref. 12) uses load cells to measure the load carried by the specimen both at the top and bottom of the sample, as shown in Exhibit C-2. Even though Nickels used grease to lubricate the inside of the container, up to 20 percent of the load applied to the top of the sample was transferred to the walls of the container by friction. Compressibility of TDA with a 75 mm (3 inches) maximum size is shown in Exhibit C-3. The initial unit weights ranged from 0.51 to 0.64 Mg/m3 (32.1 to 40.1 pcf). There is a general trend of decreasing compressibility with increasing initial unit weight. The results for tests MD1 and MD4 are most applicable to using TDA as lightweight fill since their initial unit weight is typical of field conditions. Compressibility for stresses up to 480 kiloPascals (kPa) (70 pounds per square inch [psi]) are given by Manion and Humphrey (Ref. 11) and Humphrey and Manion

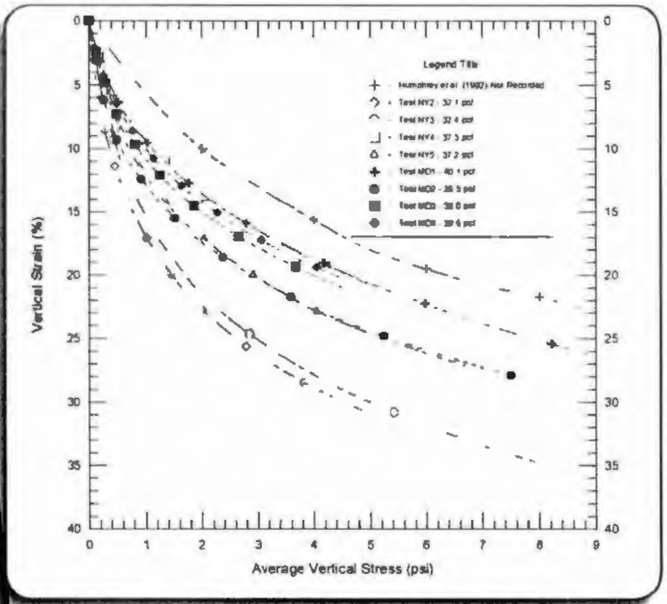

Exhibit C-3. Compressibility of TDA with a 3-inches (75-mm) maximum size (Ref. 12)

(Ref. 7). Laboratory data on the compressibility of TDA with a maximum size greater than 75 mm (3 inches) are not available; however, field measurements indicate that TDA with a 300-mm (12-inches) maximum size are less compressible than smaller TDA.

TIME-DEPENDENT SETTLEMENT

TDA exhibits a small amount of time-dependent settlement. Time-dependent settlement of thick TDA fills was measured by Tweedie and others (1997). Three types of TDA were tested with maximum sizes ranging from 38 to 75 mm (1.5 to 3 inches). The fill was 4.3 m (14 feet) thick

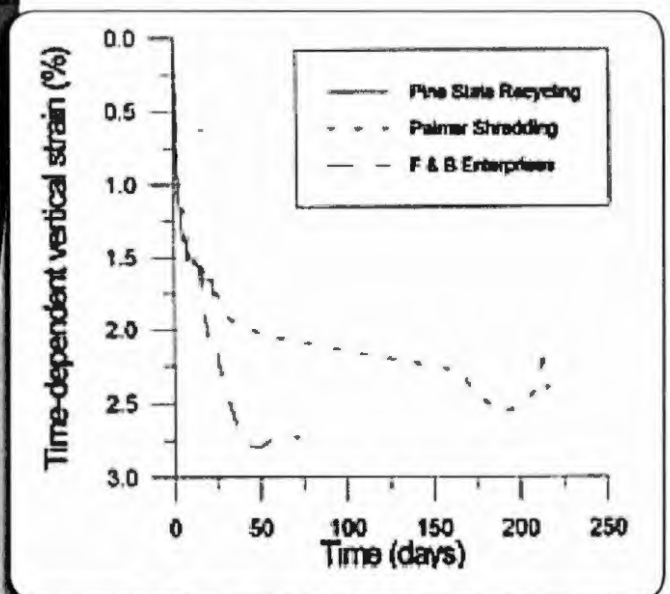

Exhibit C-4. Time-dependent settlement of TDA subjected to a surcharge of 750 psf (36 kPa) (Ref. 13)

and was surcharged with 36 kPa (750 psf), which is equivalent to about 1.8 m (6 feet) of soil. Vertical strain versus elapsed time is shown in Exhibit C-4. It is seen that time-dependent settlement occurred for about 2 months after the surcharge was placed. During the first 2 months, about 2 percent vertical strain occurred, which is equivalent to more than 75 mm (3 inches) of settlement for this 4.3-m (14-feet)-thick fill. The measurements are in general agreement with time-dependent laboratory compressibility tests conducted by Humphrey and others (Ref. 7). When TDA is used as backfill behind a pile supported bridge abutment or other structures that will experience little settlement, it is important to allow sufficient time for most of the time-dependent settlement of the TDA to occur before final grading and paving. Time-dependent settlement is of less concern when the ends of the TDA fill can be tapered from the full thickness to zero over a reasonable distance.

SHEAR STRENGTH

The shear strength of TDA has been measured using direct shear and triaxial shear apparatus. The large TDA typically used for civil engineering applications requires that specimen sizes be several times larger than are used for common soils. This method has generally been used for TDA 25 mm (1inch) in size and smaller because of the limited availability of large triaxial shear apparatus. Moreover, the triaxial shear apparatus is generally not suitable if steel belts protrude from the cut edge of the TDA since the wires puncture the membrane used to surround the specimen.

The shear strength of TDA has been measured using triaxial shear (Refs. 2, 3, 4, 8); and using direct shear (Refs.5, 6, 7, 8, 9). Failure envelopes determined from direct shear and triaxial tests for TDA with a maximum size ranging from 9.5 to 900 mm (0.37 to 35 inches) are shown in Exhibit C-5. Data from Gebhard and others (Ref. 6) on larger size TDA fall in the same range. Available data suggest that shear strength is not affected by TDA size. Moreover, results from triaxial and direct shear tests are similar. Overall, the failure envelopes appear to be concave down. Thus, best fit linear failure envelopes are applicable only over a limited range of stresses. Friction angles and cohesion intercepts for linear failure envelopes for the data shown in Exhibit C-5 are given in Table C-1. TDA requires sufficient deformation to mobilize its strength (Ref. 8). Thus, a conservative approach should be taken when choosing strength parameters for TDA embankments founded on sensitive clay foundations.

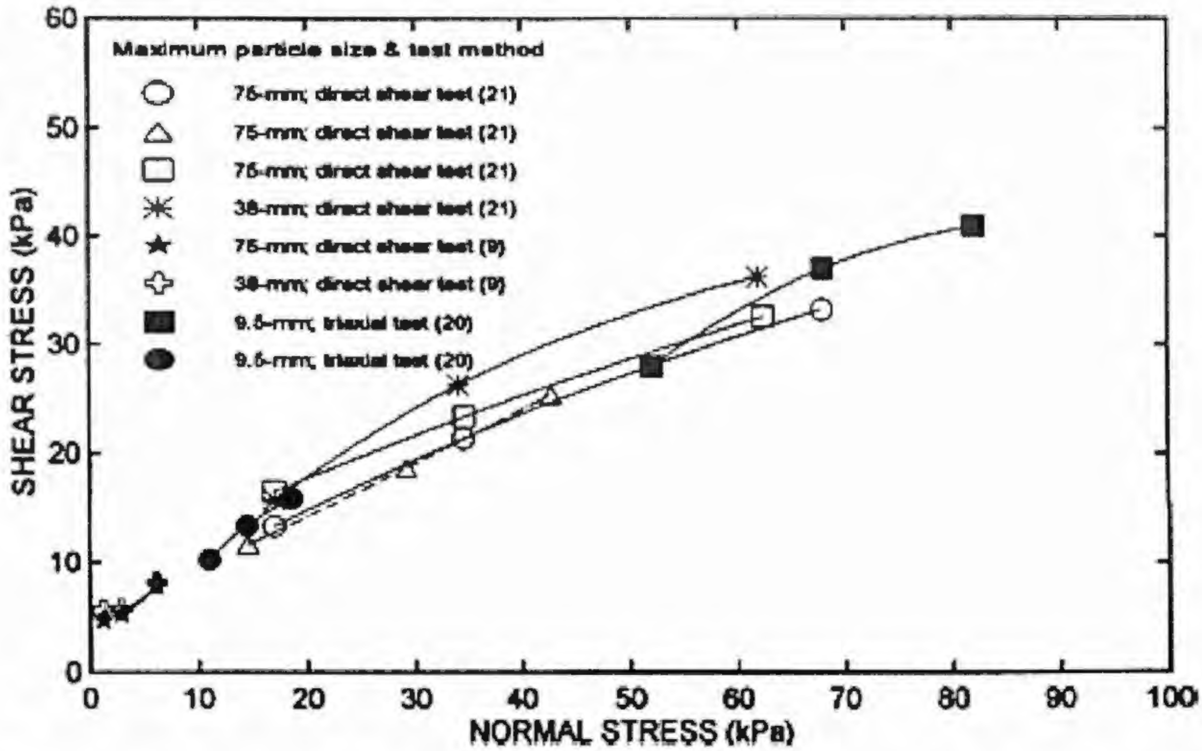

Exhibit C-5. Failure envelopes for TDA with maximum sizes ranging from 0.37 to 3 inches (9.5 to 75 mm)

Table C-1. Strength parameters for TDA.

Supplier	Maximum shred size		Test method	Applicable range of normal stress		Φ	Cohesion intercept	
	inches	mm		psf	kPa	deg.	psf	kPa
F&B	0.5	38	D.S.	360 to 1300	17 to 62	25	180	8.6
Palmer	3	75	D.S.	360 to 1300	17 to 62	19	240	11.5
Pine State	3	75	D.S.	360 to 1400	17 to 68	21	160	7.7
Pine State	3	75	D.S.	310 to 900	15 to 43	26	90	4.3
Dodger	35	900	D.S.	120 to 580	5.6 to 28	37	0	0
Unknown	0.37	9.5	Triaxial	1100 to 1700	52 to 82	24	120	6.0
Unknown	0.37	9.5	Triaxial	230 to 400	11 to 19	36	50	2.4

Note: D.S. = Direct Shear

References

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APPENDIX D

Calculation of Final In-Place Unit Weight and Overbuild

Final In-Place Unit Weight

The final in-place unit weight of the tire-derived aggregate (TDA) must be estimated during design. This unit weight is a necessary input for slope stability analysis and analysis of the stability of retaining walls. Estimation of the in-place unit weight must consider the immediate compression of the TDA under its self-weight and the weight of overlying soil and pavement. The calculation procedure is straightforward and is outlined below:

Step 1. From laboratory compaction tests or typical values, determine the initial uncompressed, compacted dry unit weight of TDA (γ_{di}) (for Type A TDA with a 75-mm [3-inches] maximum size, use 0.64 mg/m3 [40 pcf]).

Step 2. Estimate the in-place water content of TDA (w) and use the water content to determine the initial uncompressed, compacted total (moist) unit weight of TDA: $\gamma_{ti} = \gamma di\ (1+w)$. Unless better information is available, use w = 3 or 4 percent.

Step 3. Determine the vertical stress in center of TDA layer ($\sigma_{v\text{-}center}$). To calculate the vertical stress, hypothesize the compressed unit weight of TDA (γ_{tc}) (0.80 Mg/m^3 (50 pcf) is suggested for the first test).

$$\sigma_{v\ center} = t_{soil}(\gamma_{t\ soil}) + (t_{TDA}/2)(\gamma_{tc})$$

where: tsoil = thickness of overlying soil layer

$\gamma_{t\ soil}$ = total (moist) unit weight of overlying soil

t_{TDA} = compressed thickness of TDA layer *(Note: In the equation, the thickness of the TDA layer is divided by 2 since the stress in the center of the layer is being computed.)*

Step 4. Determine the percent compression (ε_v) using $\sigma_{v\text{-}cemer}$ and the measured laboratory compressibility of the TDA; for TDA with a 75-mm (3-inches) maximum size, use the results for test MD1 or MD4 in Exhibit D-1.

Step 5. Determine the compressed moist unit weight of the TDA: $\gamma_{tc} = \gamma_{ti}/(1\text{-}\varepsilon_v)$. If necessary, return to step 3 with a better estimate of the compressed moist unit weight.

This procedure was used to predict the compressed unit weight of a 4.3-m (14-feet) thick TDA fill covered by 1.8 m (6 feet) of soil built in Topsham, Maine. TDA with a 75-mm (3-inches) maximum size was used in the upper third of the fill, while TDA with a 150-mm (6-inches) maximum size was used in the lower part of the fill. The predicted compressed moist unit weight was 0.91 Mg/m3 (57 pcf). The actual in-place unit weight calculated from the final volume of the TDA zone and the weight of TDA delivered to the project was also 0.91 Mg/m3 (57 pcf). This validates the reliability of the laboratory compressibility tests and the procedure to estimate the compressed moist unit weight for TDA with maximum sizes between 75 and 150 mm (3 and 6 inches). However, when the procedure was applied to TDA with a 300-mm (12-inches) maximum size, the predicted unit weight was greater than determined in the field. For a highway embankment built in Portland, Maine, with TDA with a 300-mm (12-inches) maximum size, the predicted compressed moist unit weight was 0.93 Mg/m3 (58 pcf) compared with an actual unit weight of 0.79 Mg/m3 (49 pcf). The reasons for the difference appear to be a lower initial uncompressed unit weight and the lower compressibility for the larger TDA. It is recommended that the unit weight calculated using the procedure outlined above should be reduced by 15 percent for 300-mm (12-inches) maximum size TDA.

Calculation of Overbuild

TDA experiences immediate compression under an applied load, such as the weight of an overlying soil cover. The top elevation of the TDA layers should be overbuilt to compensate for this compression. The overbuild is determined using the procedure given below with the aid of a design chart (Exhibit D-2). The design chart was developed using a combination of laboratory compressibility tests and compression data measured from field projects. Exhibit D-2 is applicable to Type-B TDA (300-mm [12-inches] maximum size) that has been placed and compacted in 300-mm (12-inches)-thick layers. To use this procedure with smaller Type A TDA (3-inches maximum size), increase the calculated overbuild by 30 percent.

The overbuild for a single TDA layer is derived directly from Exhibit D-2. First, calculate the vertical stress that will be applied to the top of the TDA layer as the sum of the unit weights multiplied by the thicknesses of the overlying layers. Second, enter Exhibit D-2 with the calculated vertical stress and the final compressed thickness of the TDA layer to find the overbuild. Consider the following example:

0.229 m pavement at 2.56 Mg/m^3

0.610 m aggregate base at 2.00 Mg/m^3

0.610 m low permeability soil cover at 1.92 Mg/m^3

3.05-m (10 feet) thick TDA layer

The vertical stress applied to the top of the TDA layer would be:

(0.229 m x 2.56 Mg/m3 x 9.81 m/s2) + (0.610 m x 2.00 Mg/m3 x 9.81 m/s2) + (0.610 m x 1.92 Mg/m3 x 9.81 m/s2) = 29.1 kPa x 20.884 psf/kPa = 610 psf

Enter Exhibit D-2 with 610 psf (29.1 kPa) and using the line for a TDA layer thickness of 10 feet (3.05 m) results in an overbuild of 0.68 feet (0.21 m). Round to the nearest 0.1 m. Thus, an overbuild of 0.2 m is necessary.

The overbuild for the bottom TDA layer of a two-layer cross-section is also determined directly from Exhibit D-2. The procedure is the same as described above for a single TDA layer. Consider the following example:

0.229 m pavement at 2.56 Mg/m^3

0.610 m aggregate base at 2.00 Mg/m^3

0.610 m low permeability soil cover at 1.92 Mg/m^3

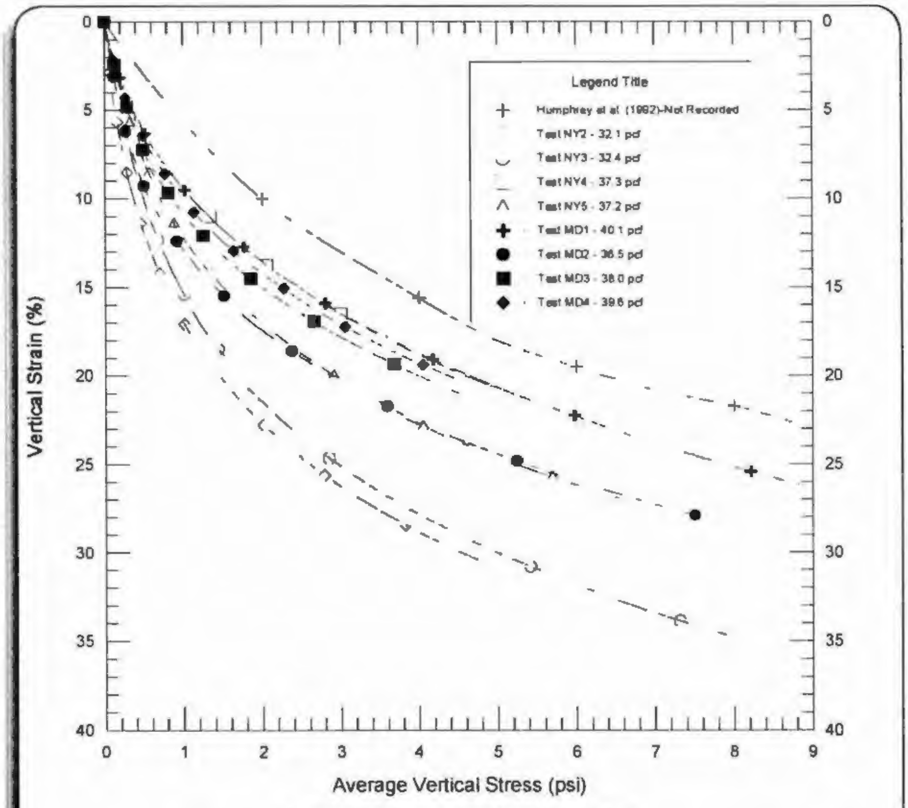
3.05-m (10 feet) thick TDA layer at 0.80 Mg/m^3

0.915 m soil separation layer at 1.92 Mg/m^3

3.05-m (10 feet) thick lower TDA layer

The vertical stress applied to the top of the TDA layer would be:

(0.229 m x 2.56 Mg/m^3 x 9.81 m/s2) + (0.610 m x 2.00 Mg/m^3 x 9.81 m/s^2) + (0.610 m x 1.92 Mg/m^3 x 9.81 m/s^2) + (3.05 m x 0.80 Mg/m3 x 9.81 m/s2) + (0.915 m x



(Note: 1 psi = 144 psf = 6.895 kPa)

Exhibit D-1. Compressibility of Type A TDA at low stresses (Ref. 1)

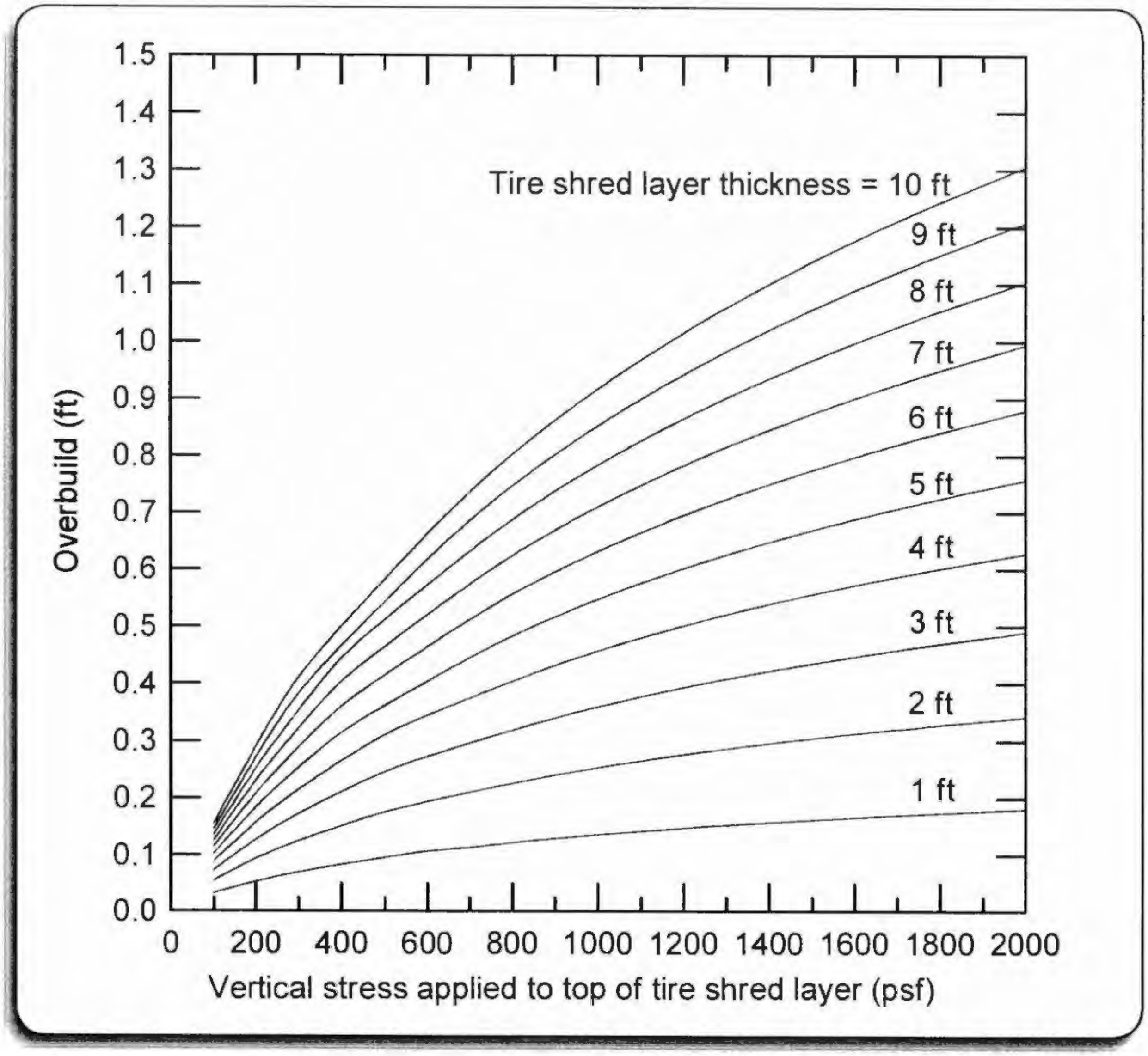


Exhibit D-2. Overbuild design chart for Type B TDA

1.92 Mg/m^3 x 9.81 m/s^2)= 70.4 kPa x 20.884 psf/kPa = 1,470 psf

Enter Exhibit D-2 with 1470 psf (70.4 kPa) and using the line for a TDA layer thickness of 10 feet (3.05 m) results in an overbuild of 1.13 feet (0.34 m). Round to the nearest 0.1 m. Thus, the use of a 0.3-m overbuild for the lower TDA layer is needed.

The overbuild of the top elevation for the upper TDA layer of a two-layer cross-section must include both the compression of the upper TDA layer when the pavement, base, and soil cover is placed, and the compression of the lower TDA layer that will still occur under the weight of these layers. In other words, the lower TDA layer has not yet compressed to its final thickness. This final compression will only occur once the embankment reaches final grade. Therefore, the question is, "How much compression of the lower TDA layer will occur due to placing the pavement, base and soil cover?" Consider the same two-layer example used above.

0.229 m pavement at 2.56 Mg/m^3

0.610 m aggregate base at 2.00 Mg/m^3

0.610 m low permeability soil cover at 1.92 Mg/m^3

3.05-m (10 feet) thick TDA layer at 0.80 Mg/m^3

0.915 m soil separation layer at 1.92 Mg/m^3

3.05-m (10 feet) thick lower TDA layer

Step 1. The final vertical stress applied to the top of the upper TDA layer would be: (0.229 m x 2.56 Mg/m3 x 9.81 m/s2) + (0.610 m x 2.00 Mg/m3 x 9.81 m/s2) + (0.610 m x 1.92 Mg/m3 x 9.81 m/s2) = 29.1 kPa x 20.884 psf/kPa = 610 psf. Enter Exhibit D-2 with 610 psf (29.1 kPa) and using the line for a TDA layer thickness of 10 feet (3.05 m) results in a compression of 0.68 feet (0.21 m).

Step 2. Once the upper TDA layer (but not the top soil cover) is in place, the vertical stress applied to the top of the lower TDA layer would be: (3.05 m x 0.80 Mg/m^3 x 9.81 m/s2) + (0.915 m x 1.92 Mg/m^3 x 9.81 m/s^2) = 41.1 kPa x 20.884 psf/kPa = 860 psf. To determine the compression of the lower TDA layer that has occurred up to this point, enter Exhibit D-2 with 860 psf (41.1 kPa) and using the line for a TDA layer thickness of 10 feet (3.05 m) results in a compression of 0.84 feet (0.26 m).

Step 3. Once the embankment reaches its final grade, the vertical stress applied to the top of the lower TDA layer would be 70.4 kPa = 1470 psf, as calculated previously. Enter Exhibit D-2 with 1470 psf (70.4 kPa) and using the line for a TDA layer thickness of 10 feet (3.28 m) results in an overbuild of 1.13 feet (0.34 m). (Note: rounding to 0.3 m would give the overbuild of the lower TDA layer.)

Step 4. Subtract the result from Step 2 from the result of Step 3 to obtain the compression of the lower TDA layer which will occur when the pavement, base, and soil cover is placed: 0.34 m – 0.26 m = 0.08 m.

Step 5. Sum the results from Steps 1 and 4 to obtain the amount the top elevation of the upper TDA layer should be overbuilt. 0.21 m + 0.08 m = 0.29 m (0.95 feet). Round to the nearest 0.1 m. Thus, the elevation of the top of the upper TDA layer should be overbuilt by 0.3 m.

Final result: Overbuild the top elevation of the lower TDA layer by 0.3 m and the upper TDA layer by 0.3 m.

Reference

1. Nickels, W.L., Jr. 1995. "The Effect of Tire Chips as Subgrade Fill on Paved Roads." M.S. Thesis, Department of Civil Engineering, University of Maine, Orono, Maine, 215 pp.

APPENDIX E

Case Histories – Use of TDA as Lightweight Embankment Fill

Case History – Portland Jetport Interchange

Tired derived aggregate (TDA) was used as lightweight fill for construction of two 9.8-m (32-feet)-high highway embankments in Portland, Maine (Ref. 5). These embankments were the approach fills to a new bridge over the Maine Turnpike. The bridge is part of a new interchange that provides better access to the Portland Jetport and Congress Street. This site was underlain by about 12.2 m (40 feet) of weak marine clay. Test results indicated that the clay is an overconsolidated, moderately sensitive, inorganic clay of low plasticity. Undrained shear strength varied from approximately 72 kiloPascals (kPa) (1,500 pounds per square foot [psf]) near the top to 19 kPa (400 psf) near the center of the layer.

The designers for the project (the Maine offices of HNTB, Inc., and Haley and Aldrich, Inc., and the University of Maine) found that embankments built of conventional soil were too heavy, resulting in an unacceptably low factor of safety against slope instability. They looked at several ways to strengthen the foundation soils, but these methods were too costly. Construction of the embankments using lightweight fill was chosen as the lowest cost alternative. They considered several types of lightweight fill, including TDA, expanded polystyrene insulation boards, and expanded shale. TDA was chosen because it was $300,000 cheaper than the other alternatives. Moreover, the project would put some 1.2 million tires to a beneficial end use. Wick drains were also used to accelerate consolidation of the foundation soils.

Project Layout and Construction

Several steps were taken to comply with the guidelines to limit heating of thick TDA fills (Refs. 1, 2). The guidelines required that a single TDA layer be no thicker than 3 m (10 feet). Therefore, the TDA layer was broken up into two layers, each up to 3 m (10 feet) thick, separated by 0.9 m (3 feet) of soil, as shown in Exhibit E-1. Low-permeability soil with a minimum of 30 percent passing the No. 200 sieve was placed on the outside and top of the fill to limit inflow of air and water. The final precaution to limit heating was to use large Type B TDA with a minimum of fines. The TDA had less than 50 percent by weight passing the 75-mm (3-inches) sieve, 25 percent passing the 38-mm (1½-inches) sieve, and less than 1 percent passing the No. 4 sieve. The TDA had a maximum size measured in any direction of 300 mm (12 inches) to ensure that it could be easily placed with conventional construction equipment. The embankment was topped with 0.61 m (2 feet) of

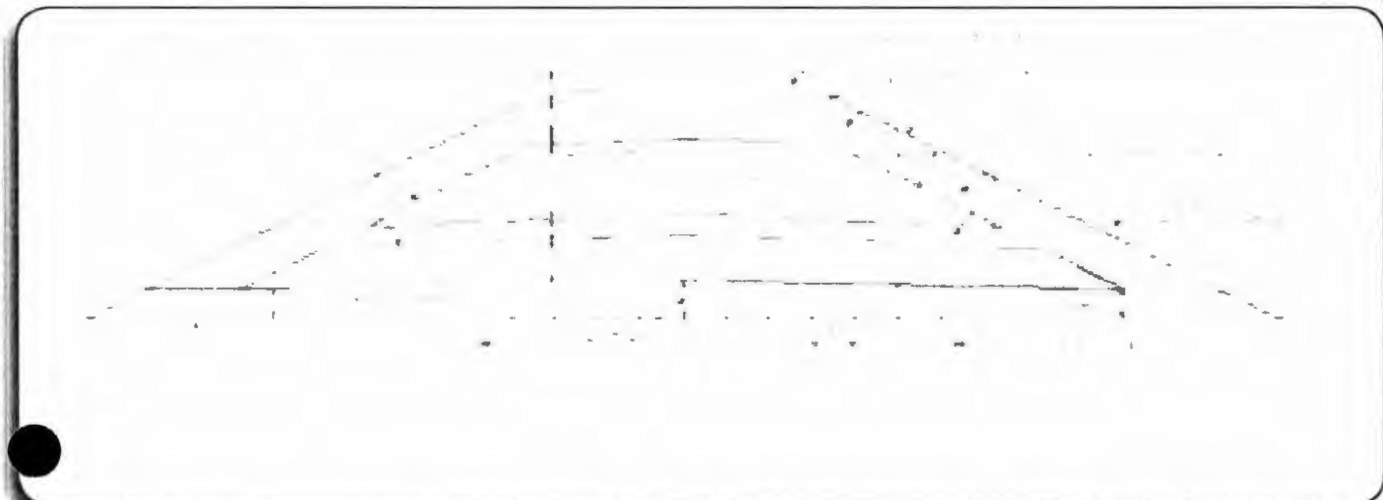


Exhibit E-1. Cross section through embankment constructed on soft marine clay for the Portland Jetport Interchange (Ref. 5)

Exhibit E-2. Caterpillar D-4 spreading TDA for lightweight embankment fill at Portland Jetport Interchange

low-permeability soil, 1.22 m (4 feet) of granular soil, plus 1.22 m (4 feet) of temporary surcharge. The purpose of the surcharge was to increase the rate of consolidation of the soft clay foundation soils and was unrelated to the TDA fill.

The TDA was placed with conventional construction techniques. First, geotextile was placed on the prepared base to act as a separator between the TDA and surrounding soil. Then, the TDA was spread in 300-mm (12-inch)-thick lifts using a Caterpillar D-4 dozer, as shown in Exhibit E-2. Each lift was compacted with six passes of a vibratory roller with a minimum 9.8-metric ton (10-ton) operating weight. After the TDA was in place, the contractor placed a geotextile separator on the sides and top of the TDA zone. The surrounding soil cover was placed as the TDA was placed.

Construction Settlement and In-place Unit Weight

Settlement plates were installed at the top and bottom of each TDA layer to monitor settlement. Compression of each TDA layer at the end of fill placement is summarized in Table E-1. The compression predicted based on laboratory compression tests on 75-mm (3-inches) maximum size TDA is also shown. It is seen that the predicted compression is significantly greater than the measured value. Thus, the compressibility of TDA with a 300-mm (12-inches) maximum size appears to be less than for 75-mm (3-inches) maximum size TDA. This compression was one factor that led to overpredicting the final in-place unit weight. The final in-place unit weight was predicted to be 0.93 Mg/m3 (58 pcf) compared with an actual value of 0.79 Mg/m3 (49 pcf), a difference of 18 percent. This difference cannot be entirely accounted for by the difference in compressibility. Thus, it is likely that the initial (uncompressed) unit weight of the larger TDA is less than for 75-mm (3-inches) maximum size TDA.

Temperature Measurements

Monitoring the temperatures of the TDA fill was of great interest because of past problems with heating of thick TDA fills (Ref. 4). The warmest temperatures were measured at the time of placement when the black TDA was heated by exposure to direct sunlight. Initial temperatures ranged from 24 to 38°C (75 to 100°F). After it was covered with the first few lifts of fill, the temperatures began dropping with time. Temperatures were still dropping when monitoring was discontinued in April 1998. Typical temperature measurements are shown on Exhibit E-3. From these results, it can be seen that there was no evidence of self-heating.

Case History – North Abutment Approach Fill

The key element of the Topsham Brunswick Bypass Project was the 300-m (984-feet) long Merrymeeting Bridge over the Androscoggin River. The subsurface profile at the location of the north abutment consisted of 3 to 6 m (10 to 20 feet) of marine silty sand overlying 14 to 15 m (45 to 50 feet) of marine silty clay. The clay is underlain by glacial till and then bedrock. The existing riverbank had a factor of safety against a deep-seated slope failure that was near 1. Moreover, the design called for an approach fill leading up to the bridge abutment that would

Table E-1.Measured compressibility of TDA layer for Portland Jetport Interchange project.

Settlement Plate No.	Location	Lower TDA layer		Upper TDA layer	
		Measured	Predicted	Measured	Predicted
SW1	25+00,C/L	12.6%	22%	8.3%	14%
SW4	26+00, C/L	13.4%	21%	11.2%	14%
SE1	30+00, C/L	19.1%	22%	10.9%	14%
SE4	31+00, C/L	17.3%	23%	9.3%	14%
Avg. C/L Plates		15.6%	22%	9.9%	14%

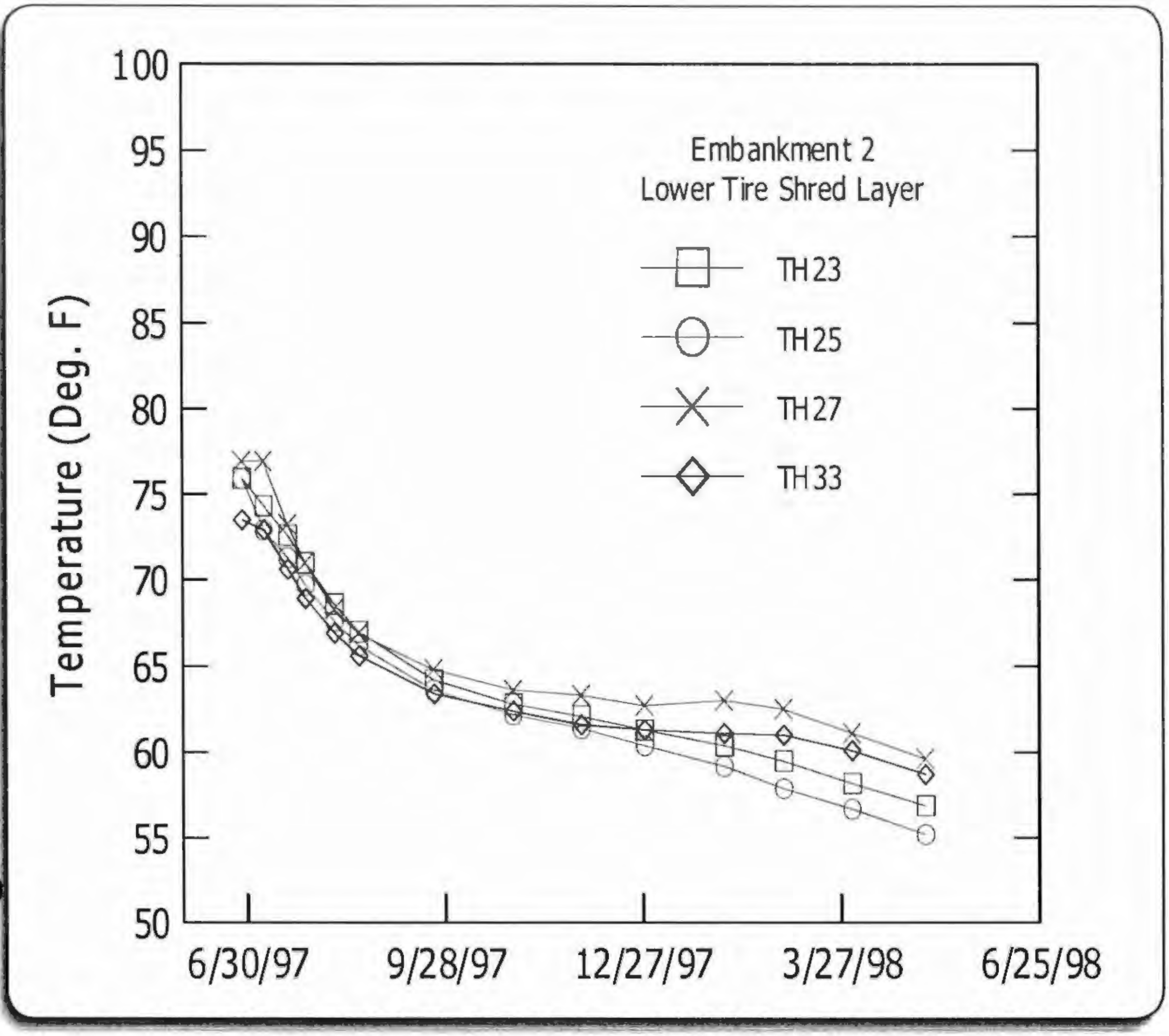


Exhibit E-3. Temperatures in lower tire shed layer of lightweight embankment fill at Portland Jetport Interchange

have further lowered the factor of safety. Thus, it was necessary to both improve the existing factor of safety and allow construction of the approach fill. The best solution was to excavate some of the existing riverbank and replace it with a 4.3-m (14-foot)-thick layer of TDA. TDA had the added advantage of reducing lateral pressures against the abutment wall. Other types of lightweight fill were considered, including geofoam and expanded shale aggregate. However, TDA proved to be the lowest-cost solution. The project used some 400,000 scrap tires (Ref. 9).

Project Layout and Construction

The surficial marine sand was excavated to elevation 5.2 m (17 feet) and then the abutment wall supported by an H-pile was constructed. A 4.3-m (14 foot)-thick zone of TDA was placed from station 53+50.6 m (175+50 feet) to the face of the abutment wall at station 53+72.0 m (176+20 feet). The fill tapers from a thickness of 4.3 m (14 feet) at station 53+50.6 m (175+50 feet) to zero thickness at station 53+35.4 m (175+00 feet) to provide a gradual transition between the TDA layer and the conventional fill. It was estimated that the TDA layer would compress 460 mm (18 inches) from the weight of the overlying soil layers. As a result, the layer was built up an additional 460 mm (18 inches) so that the final compressed thickness would be 4.3 m (14 feet). The TDA layer was enclosed in a woven geotextile (Niolon Mirafi 500X) to prevent infiltration of surrounding soil. The TDA was spread with front-end loaders and bulldozers and then compacted by six passes of a smooth drum vibratory roller (Bomag BW201AD) with a static weight of 9,432 kg (10.4 tons). The thickness of a compacted lift was limited to 305 mm (12 inches). It was determined that approximately 15 inches (381 mm) of loose TDA needed to be initially placed to obtain a compacted thickness of 305 mm (12 inches). TDA placement began on September 25, 1996, and was completed on October 3, 1996. A longitudinal section of the

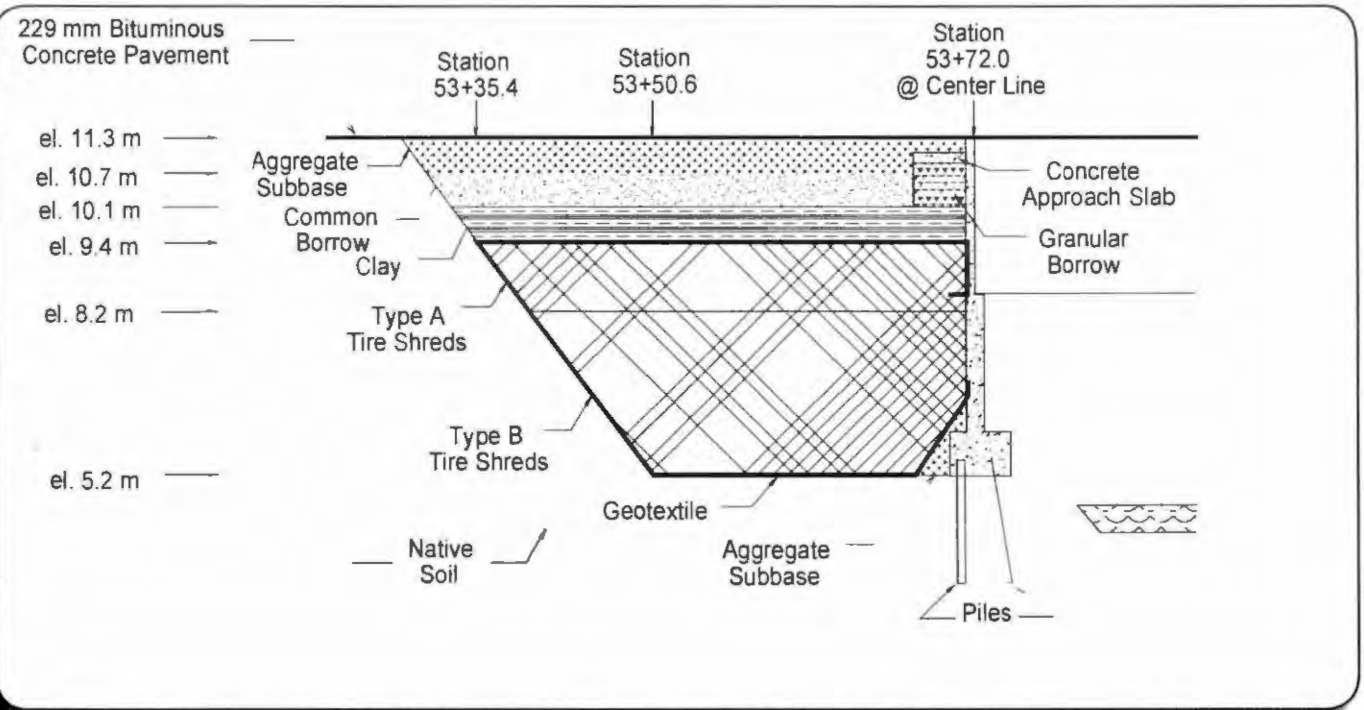


Exhibit E-4. Longitudinal section through North Abutment TDA fill

completed abutment and embankment is shown in Exhibit E-4.

This project was designed and built before the guidelines were developed to limit self-heating of TDA fills. However, the project included design features to limit self-heating. The first was to use larger Type B TDA in the lower portion of the fill from elevation 5.2 m (17 feet) to elevation 8.2 m (27 feet). The Type B TDA was specified to have a maximum dimension measured in any direction of 305 mm (12 inches); a minimum of 75 percent (by weight) passing the 203-mm (8-inches) square mesh sieve, a maximum of 25 percent (by weight) passing the 38-mm (1½-inches) square mesh sieve, and a maximum of 5 percent (by weight) passing the No. 4 (4.75-mm) sieve. No requirement for the percent passing the 3-inches (75-mm) sieve was included for this project. Gradation tests showed that the TDA generally had a maximum dimension smaller than 150 mm (6 inches). Type A TDA, with a maximum size of 75 mm (3 inches), were placed from elevation 8.2 m (27 feet) to the top of the TDA fill. It would have been preferable to use the larger Type B TDA for the entire thickness. However, a significant quantity of Type A TDA had already been stockpiled near the project prior to the decision to use larger TDA. It was judged that it would be acceptable to use the smaller Type A TDA in the upper portion of the fill. Moreover, it would have been preferable to limit the total thickness of the TDA layer to 3 m (10 feet), as recommended by the guidelines to limit self-heating.

As an additional step to reduce the possibility of self-heating, the TDA are overlain by a layer of compacted clayey soil with a minimum of 30 percent passing the No. 200 (0.075 mm) sieve. The purpose of the clay layer is to minimize the flow of water and air though the TDA. The clay layer is approximately 0.61 m (2 feet) thick and is built up in the center to promote drainage toward the side slopes. A 0.61-m (2-foot)-thick layer of common borrow was placed over the clay layer. Overlying the common borrow is 0.76 m (2.5 feet) of aggregate subbase.

TDA undergoes a small amount of time-dependent settlement. For this project, a thick TDA fill adjoined a pile-supported bridge abutment, leading to concerns that there could be differential settlement at the junction with the abutment. However, Tweedie and others (Ref. 6) showed that most of the time-dependent settlement occurs within the first 60 days. To accommodate the time-dependent settlement before paving, the contractor was required to place an additional 0.3 m (1 foot) of subbase aggregate as a surcharge to be left in place for a minimum of 60 days. In fact, the overall construction schedule allowed the contractor to leave the surcharge in place from October 1996 through October 1997. The surcharge was removed in October 1997 and the roadway was topped with 229 mm (9 inches) of bituminous pavement. The highway was opened to traffic on November 11, 1997. Additional construction information is given in Cosgrove and Humphrey (Ref. 3).

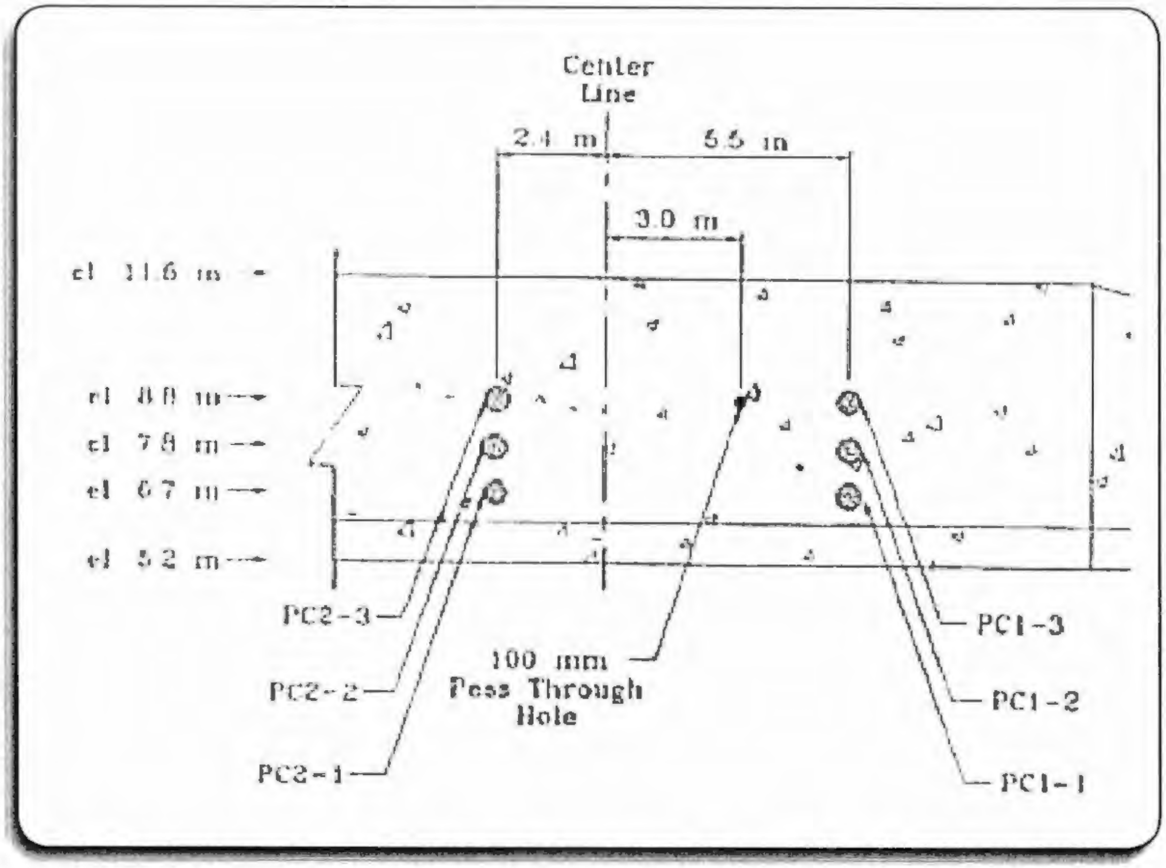


Exhibit E-5. Location of pressure cells in North Abutment (Ref. 3)

Instrumentation

Four types of instruments were installed: pressure cells cast into the back face of the abutment wall; and vibrating wire settlement gauges, settlement plates, and temperature sensors placed in the TDA fill. Vibrating wire pressure cells were installed to monitor lateral earth pressure against the abutment wall. Three Roctest model TPC pressure cells (PC1-1, PC1-2, and PC1-3) were installed on the face of the abutment wall 4 m (13 feet) right of centerline, and three Roctest model EPC pressure cells (PC2-1, PC2-2, and PC2-3) were installed 4 m (13 feet) left of centerline, as shown in Exhibit E-5. TDA was placed against all the cells.

Measured Horizontal Pressure and Settlement

The lateral pressure at the completion of TDA placement (October 3, 1996), completion of soil cover, and placement of surcharge (October 9, 1996) is summarized in Table E-2. Lateral pressures on October 31, 1996, are also shown. It is seen that the pressures increased with depth at completion of TDA placement. However, at completion of soil cover and surcharge placement, the pressures recorded by cells PC1-1, PC1-2, and PC1-3 were nearly constant with depth and ranged between 17.05 and 19.61 kPa (356 and 410 psf). These findings are consistent with at-rest conditions measured on an earlier project (Tweedie and others 1997; 1998a). Cells PC2-1, PC2-2, and PC2-3 showed different behavior. At completion of TDA placement 9, 1996, cell PC2-2 showed a pressure of 30.22 kPa (631psf), while cell PC2-1, located only 1.07 m (3.5 feet) lower, was 20.04 kPa (418 psf) and cell PC2-3, located 1.07 m (3.5 feet) above PC2-2, was 12.31 kPa (257 psf). These cells were the less stiff EPC cells. Large scatter has been observed with EPC cells on an earlier TDA project (Refs. 6, 7, 8). This scatter is thought to be caused, at least in part, when the large TDA creates a non-uniform stress distribution on the face of the pressure cell. The average pressure recorded by the three PC2 cells was 20.85 kPa (435 psf), which is slightly higher than the PC1 cells. Between October 9, 1996 and October 31, 1996, the lateral pressure increased by 1 to 2 kPa (20 to 40 psf). The pressures have been approximately constant since that time.

The TDA fill compressed about 370 mm (14.6 inches) during placement of the overlying soil cover. In the next 60 days, the fill settled an additional 135 mm (5.3 inches). Between December 15, 1996, and December 31, 1997, the fill underwent an additional 15 mm (0.6 inches) of time-dependent settlement. The rate of settlement had decreased to a negligible level by late 1997. The total compression of the TDA fill was 520 mm (20.4 inches) which was 13 percent greater than

Table E-2. Summary of Lateral Pressures on Abutment Wall.

Date	PC1-1	PC2-1	PC1-2	PC2-2	PC1-3	PC2-3
	Cell elev. = 6.70 m		Cell elev. = 7.77m		Cell elev. = 8.84 m	
10/3/96[2]	7.84[1]	7.41	6.04	7.27	2.62	1.41
10/9/96[3]	17.04	20.04	19.61	30.22	17.05	10.91
10/31/96	18.27	21.05	20.98	32.84	20.24	12.31

[1]Horizontal pressure in kPa.
[2]Date TDA placement completed.
[3]Date soil cover and surcharge placement completed.

the 460 mm (18 inches) that was anticipated based on laboratory compression tests. The difference is the result, at least in part, of time-dependent settlement that is not accommodated in the short-term laboratory tests. The final compressed density of the TDA was about 0.9 Mg/m3 (57 pcf), higher than for the Portland Jetport Project, most likely because of the smaller size of the TDA used for this project.

Temperature of TDA Layer

A small amount of self-heating of the TDA occurred. Five out of the 12 thermistors in the Type A TDA experienced a peak temperature of between 30 and 40°C (86 and 104°F). In contrast, only two of the 18 thermistors in the larger Type B TDA experienced a peak in this range, and these two sensors may have been influenced by warmer overlying Type A TDA. This difference suggests that larger TDA is less susceptible to heating. In any case, the peak temperatures were too low to be of concern. Since early 1997, the overall trend has been one of decreasing temperature. However, the temperature of the TDA appears to be slightly influenced by seasonal temperature changes.

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APPENDIX G

Scrap Tire Processing Facility Economic Parameters

BASIS

The projected operating mode is a single facility capable of receiving and processing 250,000 to 1,000,000 passenger tire equivalents (PTEs)/year into specific shredded product sizes ranging from Class B tire-derived aggregate (TDA) to 1-inch nominal chips

SITE PARAMETERS

Property Size:

Approximately 5 acres of flat, dry land in a central location with highway access and stable soil, plus additional property for product storage if more than 1 month's inventory is required.

Property Use:

3 acres for site operations, equipment movement and limited tire storage

2 acres for office and maintenance trailers and limited product storage, as well as water storage if applicable

Common Property Improvements:

Fenced and gated perimeter provides access control to decrease theft, vandalism, and arson

Operating area lighting, and possibly storage area lighting (depending on surroundings), enhances operating flexibility, safety, and security

Soil stabilization of storage and working areas: (1) decreases tire contamination and associated equipment maintenance, and (2) decreases product contamination for greater marketability and value

Concrete over about 1 acre of the centralized operating area prevents water displaced from tires during handling and processing; creating wet and undesirable conditions. A berm (3 to 4 feet high) around the perimeter of the storage area controls dispersion of pyrolytic oil or water if there is a fire.

Water accessibility or a water storage pond (lined if necessary) for emergency fire fighting

Electrical power for processing equipment, including a transformer if the available power is not stepped down

Office and associated equipment required to conduct business

Shop area and tools required to maintain equipment

Basic operation can be conducted outside, but efficiency may be impaired by weather. A portable cover may be desirable for shredder maintenance.

Additional Product Storage Requirements:

Depending on the products and markets, seasonal markets may require inventory up to 80 percent of annual production in an environmentally safe manner that minimizes the probability of a fire and maximizes the ability to control a fire if one occurs. Such an inventory would require an additional:

5 acres for 10 piles 50 x 150 x 10 feet (with 50 feet clear around each one) for storage of 800,000 PTEs of TDA

About 760 meters (2,500 linear feet) of fencing to enclose this area

EQUIPMENT FOR TYPE B TDA

Processing - If the sole product is Type B TDA, one of the least expensive single machines to purchase and maintain is the Barclay 4.9-inch horizontal primary shredder mounted at a 45-degree angle with a classification and recycle system. Alternatives include tire shredders with 4-inch knife spacing, but these generally have higher capital and operating costs. The major components and approximate current costs in $US are as follows:

Shredder with extended infeed conveyor	$230,000
Classifier	$45,000
Recycle conveyors (local supply)	$36,000
Discharge conveyor (local supply)	$50,000
Transportation (estimated from California)	$5,000
Equipment Subtotal	**$366,000**
Installation (approximate)	$75,000
Spare parts	$40,000
Miscellaneous and contingency	$100,000
Total processing equipment	**$581,000**

Additional Equipment – Required for movement of tires and shreds

Front end loader (used)	$60,000
Supplemental Bobcat	$20,000
Electrical supply/controls (estimate)	$25,000
Dump truck/trailer for on-site shred movement	$20,000
Total additional equipment	**$125,000**

FOR NOMINAL 2 INCH SHREDS (3-4 INCH MAX SIZE)

Processing - Normal use is a single high-capacity tire shredder with a classification and recycle system for volumes up to 1 million tires/year. The major components and approximate current costs in $US are as follows:

Shredder	$350,000 - $500,000
Infeed conveyor/mechanical system	$ 25,000 - $150,000
Classifier	$ 45,000 - $230,000
Recycle conveyors (local supply)	$ 36,000
Discharge conveyor (local supply)	$ 50,000
Transportation (estimated)	$ 12,000 - $ 20,000
Equipment Subtotal	**$518,000 - $986,000**
Installation (approximate)	$100,000
Spare parts	$ 60,000
Miscellaneous and contingency	$125,000
Total processing equipment	**$803,000 -$1,271,000**

Additional Equipment – Required for movement of tires and shreds

Front end loader (used)	$60,000
Supplemental Bobcat	$20,000
Electrical supply/controls (estimate)	$ 25,000
Dump truck/trailer for on-site shred movement	$ 20,000
Total additional equipment	**$125,000**

FOR NOMINAL 1 INCH SHREDS

Processing – Processing capital costs will be the same as for 2-inch shreds, but magnets may be required to remove chips that contain bead wire for some applications. If there is no market or reasonable disposal alternative for this material (30 to 40 percent), then additional equipment can be installed to liberate the wire for sale (as previously discussed) and salvage the rubber in a variety of sizes down to crumb rubber. The major components and approximate current costs in $US are as follows:

Total 2-inch equipment	$803,000 - $1,271,000
Additional magnets/conveyors	$ 60,000 -$ 110,000
Total processing equipment	**$863,000 -$1,381,000**
Additional cost for wire liberation/recovery/ Classification equipment to produce saleable wire and some crumb rubber products	$500,000 -$1,200,000

OPERATING COST COMPONENTS

Typical Staffing level for one shift/5 day operation (some jobs can be combined in low-volume operations)

- 1 Manager
- 1 Office/accounting
- 1 Shipment receiving/monitoring
- 1 Supervisor/maintenance manager
- 1 Loader operator
- 1-2 Laborer/maintenance

Professional Services (such as accounting, marketing, and legal)

Processing/Maintenance

For Class B TDA

Processing equipment maintenance	$ 6.00/ton
Loader/Bobcat maintenance	$ 2.00/ton
Power for Equipment	

For 1.0 million tires/year
(150 hp x 70% load x .746 kilowatt [kW] conversion = 78 kW/hour x 2,080 hours/yr = 162,240 kW/year)

For 0.5 million tires/year, est 50 % load factor or 115,000 kW/year

For 0.25 million tires/year, est 40 % load or 92,000 kW/yr

For 2-inch nominal shreds

Processing equipment maintenance	$15.00/ton
Loader/Bobcat maintenance	$ 2.00/ton
Power for Equipment	

For 1.0 million tires/year

(250 hp x 70% load x .746 kW conversion = 131 kW/hour x 2,080 hours/yr = 272,480 kW/year)

For 0.5 million tires/year, est 50% load factor or 195,000 kW/year

For 0.25 million tires/year, est 40% load or 156,000 kW/yr

For 1-inch nominal shreds

Processing equipment maintenance	$25.00/ton
Loader/Bobcat maintenance	$ 2.00/ton
Power for Equipment	

For 1.0 million tires/year

(250 hp x 85%load x .746 kW conversion = 159 kW/hour x 2,080 hours/yr = 330,000 kW/year)

For 0.5 million tires/year, est 70% load factor or 272,000 kW/year

For 0.25 million tires/year, est 55% load or 213,000 kW/yr

OTHER FIXED COST COMPONENTS

Insurance

Financing

Government Taxes

APPENDIX H

Comparative Volume Sensitivity of Tire Processing Facilities

TIRE-DERIVED AGGREGATE (TDA) PRODUCT

VARIABLE COSTS

COST COMPONENT	PROCESSING RATE (Tires/year)								
	250,000			500,000			1,000,000		
	Number	Cost/year	Cost/tire	Number	Cost/year	Cost/tire	Number	Cost/year	Cost/tire
Labor									
Supervisor	1	$40,000	$0.16	1	$40,000	$0.08	1	$40,000	$0.04
Manual	2	$48,000	$0.19	2	$48,000	$0.10	3	$72,000	$0.07
Subtotal	3	$88,000	$0.35	3	$88,000	$0.18	4	$112,000	$0.11
Power (mw/yr) @ $100/mw	92	$9,200	$0.04	115	$11,500	$0.02	162	$16,200	$0.02
Maintenance									
Shredder ($/ton)	6	$15,000	$0.06	6	$30,000	$0.06	6	$60,000	$0.06
Other ($/ton)	2	$5,000	$0.02	2	$10,000	$0.02	2	$20,000	$0.02
Subtotal	8	$20,000	$0.08	8	$40,000	$0.08	8	$80,000	$0.08
Wire Disposal (tons)	0	-	-	0	-	-	0	-	-
TOTAL VARIABLE COST		$117,200	$0.47		$139,500	$0.28		$208,200	$0.21

Depreciation (real with tire processing equipment – typically 5 – 8 years)

FIXED COSTS

COST COMPONENT	PROCESSING RATE (Tires/year)								
	250,000			500,000			1,000,000		
	Number	Cost/year	Cost/tire	Number	Cost/year	Cost/tire	Number	Cost/year	Cost/tire
Administration									
Manager	1	$50,000	$0.20	1	$50,000	$0.10	1	$50,000	$0.05
Sales/service	By Mgr	-	-	By Mgr	-	-	1	$40,000	$0.04
Clerical	1	$20,000	$0.08	1	$20,000	$0.04	1	$20,000	$0.02
Office expense		$18,000	$0.07		$18,000	$0.04		$18,000	$0.02
Prof. Services		$5,000	$0.02		$10,000	$0.02		$10,000	$0.01
Subtotal		$93,000	$0.37		$98,000.00	$0.20		$138,000.00	$0.14
Capital charges									
Amortization (12.5%/year)		$97,813	$0.39		$97,813	$0.20		$97,813	$0.10
General Expense									
Insurance (1% of $1M)		$10,000	$0.04		$10,000	$0.02		$10,000	$0.01
Prop Tax (1% of $1M)		$10,000	$0.04		$10,000	$0.02		$10,000	$0.01
Subtotal		$20,000	$0.08		$20,000	$0.04		$20,000	$0.02
TOTAL FIXED COSTS		$210,813	$0.84		$215,813	$0.43		$255,813	$0.26
TOTAL COST		$328,013	$1.31		$355,313	$0.71		$464,013	$0.46
PROFIT (25% ROC on $1M)		$250,000	$1.00		$250,000	$0.50		$250,000	$0.25
TOTAL PRICE		$578,013	$2.31		$605,313	$1.21		$714,013	$0.71

COMPARATIVE VOLUME SENSITIVITY OF TIRE PROCESSING FACILITIES

NOMINAL 2-INCH SHREDS

VARIABLE COSTS

COST COMPONENT	PROCESSING RATE (Tires/year)								
	250,000			500,000			1,000,000		
	Number	Cost/year	Cost/tire	Number	Cost/year	Cost/tire	Number	Cost/year	Cost/tire
Labor									
Supervisor	1	$40,000	$0.16	1	$40,000	$0.08	1	$40,000	$0.04
Manual	2	$48,000	$0.19	2	$48,000	$0.10	3	$72,000	$0.07
Subtotal	3	$88,000	$0.35	3	$88,000	$0.18	4	$112,000	$0.11
Power (mw/yr) @ $100/mw	156	$15,600	$0.06	195	$19,500	$0.04	272	$27,200	$0.03
Maintenance									
Shredder($/ton)	15	$37,500	$0.15	15	$75,000	$0.15	15	$150,000	$0.15
Other($/ton)	2	$5,000	$0.02	2	$10,000	$0.02	2	$20,000	$0.02
Subtotal	17	$42,500	$0.17	17	$85,000	$0.17	17	$170,000	$0.17
Wire Disposal(tons)	0	-	-	0	-	-	0	-	-
TOTAL VARIABLE COST		$146,100	$0.58		$192,500	$0.39		$309,200	$0.31

FIXED COSTS

COST COMPONENT	PROCESSING RATE (Tires/year)								
	250,000			500,000			1,000,000		
	Number	Cost/year	Cost/tire	Number	Cost/year	Cost/tire	Number	Cost/year	Cost/tire
Administration									
Manager	1	$50,000	$0.20	1	$50,000	$0.10	1	$50,000	$0.05
Sales/service	By Mgr	-	-	By Mgr	-	-	1	$40,000	$0.04
Clerical	1	$20,000	$0.08	1	$20,000	$0.04	1	$20,000	$0.02
Office expense		$18,000	$0.07		$18,000	$0.04		$18,000	$0.02
Prof. Services		$5,000	$0.02		$10,000	$0.02		$10,000	$0.01
Subtotal		$93,000	$0.37		$98,000	$0.20		$138,000	$0.14
Capital charges									
Amortization (12.5%/year)		$150,000	$0.60		$150,000	$0.30		$150,000	$0.15
General Expense									
Insurance (1% of $1.5M)		$15,000	$0.06		$15,000	$0.03		$15,000	$0.02
Prop Tax (1% of $1.5M)		$15,000	$0.06		$ 15,000	$0.03		$15,000	$0.02
Subtotal		$30,000	$0.12		$30,000	$0.06		$30,000	$0.03
TOTAL FIXED COSTS		$273,000	$1.09		$278,000	$0.56		$318,000	$0.32
TOTAL COST		$288,000	$1.15		$293,000	$0.59		$333,000	$0.33
PROFIT (25% ROC on $1.5M)		$375,000	$1.50		$375,000	$0.75		$375,000	$0.38
TOTAL PRICE REQUIRED		$663,000	$2.65		$668,000	$1.34		$708,000	$0.71

COMPARATIVE VOLUME SENSITIVITY OF TIRE PROCESSING FACILITIES

NOMINAL 1-INCH SHREDS

VARIABLE COSTS

COST COMPONENT	PROCESSING RATE (Tires/year)								
	250,000			500,000			1,000,000		
	Number	Cost/year	Cost/tire	Number	Cost/year	Cost/tire	Number	Cost/year	Cost/tire
Labor									
Supervisor	1	$40,000	$0.16	1	$40,000	$0.08	1	$40,000	$0.04
Manual	2	$48,000	$0.19	2	$48,000	$0.10	3	$72,000	$0.07
Subtotal	3	$88,000	$0.35	3	$88,000	$0.18	4	$112,000	$0.11
Power (mw/yr) @ $100/mw	213	$21,300	$0.09	272	$27,200	$0.05	330	$33,000	$0.03
Maintenance									
Shredder($/ton)	25	$62,500	$ 0.25	25	$125,000	$0.25	25	$250,000	$0.25
Other($/ton)	2	$5,000	$0.02	2	$10,000	$0.02	2	$20,000	$0.02
Subtotal	27	$67,500	$0.27	27	$135,000	$0.27	27	$270,000	$0.27
Wire Disposal(tons)	50	$1,500	$0.01	100	$3,000	$0.01	200	$6,000	$0.01
TOTAL VARIABLE COST		$178,300	$0.71		$253,200	$0.51		$421,000	$0.42

FIXED COSTS

COST COMPONENT	PROCESSING RATE (Tires/year)								
	250,000			500,000			1,000,000		
	Number	Cost/year	Cost/tire	Number	Cost/year	Cost/tire	Number	Cost/year	Cost/tire
Administration									
Manager	1	$50,000	$0.20	1	$50,000	$0.10	1	$50,000	$0.05
Sales/service	By Mgr	-	-	By Mgr		-	1	$40,000	$0.04
Clerical	1	$20,000	$0.08	1	$20,000	$0.04	1	$20,000	$0.02
Office expense		$18,000	$0.07		$18,000	$0.04		$18,000	$0.02
Prof. Services		$5,000	$0.02		$10,000	$0.02		$10,000	$0.01
Subtotal		$93,000	$0.37		$98,000	$0.20		$138,000	$0.14
Capital charges									
Amortization (12.5%/year)		$162,500	$0.65		$162,500	$0.33		$162,500	$0.16
General Expense									
Insurance (1% of $1.6M)		$16,000	$0.06		$16,000	$0.03		$16,000	$0.02
Prop Tax (1% of $1.6M)		$16,000	$0.06		$16,000	$0.03		$16,000	$0.02
Subtotal		$ 32,000	$0.13		$32,000	$0.06		$32,000	$0.03
TOTAL FIXED COSTS		$287,500	$1.15		$292,500	$0.59		$332,500	$0.33
TOTAL COST		$303,500	$1.21		$308,500	$0.62		$348,500	$0.35
PROFIT (25% ROC on $1.6M)		$400,000	$1.60		$400,000	$0.80		$400,000	$0.40
TOTAL PRICE		$703,500	$2.81		$708,500	$1.42		$748,500	$0.75