Evaluation of
Hydroseed for the Re-establishment of Residential Lawns

Omaha Lead Site, Omaha, Nebraska

Written By:
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SCOPE OF EVALUATION

The U.S. Environmental Protection Agency (USEPA) Region 7 Superfund Division tasked Project Resources Inc. (PRI), under PRI's Technical Assistance (TA) contract, to perform a literature review on hydroseeding, evaluate two hydroseed test plots constructed during the summer of 2004 by the USEPA, and provide a comparison between hydroseeding and the placement of sod to restore areas disturbed during the removal of lead-impacted soils from residential properties located in Omaha, Nebraska, in the Omaha Lead Superfund Site.

This document is only a preliminary qualitative analysis of using hydroseed and a summary of its associated materials, methods, costs and potential benefits. It was not a comprehensive study that measured growth-specific variables of using hydroseed versus sod to restore areas disturbed during removal of residential soils in Omaha. A more quantitative investigation could be undertaken that would directly measure and compare growth rates of hydroseed versus sod during different seasons of the year, under variable site-specific conditions, using multiple hydroseed products and techniques. These quantitative variables were not measured by this investigation.

LITERATURE REVIEW

A review of available literature and correspondence with hydroseed experts familiar with the Omaha, Nebraska, area was performed to provide a background of hydroseeding, the available hydroseed products and techniques, maintenance requirements, and the reported market costs of hydroseeding.

A. Hydroseeding Background

Hydroseeding is used to establish vegetative cover and control soil erosion of lawns, along roadsides, in construction zones, and other soil areas disturbed by man or nature (Robinson 2002). Hydroseeding is a cultivation process that utilizes a combination of materials including cellulose fibers or mulch, seeds of desired vegetation species, green dye, and fertilizers,

combined into water-based slurry (Burton 2001), which is then sprayed onto the disturbed soil areas using a hydroseed machine. Hydroseed machines are composed of three main components: a mixing tank, agitation system, and slurry pump (Figure 1). The green dye used in hydroseed slurries aids in consistent slurry application over an area based on specified application rates and confirmed by homogenous coloration of seeded versus unseeded areas (Figure 1).

The literature reviewed and correspondence with hydroseed experts states that there are numerous advantages to using hydroseed. Hydroseed provides a more even application of seeds than is achieved using standard broadcast seeding. It also helps maintain soil temperature, protects seeds from birds, and reduces erosion when properly mixed with mulch materials (Burton 2001).

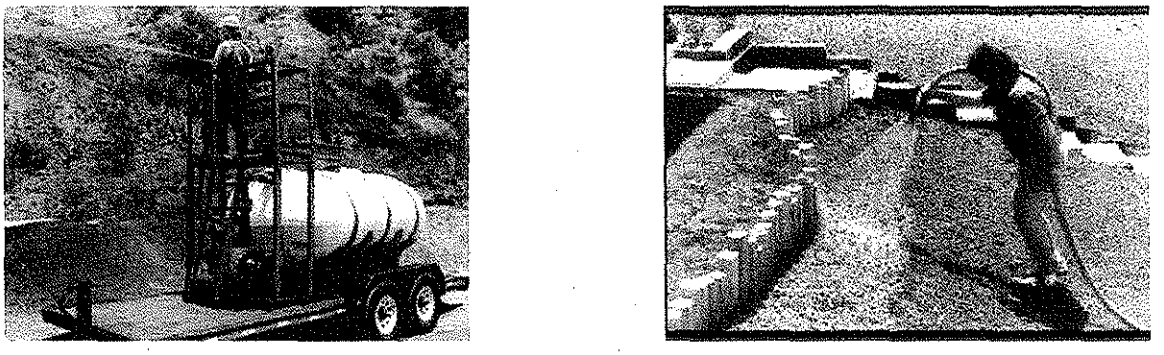

Figure 1 – Hydroseed application

There are many requirements that must be addressed prior to hydroseeding an area, especially for residential lawn establishment where rapid growth, erosion control, and visual appearance are important concerns. Requirements include mulch and erosion control, grass seed selection, and lawn establishment. Each of these requirements should be addressed prior to formulating a project-specific hydroseed slurry and application rate.

1. Mulch and Erosion Control

Mulch is the primary erosion-control component and is often the most important constituent in a hydroseed slurry. In erosion-prone areas with steep slopes or increased exposure

to runoff or wind, extra mulch can be especially beneficial in decreasing the erodability of a hydroseeded area.

Mulch materials are used to retain soil moisture and temperature, to provide organic matter to the soil as the lawn becomes established, to absorb the energy released from rainfall, and to keep seed and fertilizer in place (Roadside Landscape Ecology Project 2001). Mulches are made from processed or unprocessed materials, and from byproducts or wastes from other industries. Mulches can be used alone or in combination with compost materials to enhance the nutrient content of the base medium for hydroseeding applications (Tech Help 1999). The most common mulches consist of straw and wood residues including sawdust, wood-chips, and bark. Cellulose mulch is also available, and is made of recycled paper products (Roadside Landscape Ecology Project 2001).

Conwed® Fibers, a leader in hydromulch technologies, provides customers with five main mulch options: Hydromulch® 2500 (90% wood fiber and 10% cross-linked hydro-colloid tackifier), Hydromulch® 2000 and 1000 (100% wood fiber), EnviroBlend® (70% wood and 30% paper fibers), and Cellulose (100% paper fiber) (Profile Products 2004a). In addition to these five, Conwed® also has another mulch product, Flexible Growth Medium™ (Flexterra™), that is used in a slightly different manner: using a hydroseeding machine, Flexterra™ is applied to the soil after it has been seeded, to hold moisture and provide erosion control. Flexterra™ uses patented technologies to bond the medium to the soil, and does not require a 24-hour cure time like most mulch products (Profile Products 2004b). Table 1 shows the typical application rates for the Conwed® products on varying sloped terrain.

Other non-mulch erosion control mechanisms are also available to supplement the hydroseeding process. Tackifiers or synthetic glues can be added to hydroseed slurries to increase their effectiveness and erosion resistance. Erosion control blankets can also be used. These blankets are rolled atop freshly hydroseeded areas and hold surface materials in place. The blankets are typically made from natural materials like coconut fiber, coir, jute, or straw, and come in variable thickness (Roadside Landscape Ecology Project 2001). Bonded fiber matrix materials and liquid co-polymers are also an experimental class of supplements for erosion and dust control purposes (Corvallis Community Development 2004).

MODEL	SURFACE SLOPE			
	4:1	3:1	2:1	1:1
Cellulose	2000	--	--	--
EnvironBlend®	--	2000	2500	2500
Hydromulch® 1000	1500	2000	2500	--
Hydromulch® 2000	--	2000	2500	2500
Hydromulch® 2500	3000	3000	3500	4000
Flexterra™	3000	3500	4000	4500

(--) Information Not Available. Data are in pounds per acre.

Table 1 -- Typical application rates of mulch

One final erosion control supplement is the Futerra® Blanket, a non-woven erosion control vegetation blanket produced by Conwed® Fibers. It contains no seed or fertilizers, and is used to prevent erosion in areas that have already been seeded. It is composed of a photodegradable polypropylene netting that has been laminated to a matrix of wood fibers and interlocking, crimped synthetic fibers. Photodegradable staples or stakes securely hold the blanket in place above the soil. The wood fibers biodegrade within six weeks, adding organic material to the soil. The photodegradable netting, staples, and stakes break down in six to fifteen months. The Futerra® Blanket is effective at reducing seed bed migration caused by water flow on 1:1 to 4:1 slopes (Profile Products 2004c).

2. Grass Seed Selection

There are also various grass seeds on the market that grow better in certain areas, under particular conditions, and at different times of the year. These seed types can be used in monoculture or in combination, depending on the soil and other site-specific environmental variables. The keys to selecting the appropriate seed for a particular site include the anticipated maintenance, climate conditions, temperature tolerance, drought resistance, shade adaptation, and wear resistance (Burton 2001).

In eastern Nebraska, a part of the Midwest or Heartland climate regime, the climate is known for cold hard winters and hot humid summers. Wide seasonal temperature variations are

common, and can make growing a hydroseeded lawn difficult. These conditions favor cool season grasses in the early spring and fall, and warm season grasses during the summer months (All About Lawns 2000). According to local geoproducts sales manager Steve Pudenz, hydroseed, especially in residential areas, is not typically used after the first of October until March or April, when temperatures increase enough to allow seed germination. It is also difficult to hydroseed in mid-summer, unless care is taken to keep hydroseeded areas consistently moist for one month after seeding (Pudenz 2004).

3. Lawn Establishment

Once the hydroseed slurry has been applied, the hydroseeded area must be nurtured and maintained to establish a new lawn. During the first 24-hours following hydroseed application, the lawn must not be watered. This allows the mulch and/or tackifier to properly attach to the soil (LCM--Lawn Company Maintenance Inc. 2004). However, over the next three weeks, the soil must be kept moist. Jim Ruff, a local hydroseed contractor, tells his customers to keep hydroseeded areas moist for one month after seeding (Ruff 2004). This is achieved through light watering three times per day for the first month. Other hydroseed experts suggest as many as four to five short watering cycles per day (LCM 2004). The current method of watering sod at the Omaha Lead Site (i.e., watering once every one to two days) would likely be insufficient for maintaining hydroseed, leaving that responsibility up to the homeowner. Additionally, while it is important to keep a hydroseeded soil moist, a new lawn should not be over-watered (LCM 2004).

Once grass is established and grows to three inches high, the number of watering cycles can be reduced and the grass can be mowed to a height of two inches. Lawn traffic should be kept to a minimum for the first three weeks. Some hydroseed companies recommend no repetitive traffic (i.e., dogs or playing children) for the first six weeks (LCM 2004).

HYDROSEED TEST PLOTS

To supplement the literature review and to test the effectiveness of hydroseed within the Omaha Lead Site boundary, two test plots were applied with hydroseed and the progress of

growth documented. The first test plot was located at the USEPA Omaha Lead Site Command Post, where USEPA built a small-scale 50 X 50 ft (i.e., 2500 ft^2) enclosed area, using the standard excavation procedures and backfill soil that are used at a typical Omaha Lead Site property. Furthermore, one property (P0294), undergoing remediation at the time, was hydroseeded with the property owner's permission. PRI collected photo-documentation and field observation notes over a four-month period at both test plots.

It is important to note that no quantitative measurements were taken so only qualitative comparisons between hydroseeding, sod, or other lawn establishment methodologies are possible, and limited to the available literature and correspondence with hydroseed experts.

The USEPA contacted a hydromulch and erosion control product distributor, Lumbermen's, and a hydroseed company, Nebraska Hydro-Seeding, to hydroseed the test plots. The hydroseeded test areas were maintained by the USEPA by watering once per day for two weeks, and with no other maintenance procedures being performed.

At the Omaha Lead Site Command Post, the 50 X 50 ft area was excavated on June 9, 2004, and backfilled and hydroseeded the next day. The residential property (P0294) was excavated on June 26, 2004, and backfilled between July 1, 2004 and July 7, 2004. This property was hydroseeded on July 19, 2004. Both test sites were relatively flat surfaces with no added non-mulch erosion control supplements. Excavation and backfilling of the test areas were completed in the same way that properties are currently prepared for laying sod at the site.

Jim Ruff of Nebraska Hydro-Seeding was responsible for the hydroseeding at both test sites. He seeded both locations using the Super Turf I Mixture, which is a seed blend certified by the Nebraska Crop Improvement Association, and was suggested by Mr. Ruff as being a typical blend for use in this region, at this time of year.

This mixture consisted of 22.05% Arid III Tall Fescue, 22.05% Jaguar III Tall Fescue, 22.05% Masterpiece Tall Fescue, 22.05% Rembrandt Tall Fescue, and 9.80% Top Gun Perennial Ryegrass. The final 2% of the seed mixture included 0.25% Crop, 1.70% inert material, and 0.05% weeds. Mr. Ruff also used a (32-5-5) fertilizer additive, which included 50% slow release nitrogen, 32% nitrogen, 5% available phosphoric acid, and 5% potassium (as K_2O) in the slurry.

Three different mulches were used in the hydroseed slurries at the two test sites to compare their relative effectiveness when used with the same seed mixture, fertilizer, and backfill soil. The west half of the 2500 ft^2 test plot was mulched using a 100% cellulose or paper fiber mulch, while the eastern half of the test plot was mulched with the Enviroblend mulch containing 70% wood and 30% paper fibers. The P0294 test plot was mulched using the Hydromulch 1000 product, a 100% wood fiber mulch. Mulch was included in the hydroseed slurries at both test sites for water absorption, and for protecting and bonding grass seeds to the soil. Other erosion control supplements were not necessary, as they would be in yards with sloped terrain. Hydroseed slurries were applied at typical rates of approximately 8 to 10 pounds per 1000 ft^2.

Hydroseed test site results are photo-documented in Appendix 1 of this report. The photo-log along with field notes were maintained by PRI at the Command Post test plot between June 6 and August 26, 2004 (Appendix 1), but no specific quantitative measurements were made. The hydroseeded lawn at P0294 was photo-documented on August 17, 2004, to analyze its status one month after seeding.

A. Observation of USEPA Command Post Test Plot

One week after hydroseeding the test plot, between June 9 and June 16, there was no observed turf growth. A significant rain event (1.68 inches) occurred on June 12, two days after hydroseeding the test plot (Accuweather 2004). This rain event may have stunted growth or washed out part of the original hydroseed slurry, especially on the west half of the plot, which was mulched using the 100% paper or cellulose fiber mulch. On June 17, orange barrier fencing was placed around the site to prevent deer from entering. During week two, on June 18, small patchy sections of grass were observed sprouting in the test area. By June 21, these patchy areas began filling-in, while other areas on the plot still showed bare soil.

On June 24, two weeks after planting, patchy areas of grass continued to grow, and no weeds were apparent. During week three, grass growth on the western half of the test plot was visibly inferior to that observed on the east portion, but turf growth was patchy and bare ground

abundant on the entire plot. The fact that turf growth was superior on the eastern half of the plot could suggest that the mulch containing some wood fibers was superior to the cellulose-only mulch in sustaining the newly laid hydroseed during the significant rain event that occurred two days after planting.

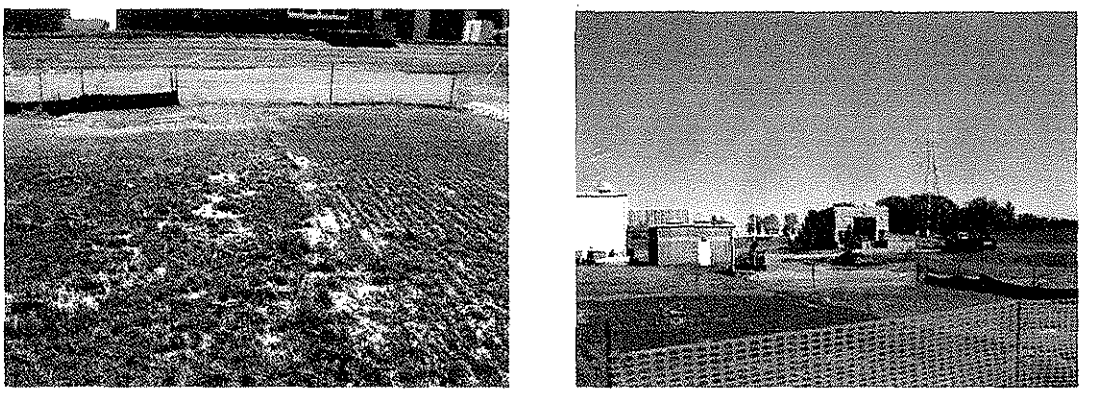

Figure 2 – Command post test plot

On July 6, nearly four weeks after planting, grass was starting to get longer and thicker, but many areas were still patchy, broadleaf weeds were observed, and the west side of the test plot was still noticeably less productive than the east side. After one month of growth, between July 12 and 15, the grass, especially on the eastern portion of the test plot, was becoming long enough to require mowing; however, weeds were still present, and bare soil was still a significant concern.

On July 19, the test plot conditions were similar to those observed the week before. Because there was a significant amount of the bare ground present on the west half of the test plot, it was decided that it would be power-raked and re-hydroseeded. The next day, on July 20, the west half of the 2500 ft^2 plot was power-raked and re-hydroseeded, using the same 100% paper fiber cellulose mulch slurry that was originally applied to the west half of the plot.

It is important to note that on July 22 again two days after re-hydroseeding the west half, another significant rain event (2.66 inches) occurred (Accuweather 2004). By August 13, however, grass was more productive on the west portion of the test plot than before reseeding.

Patchiness, bare ground, and weeds were all still observed throughout the entire test plot on this date. Based on these observations, it appeared that the cellulose mulch held up better to the more significant (2.66-inch) rain event after re-hydroseeding than it did to the other (1.68-inch) rain event that occurred after the original hydroseed slurry with cellulose mulch was applied, possibly due to the extra power-raking step or to the doubled seed supply after re-hydroseeding the west half of the plot.

On August 19, ten weeks after initial planting, the east portion of the test plot was a brownish-green color, with significant weed growth and patches of bare ground. In the raked and reseeded half of the test area, grass was much greener and turf growth somewhat thicker than in the half that was not raked or reseeded. Patches of bare soil were still observed on the entire plot, where seed germination was obviously hindered. Final notes were taken at the test site on August 26, nearly eleven weeks after planting. The status of the test plot remained the same: patchiness, bare soil, and broadleaf weeds were all observed. Because the western half of the test plot was raked and re-hydroseeded, using the cellulose mulch each time, it was slightly more productive after eleven weeks than the eastern half.

B. Observation of Property P0294

On July 19, the residential P0294 site was hydroseeded using the same seed mixture that was applied to the Command Post test plot, using a 100% wood fiber mulch in the hydroseed slurry, rather than a cellulose fiber or paper-containing mulch. This site was photo-documented approximately one month later on August 17, and again on October 1. On August 17, grass was growing on the entire hydroseeded lawn, but small patches of bare ground were also observed in portions of the property. Weed growth was minimal on this date in the hydroseeded lawn.

Follow-up photographs were taken at each of the hydroseeded test plots. Photographs were taken on October 3, 2004, at the 2500 ft^2 Omaha Lead Site Command Post test plot and on October 1, 2004, at the P0294 test plot, representing the final observations of each site (see figures 2 and 3). Overall, the P0294 residential test plot that was hydroseeded using the 100% wood fiber mulch was more productive in producing a continuous healthy turf than the

Command Post test plot, where both paper and combination wood and paper mulches were used. Furthermore, the residential test site experienced the same July 22 rain event three days after hydroseeding the property that the re-hydroseeded west half of the Command Post test plot received two days after planting. P0294 seemed to recover well from this event, with no large patches of seed loss or bare ground observed during final observations on October 1.

Figure 3 -- Property P0294 test plot

C. **Observation Summary**

The hydroseeding test at the Command Post plot was not as visibly productive as observed at the P0294 site. Weed growth, patches of bare ground, and an unproductive west half of the test plot requiring that portion to be reseeded, were all shortcomings. When viewing across the entire lot, the hydroseeded property at P0294 produced a relatively healthy turf; however, when looking closer at the grass, the turf appeared somewhat patchy and not as thick. For the most part, the P0294 turf was green, growing, and appeared healthy. Within three days of both hydroseeding and re-hydroseeding the two halves of the Command Post test plot and the P0294 site, there were significant (>1.00 inch) rainfall events. The P0294 site hydroseeded with the 100% wood mulch seemed to produce a better turf than either half of the command post plot, before and after the west half was re-hydroseeded. This could suggest wood mulch as a superior alternative to paper mulch at least under the limited scope and variables analyzed by this report. Further research and scientific experimentation could be undertaken to test this hypothesis under

variable site specific conditions including slopes, time of year, hydroseed slurry combinations and maintenance conditions.

COMPARISON OF HYDROSEEDING AND SOD (TECHNICAL)

Table 2 (A-G) lists the technical advantages and disadvantages between using hydroseed and sod for establishing a lawn. This table is summarized below.

A. Planting Season

The planting seasons for the two methods are different. Sod can be planted year-round, though spring or fall planting is preferred. The availability of sod during the winter can be limited by snow cover and frozen ground (Corvallis Community Development 2004). The planting season of hydroseed is more limited than it is for sod. Hydroseed can be applied from late spring through the early fall, depending on weather conditions. The hydroseeding of residential lawns is not typically recommended after October 1st or at soil temperatures below 60° F, when grass seeds may not germinate (Ruff 2004). During the warmest summer months, both methods can require extra water and maintenance to prevent damage from excessive heat.

B. Soil Preparation

Soil preparation for laying sod or hydroseeding is typically the same. With sod, a layer of thatch and root system has already been established in an appropriate soil layer. Consequently, the underlying soil characteristics (including texture, structure, pH, and nutrient composition) are likely more significant in preparing a site for hydroseeding than for laying sod. Sod roots will penetrate rapidly to underlying soils and become firmly established within a couple of weeks (Colt *et al.* 1997).

C. Water Requirements

Watering is a critical maintenance requirement for any kind of turf establishment. Daily watering is required for both hydroseed and sod for several weeks after planting; however, because sod already consists of established plants, the amount and application rates are not as critical as they are for hydroseed. During most of the year, watering a freshly sodded area once

FACTORS	HYDROSEED	SOD
A. Planting Season	Not recommended for winter or summer. Possible in spring, best in fall for most areas.	Year-round installation, if sod is available. Spring or fall is preferred.
B. Soil Preparation	Same for all types of lawn installation: deeply till soil, add necessary amendments and fertilizers, grade and level for smooth surface, remove debris, lightly pack and moisten.	Same for all types of lawn installation: deeply till soil, add necessary amendments and fertilizers, grade and level for smooth surface, remove debris, lightly pack and moisten.
C. Water Requirements	Moderate to high water needs. Mulch will retain some moisture.	Lower water needs. Grass will shade soil and reduce drying.
D. Usability	Low traffic use 2 to 4 months after hydroseed application. Normal to high use after first year.	Low traffic after sodding. Normal to high traffic levels within 3 to 4 weeks.
E. Weed Control	Herbicide additions usually required to control weeds until grass is established. Mulch layer may reduce some problems.	Minimal, if any, herbicides needed.
F. Erosion	Heavy rains or sloping areas will cause soil and seed to wash onto sidewalks. Mulch will reduce erosion for several months.	Capable of handling heavy rains with little erosion.
G. Visual Appearance	Mulched ground cover until grass matures.	Immediate grass.

*Modified from: (TPI 1999)

Table 2 – Technical factors of hydroseeding vs. sod

per day should suffice. With a freshly hydroseeded area, the ground must be kept moist, but not over-watered, which poses a serious threat to turf establishment. It is therefore suggested by Nebraska Hydro-Seed that for approximately the first month after seeding, a hydroseeded area be lightly watered three to four times daily, making sure the ground remains moist and that no significant surface runoff occurs (Ruff 2004).

Because it may not be feasible for EPA contractors to revisit a property three to four times daily for several weeks after hydroseeding a property, property owners would likely take on the burden of watering their own hydroseeded lawns immediately. Some form of reimbursement could be issued to the owners for these extra watering and maintenance costs. However, if the owners did not properly maintain and water their lawns for the first few weeks, the question could arise as to who would be responsible for re-hydroseeding costs at lawns with failed first efforts that were either not cared for or died from other causes like heavy precipitation events or trampling.

D. Usability

Traffic should be kept to a minimum on both freshly sodded and hydroseeded areas. Sod is slightly more wear resistant because it is composed of a pre-established turf. Low traffic is recommended for up to three weeks after sodding. Higher traffic is acceptable three to four weeks after sodding, as long as the sod appears healthy (Colt *et al.* 1997). Traffic on hydroseeded areas should be minimal for a longer period of time than on sodded areas: two to four months of minimum foot traffic is suggested for hydroseeded areas, so that seeds can germinate and grass can fill in the entire area of the lawn. On properties with dogs, other outdoor pets, or children, this can be a significant constraint for hydroseeding applications (LCM 2004). Furthermore, post-application maintenance and mowing of newly seeded areas can be the hardest part of a hydroseed operation. Though mowing is necessary, it can endanger a recently hydroseeded area if not done properly and at the right time (Tilton 2004).

E. Weed Control

After hydroseeding, herbicide applications are often necessary to control weeds, while grass seeds germinate in their new habitat. Again, because sod already consists of an established

turf, where seeds have already germinated and rolls are laid to completely cover the terrain, weed competition and bare ground are not as significant (TPI 1999). Therefore, when considering both weed control and bare ground, sod is likely the preferred method, although these issues can be controlled in a hydroseed operation.

F. Erosion

Erosion control is a significant concern for both hydroseed and sod, although sod is typically able to handle rain events better than hydroseed. If a significant rain event (i.e., > 0.5 inch) occurs within one month after hydroseeding, a follow-up inspection of the hydroseeded area is recommended (Corvallis Community Development 2004). Tackifiers and mulches, in extreme cases, would likely be required. Erosion control blankets, like the Futerra® by Conwed Fibers, would likely need to be used on steep slopes.

It should be noted that in some cases, sodded lawns excavated for the Omaha Lead project have also experienced erosion problems, where backfilled soil eroded from beneath freshly sodded lawns, especially at properties with sloped terrain after significant rain events. These erosion problems have required follow-up maintenance, including additional backfill, re-sodding, and cleanup of eroded soils from walkways, neighboring properties, and other areas.

G. Visual Appearance

Sod provides an instantaneous turf that is visually appealing as long as it is properly cared for, especially for the first few weeks after planting. Hydroseeded terrain, on the other hand, takes more time to establish and has the appearance of green-dyed soil (see Figure 1). Sod is therefore a quicker method for establishing a visually appealing lawn; however, with the proper maintenance, a similar result can be achieved through hydroseeding in as little as three weeks time (Burton 2001). Without proper care and maintenance, neither sod nor hydroseed will produce adequate results. Because typical maintenance and watering procedures are simpler for sod, it could be argued that sod is the simpler method for achieving a visually satisfying turf, but it is also the more expensive method. Follow-up fertilization is suggested for both new sod and hydroseeded areas about one month after sodding or seeding (Colt *et al.* 1997).

COMPARISON OF HYDROSEEDING AND SOD (COST)

A detailed analysis of the cost of hydroseeding versus sod would require a fully developed feasibility study that takes into account not only direct costs (some given below), but also indirect costs, such as resource availability, scheduling constraints, and target production rates for the overall project. As such, this document is limited to providing some basic direct cost data for the reader's use.

Area Covered	Hydroseeding	Sod
< 5000 ft^2	\$0.14 / square foot, with a \$350.00 minimum charge	
5000 – 10,000 ft^2	\$0.07 / square foot	
10,000 – 20,000 ft^2	\$0.06 / square foot	
20,000 – 30,000 ft^2	\$0.05 / square foot	
30,000 – 40,000 ft^2	\$0.045 / square foot	
Any		\$0.245 / square foot

Note: Hydroseed rates are based on applying a suitable regional seed combination (Super Turf I Mixture), a typical 70% wood 30% paper mulch, and a 32-5-5 Slow-release Nitrogen fertilizer additive. Rates include all labor and associated fees of product application (Ruff 2004).

Table 3 – Comparison of costs for hydroseeding versus sod

Table 3 provides hydroseed and sod costs for comparable properties. Hydroseed costs were provided by Jim Ruff (Nebraska Hydro-seeding), and reflect the hydroseed work at the 2500 ft^2 test plot and his standard pay rates for hydroseeding larger areas. Sod laying costs were provided by Logan Valley Sod, and include materials and labor. Laying sod, unlike hydroseeding, is performed at a fixed rate per area regardless of slope, terrain, or size of site. Table 4 gives the costs of hydroseeding using various erosion control strategies. These cost estimates in Table 4 were reported by, Doug Wilcox of Doug's Turf Care in Omaha (Wilcox 2004).

Erosion Control Strategy (2500 ft^2 area):	Cost of Hydroseeding:
Slurry includes a 70/30 wood/paper mulch, a #10 Turf Fescue or a #6 bluegrass/ryegrass seed mixture, a starter fertilizer, and relatively smooth and flat seed surfaces.	\$350.00 (\$0.14 / ft^2)
Hydroseed mixture same as above, except on sloped terrain. Mixture includes extra fibers and a tackifier.	\$450.00 (\$0.18 / ft^2)
Same as above, except on severely sloped terrain. Application of a double net straw mat with the seed mixture.	\$550.00 (\$0.22 / ft^2)

Note: Rates for hydroseeding a 2500 ft^2 area provided by Doug's Turf Care, a certified hydroseed company in the Omaha area. Cost estimates include three typical slurries and erosion control methods, based on site-specific slope conditions (Wilcox 2004).

Table 4 -- Hydroseed costs using different erosion control strategies

CONCLUSION

Hydroseed is becoming a common way for establishing healthy vegetation in many different areas and applications, including commercial areas, along roadsides, golf course construction projects, and residential lawns (Robinson 2002). As indicated by a literature review and observation of the test plots, the applicability of hydroseeding in residential areas may need to be addressed by a feasibility study addressing the site-specific issues of post-application maintenance, erosion control, watering, weed infestation, usability, visual appearance, and planting season, based on site-specific variables, the needs of the homeowners, and the time of year.

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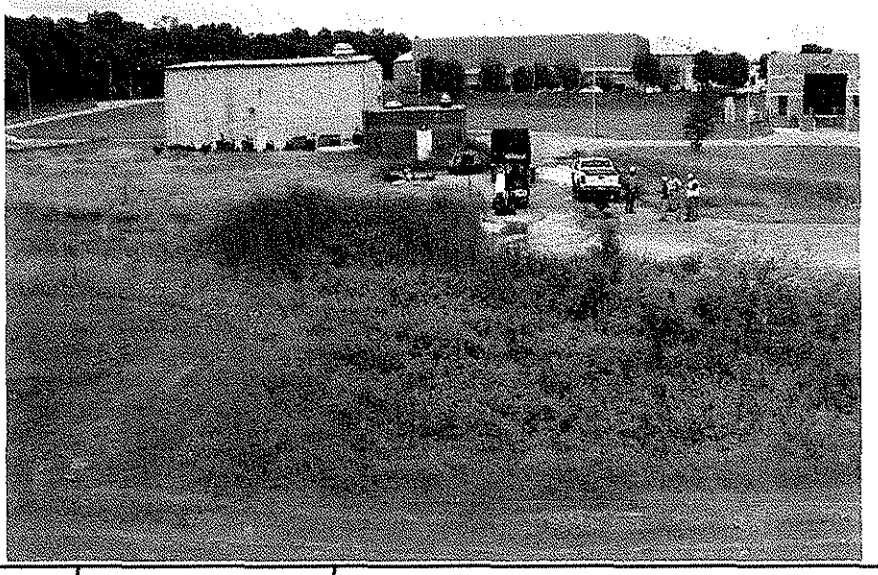
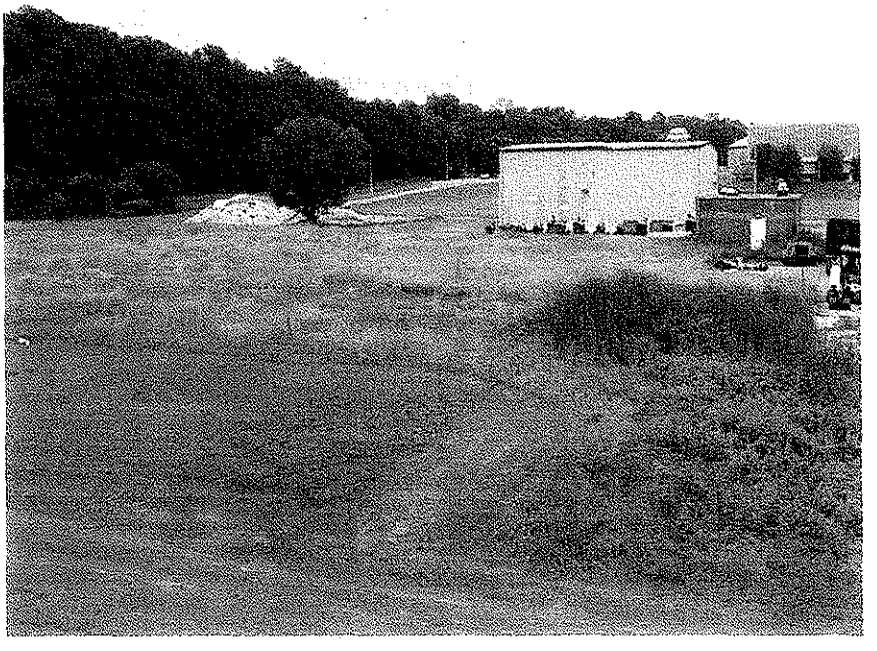
Appendix 1

Appendix I

Omaha Lead Site Hydroseed Project Test Plot Area at the Missouri Wastewater Treatment Plant

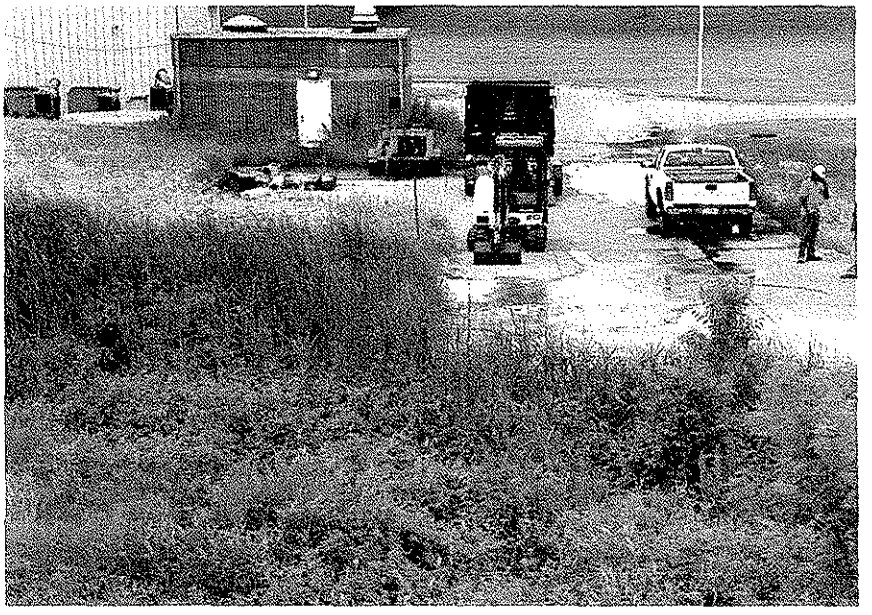


PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (pre-excavation)	1
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	06/09/2004



PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (pre-excavation)	2
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	06/09/2004

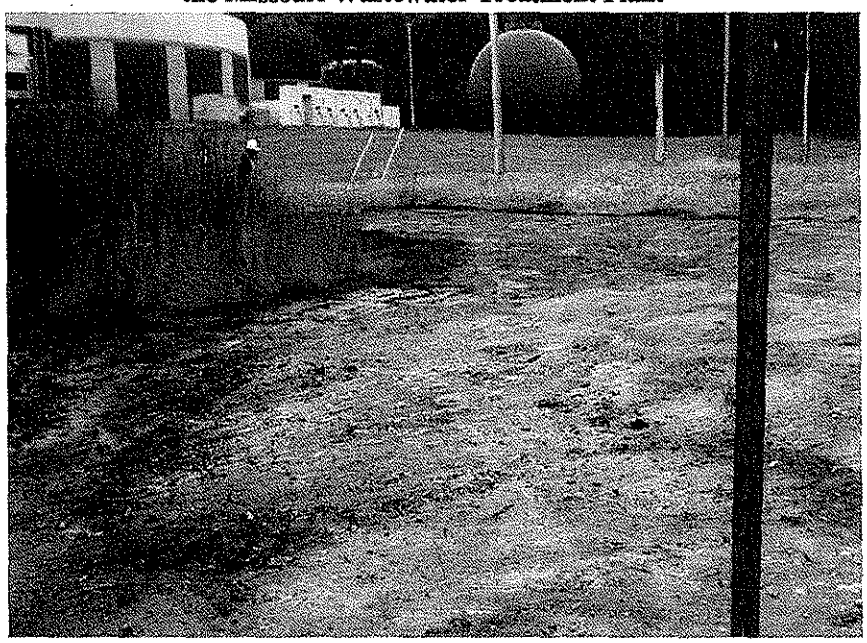
Omaha Lead Site Hydroseed Project Test Plot Area at the Missouri Wastewater Treatment Plant



PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (pre-excavation)	3
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	06/09/2004

PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (pre-excavation)	4
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	06/09/2004

Omaha Lead Site Hydroseed Project Test Plot Area at the Missouri Wastewater Treatment Plant

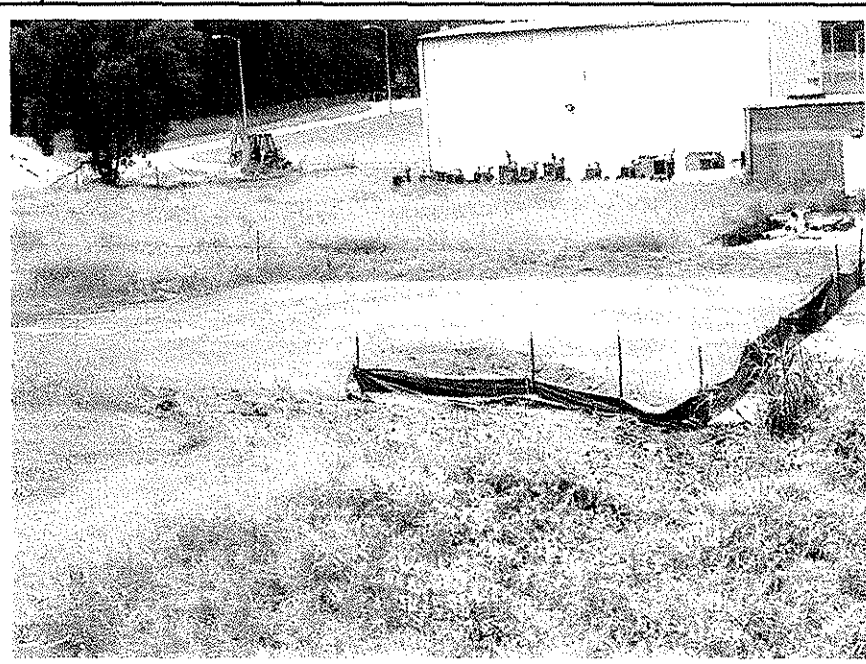


PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (post-excavation)	5
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	06/09/2004

PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (post-excavation and backfilled)	6
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	06/09/2004

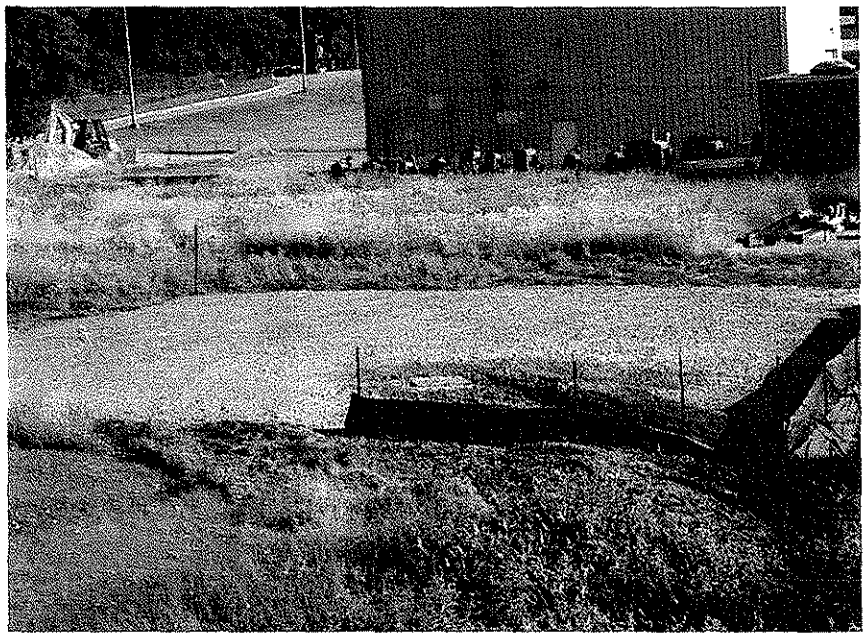
Omaha Lead Site Hydroseed Project Test Plot Area at the Missouri Wastewater Treatment Plant

PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (post-excavation and backfilled)	7
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	06/10/2004

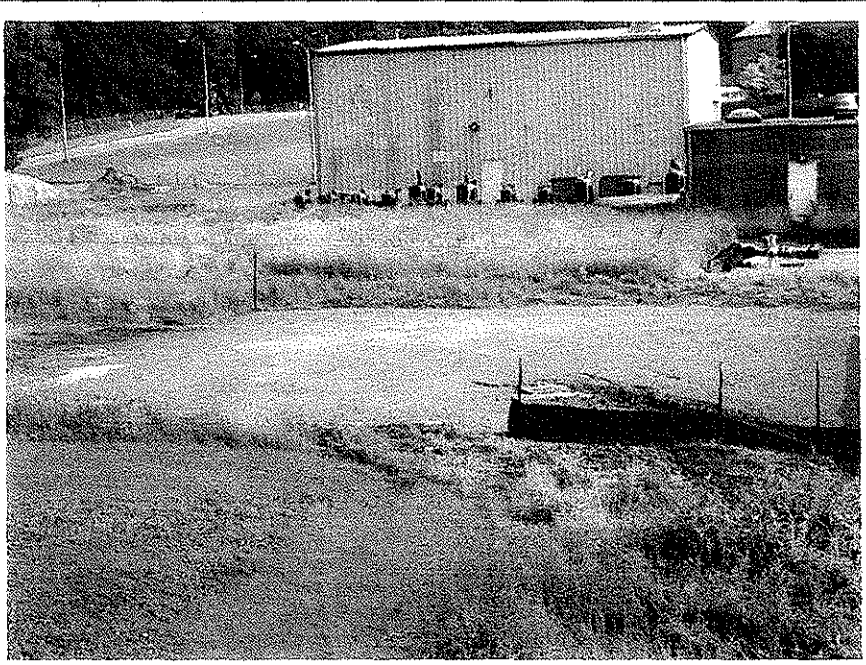


PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (after hydroseeding)	8
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	06/10/2004

Omaha Lead Site Hydroseed Project Test Plot Area at the Missouri Wastewater Treatment Plant

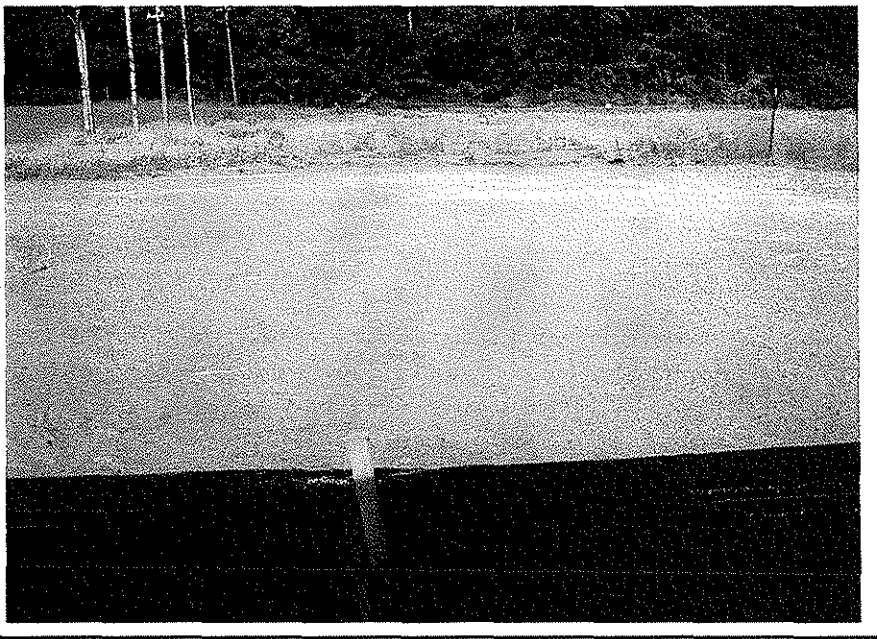


PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (day 2)	9
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	06/12/2004

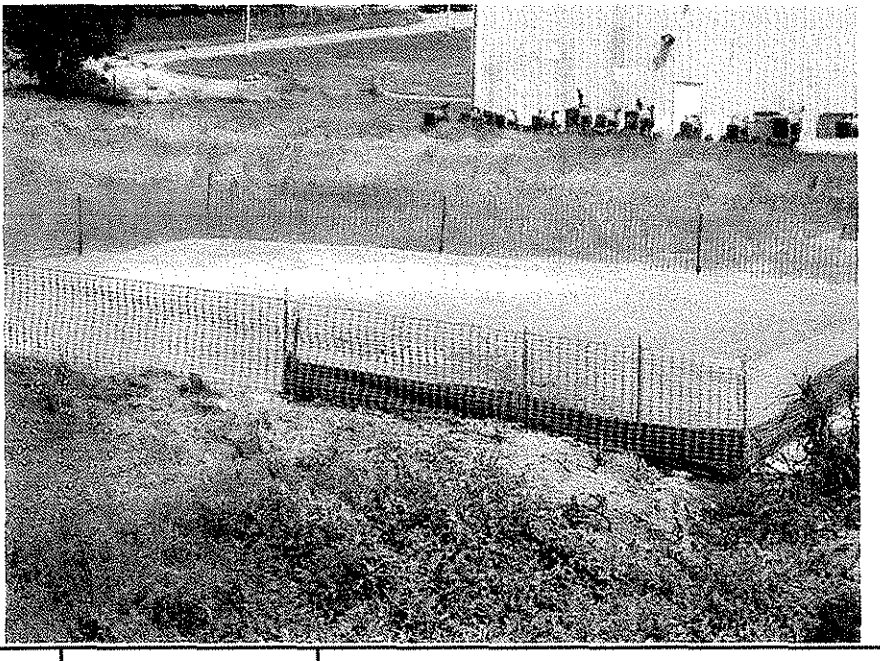


PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (week 1)	10
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	06/16/2004

Omaha Lead Site Hydroseed Project Test Plot Area at the Missouri Wastewater Treatment Plant



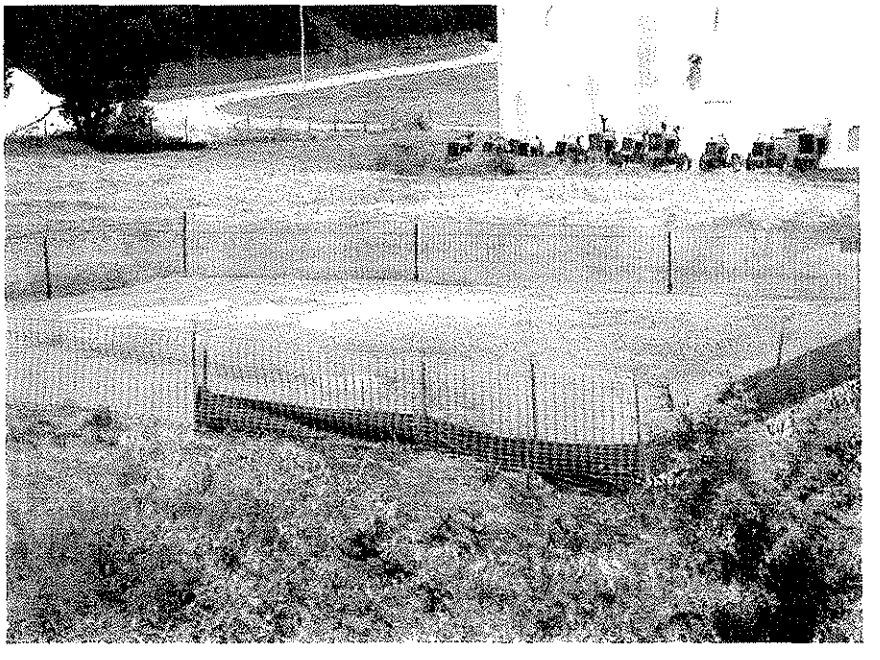
PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (week 1)	11
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	06/16/2004



PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (week 1)	12
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	06/17/2004

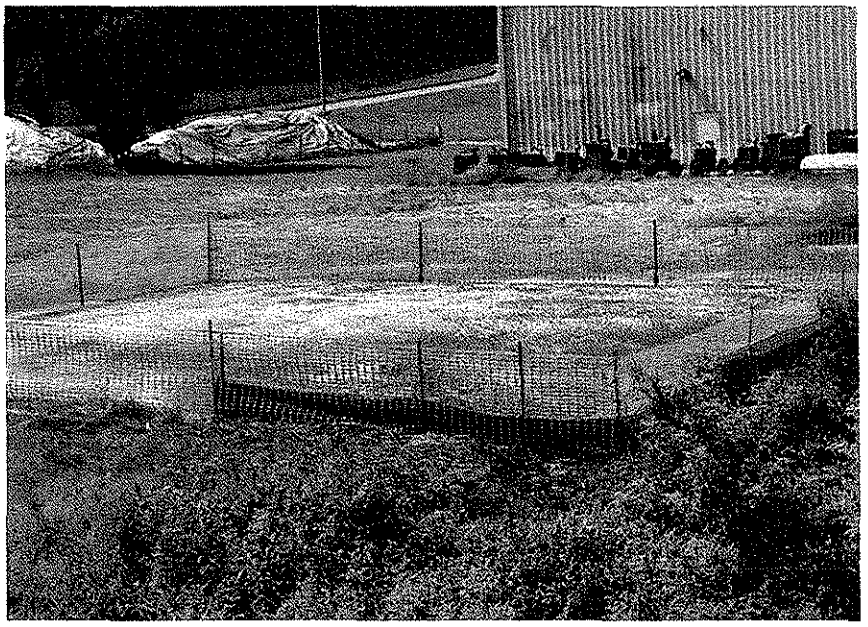
Omaha Lead Site Hydroseed Project Test Plot Area at the Missouri Wastewater Treatment Plant

PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (week 2)	13
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	06/21/2004

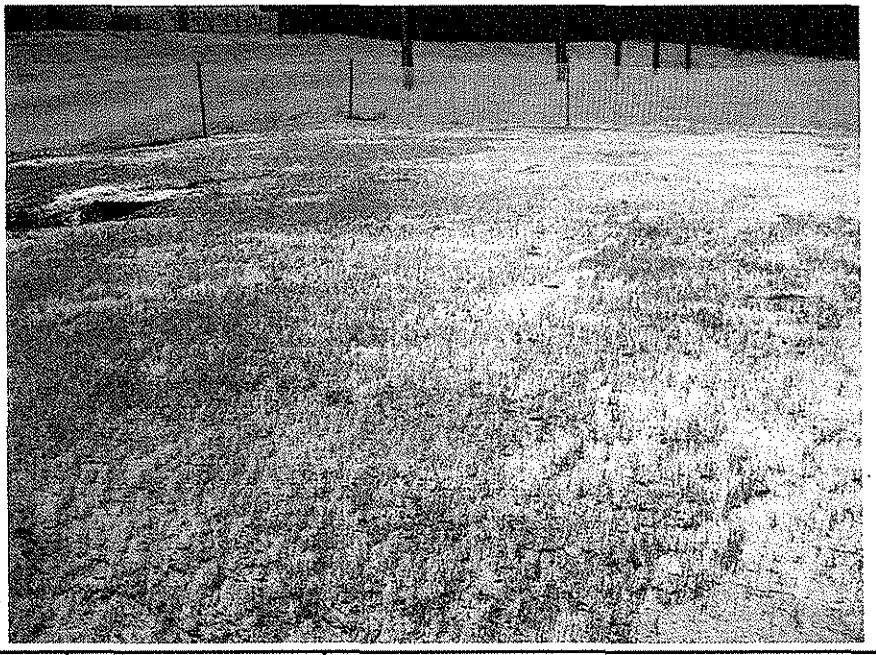


PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (week 2)	14
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	06/21/2004

Omaha Lead Site Hydroseed Project Test Plot Area at the Missouri Wastewater Treatment Plant



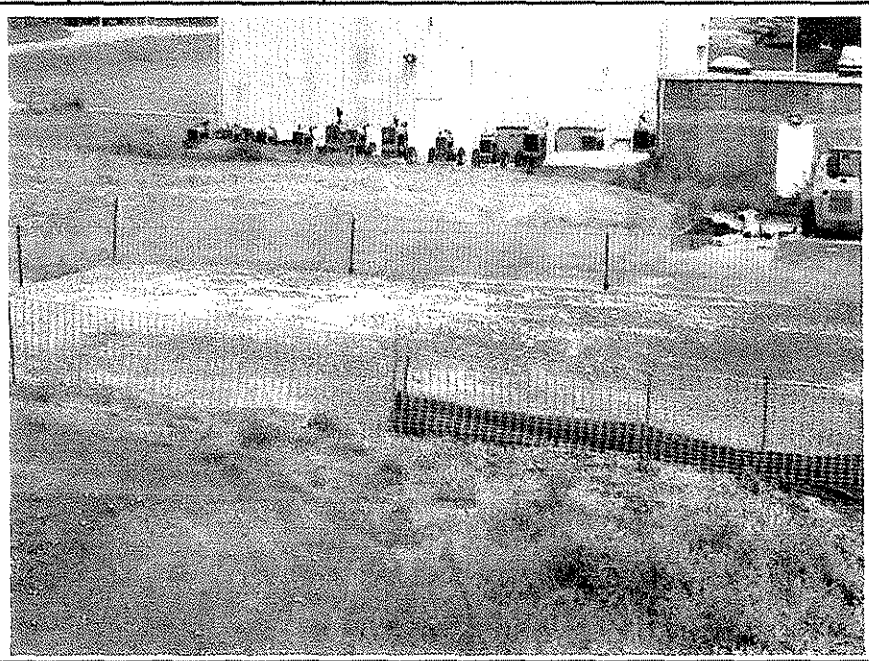
PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (week 2)	15
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	06/24/2004



PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (week 2)	16
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	06/24/2004

Omaha Lead Site Hydroseed Project Test Plot Area at the Missouri Wastewater Treatment Plant

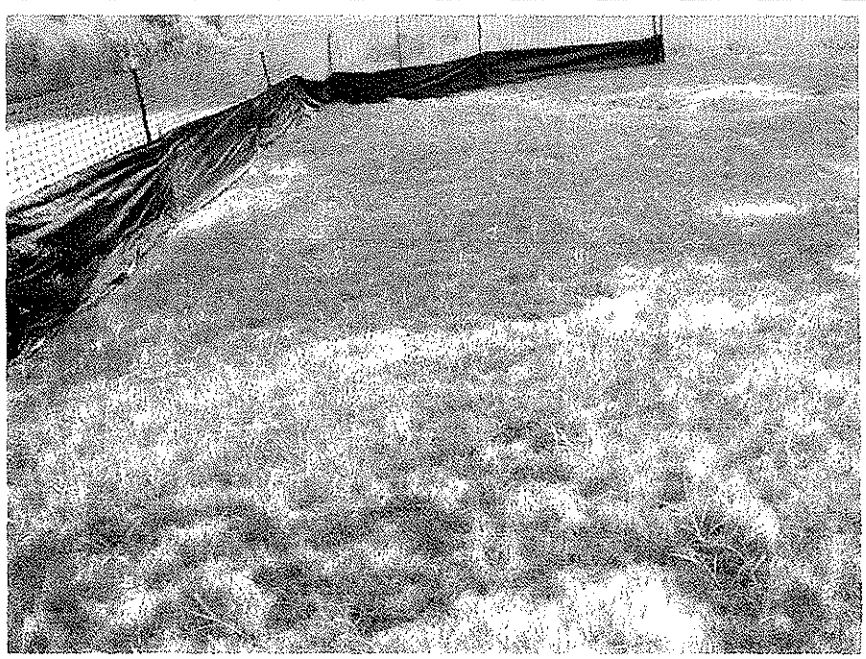
PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (week 3)	17
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	06/28/2004



PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (week 3)	18
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	06/29/2004

Omaha Lead Site Hydroseed Project Test Plot Area at the Missouri Wastewater Treatment Plant

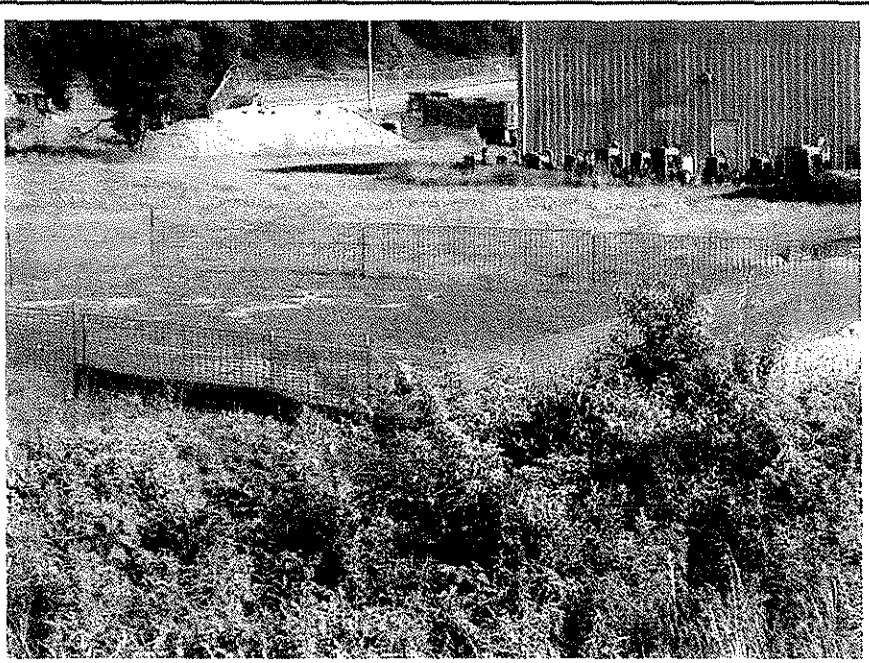
PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (week 4)	19
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	07/06/2004



PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (week 4)	20
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	07/06/2004

Omaha Lead Site Hydroseed Project Test Plot Area at the Missouri Wastewater Treatment Plant

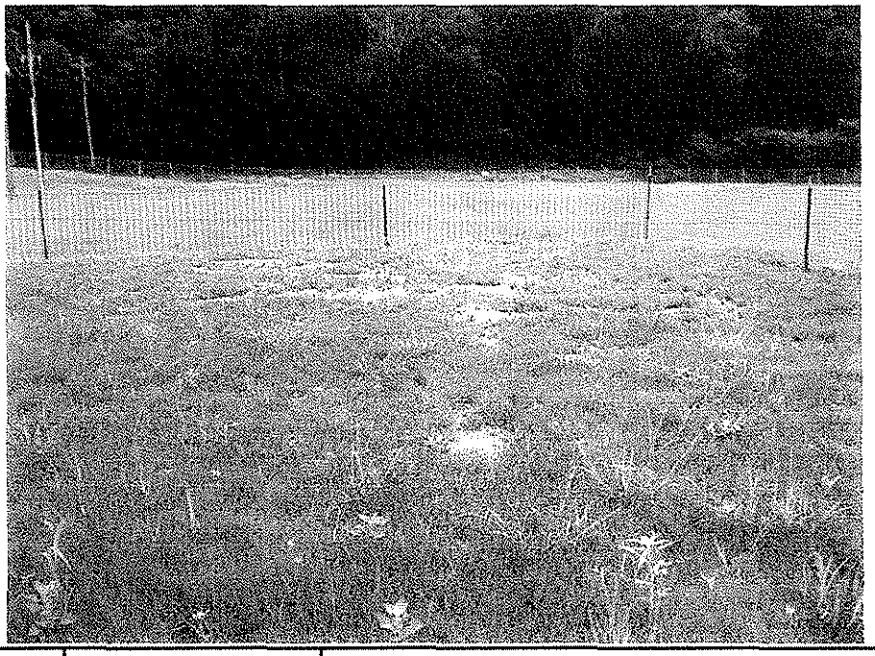
PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (week 4)	21
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	07/06/2004



PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (week 5)	22
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	07/12/2004

Omaha Lead Site Hydroseed Project Test Plot Area at the Missouri Wastewater Treatment Plant

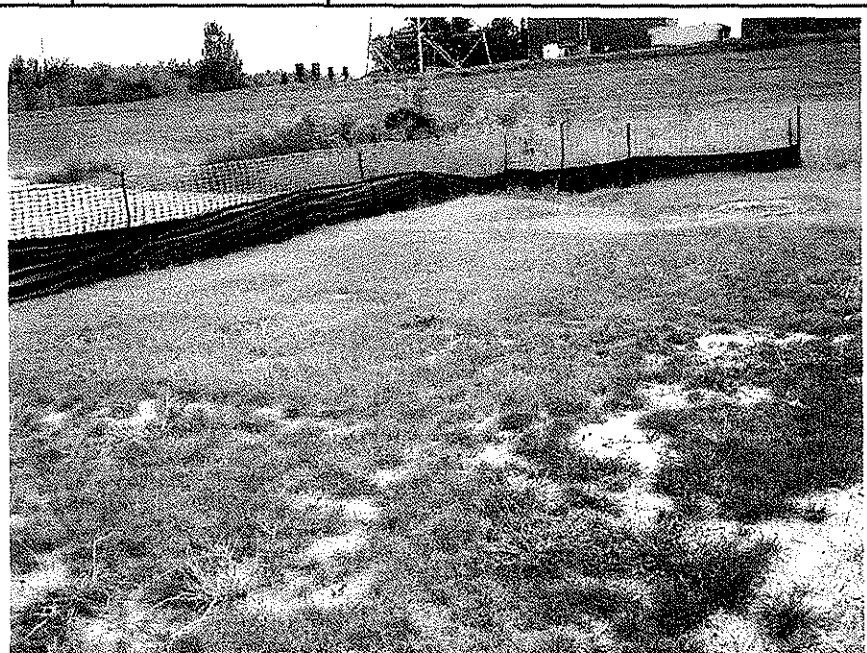
PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (week 5)	23
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	07/14/2004



PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (week 5)	24
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	07/15/2004

Omaha Lead Site Hydroseed Project Test Plot Area at the Missouri Wastewater Treatment Plant

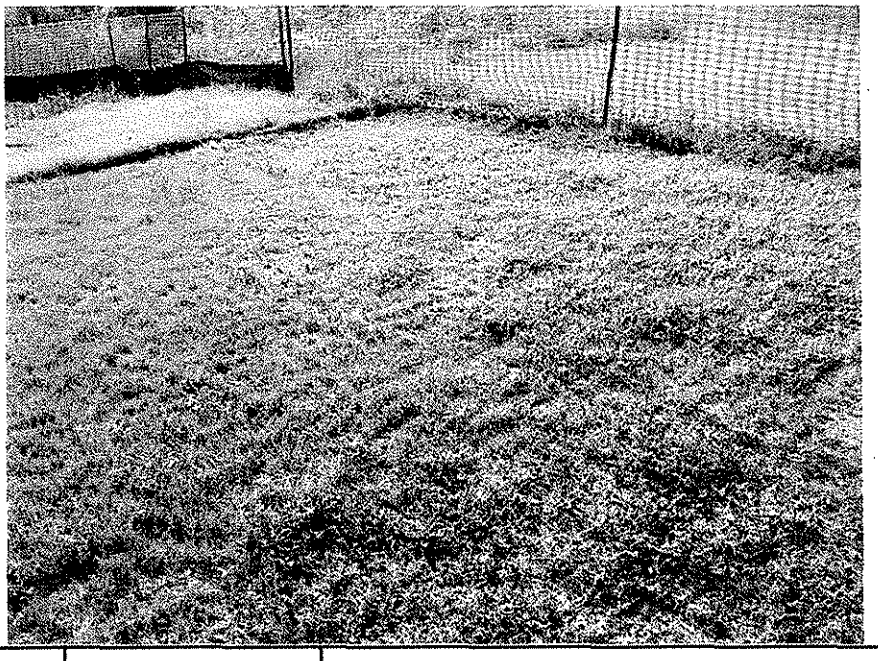
PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (week 10)	31
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	08/19/2004



PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (week 11)	32
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	08/23/2004

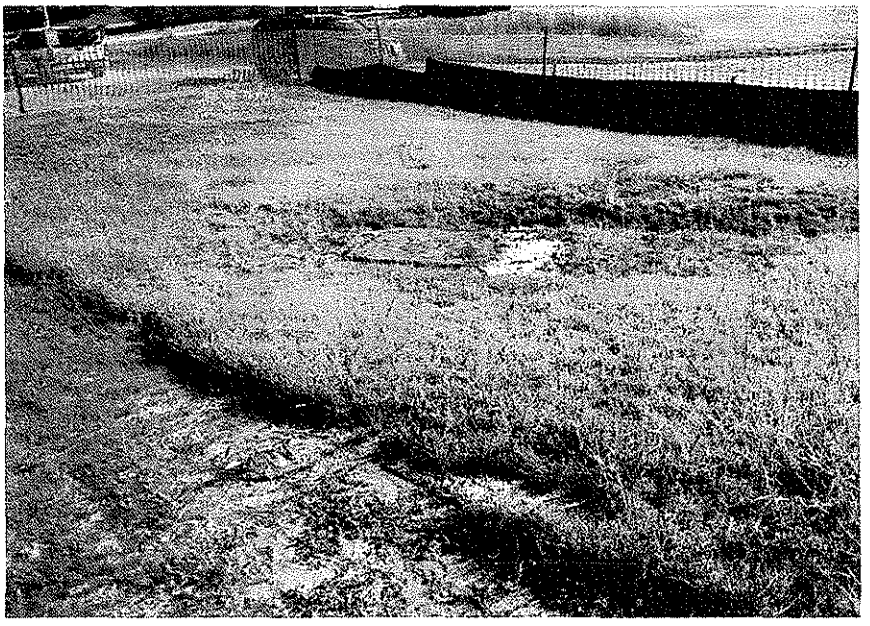
Omaha Lead Site Hydroseed Project Test Plot Area at the Missouri Wastewater Treatment Plant

PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (week 11)	33
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	08/26/2004



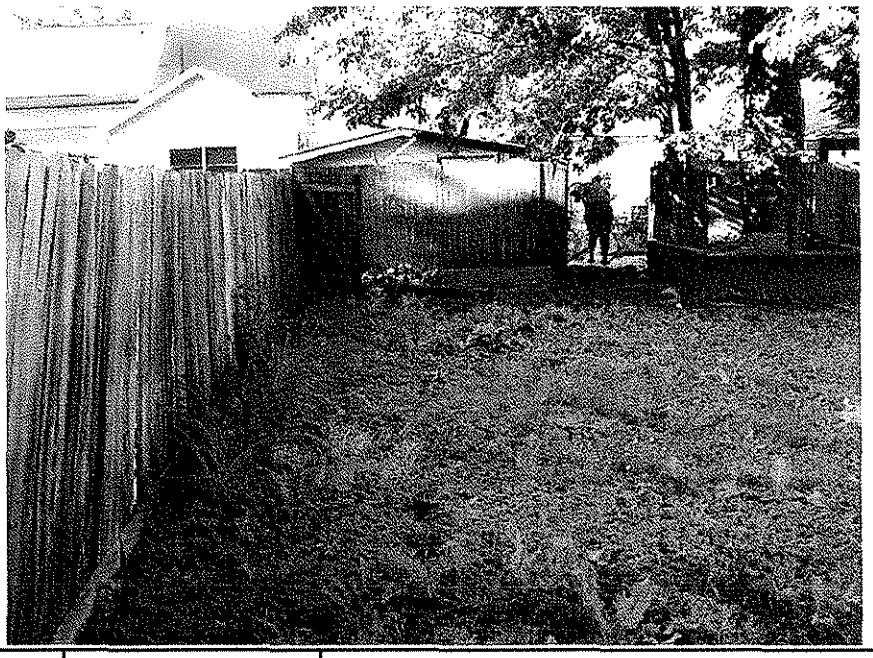
PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (week 11)	34
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	08/26/2004

Omaha Lead Site Hydroseed Project Test Plot Area at the Missouri Wastewater Treatment Plant

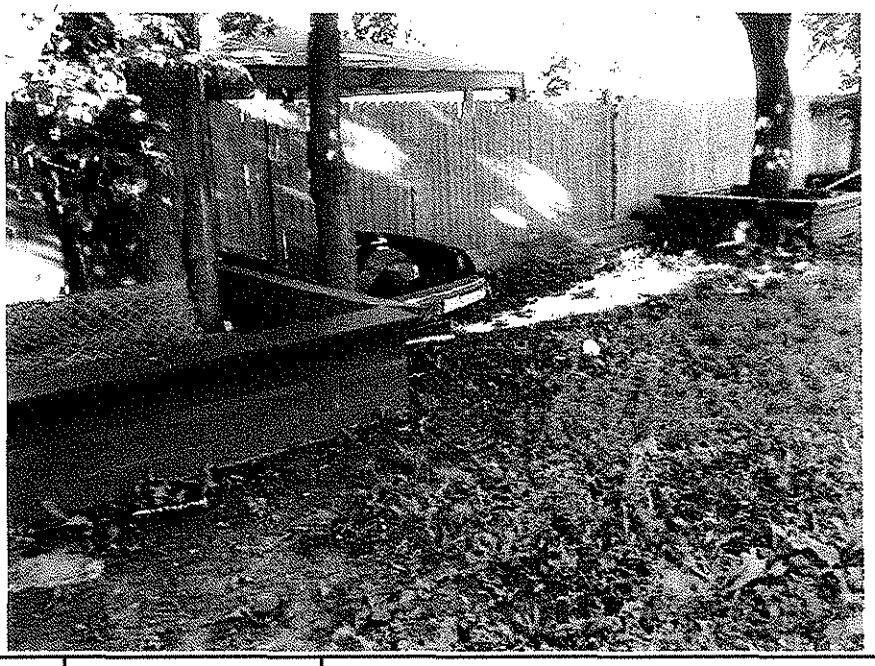


PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (week 11)	35
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	08/26/2004

Hydroseed Project: P0294 Test Plot

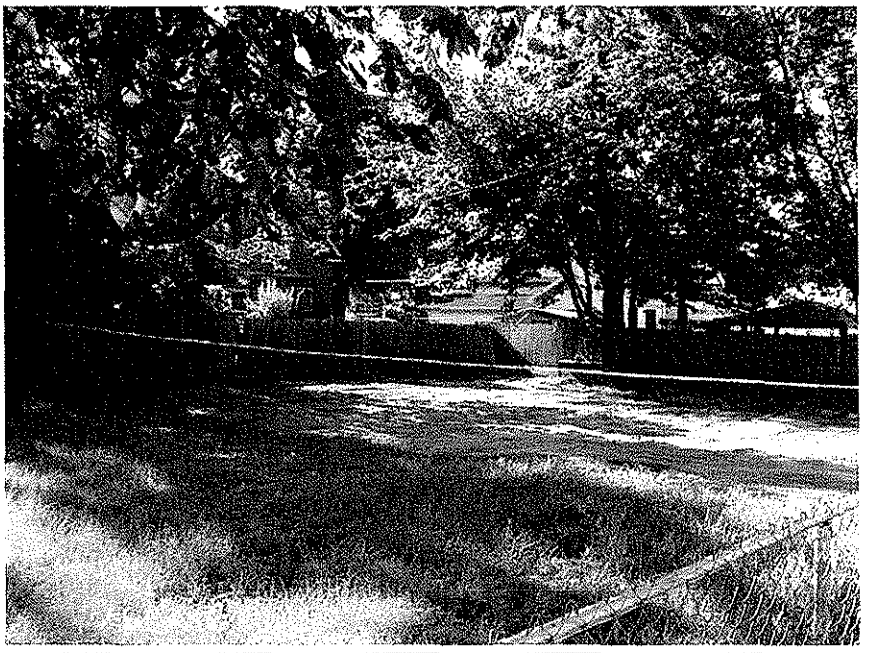


PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (pre-excavation)	36
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	06/03/2004

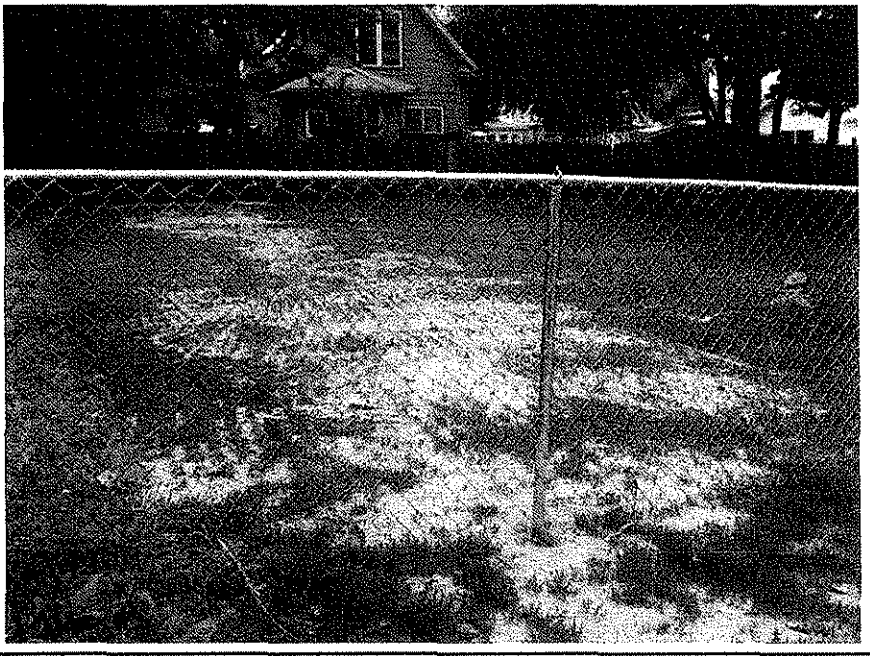


PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (pre-excavation)	37
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	06/03/2004

Hydroseed Project: P0294 Test Plot



PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (post-excavation). Lead levels were above 400 ppm after the 12" excavation, which required barrier fence to be laid down.	38
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	06/28/2004



PROJECT RESOURCES PROJECT NO. 209010.01	DESCRIPTION	Omaha Lead hydroseed test plot (hydroseed 3-4 weeks growth)	39
	CLIENT	U.S. Environmental Protection Agency Region 7	Date
	PHOTOGRAPHER	Matt Fohlmeister	08/17/2004