

**Assessing the Social Acceptability of Endophyte-Assisted
Phytoremediation of Polycyclic Aromatic Hydrocarbons: A Case
Study at Gas Works Park**

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Abstract

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Gas Works Park is a former gas production site that has been converted to a public park. Some of the contaminants have been remediated, however much of the soil is still contaminated with polycyclic aromatic hydrocarbons (PAHs). PAHs are toxic pollutants that have been shown to have numerous negative health effects. The primary form of remediation at Gas Works Park has been capping, which is usually considered a temporary remediation strategy since it does not remove contaminants from the site but simply covers them, and this requires repeated re-capping efforts. Phytoremediation is the use of plants to naturally remove contaminants from soil, sediment, and water. Endophytes can be added to plants to help improve phytoremediation capabilities and decrease phytotoxicity. Endophyte-assisted phytoremediation using willow shrubs is an alternative remediation strategy that could greatly improve soil quality and permanently reduce contaminant levels in the soil. The goal of the present study was to explore the social acceptability of utilizing phytoremediation strategies at Gas Works Park. Focus groups

and surveys were used to explore public perceptions of the park and of using phytoremediation to clean up existing contamination. Focus group conversations revealed an overall positive attitude toward phytoremediation at the park, and participants introduced ideas for improving phytoremediation acceptability and recommended locations for planting. Data from focus group analysis was subsequently used to inform the development of surveys that were administered to a larger segment of the population of park users. Surveys were used to examine the relationship between phytoremediation acceptability and risk, values, and concern. The relationship between demographic variables and social acceptability was also assessed. Focus group and survey findings indicated a high level of social acceptability of phytoremediation at Gas Works Park. Additionally, ecocentrism and concern were shown to be significant predictors of phytoremediation acceptability. Risk and anthropocentrism were not significant predictors of acceptability. Results and implications are discussed, and suggestions are made for future research and potential remediation actions at Gas Works Park.

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Chapter 1: Introduction and Literature Review

1.1 Study Site

Gas Works Park sits on land that was the site of a manufactured gas plant from 1900 until 1956. The land was purchased by the city of Seattle and, following about 10 years of debate, the decision was made to convert the space into a park. In 1980, the park became a state Superfund site and remediation efforts began (Washington State Department of Ecology [WSDOE], 2005). The primary contaminants of concern were benzene and polycyclic aromatic hydrocarbons (PAHs). Benzene was effectively remediated down to acceptable levels at the site through the use of air sparging and soil vapor extraction. Naphthalene, a PAH, was expected to degrade naturally, and levels were monitored regularly. Other PAHs were reduced to some degree through bioremediation efforts. Further remediation involved removal of the top layer of contaminated soil and subsequent capping with 12-18 inches of non-contaminated soil and grass. Capping was viewed as sufficient for further reducing human contact with PAHs, which are both carcinogenic and acutely toxic (Washington State Department of Ecology [WSDOE], 2005).

The current state of the park is satisfactory for the most part, but there are still some problems. During periods of heavy foot traffic, the soil cap is degraded and PAHs can leach up through the grass, exposing park users to the contaminants. Endophyte-assisted phytoremediation using willows is a promising strategy for removing PAHs from the contaminated soil and thereby preventing human contact with the contaminants. Phytoremediation is the use of plants to naturally remove contaminants from soil, sediment, and water. Endophytes are bacteria found within plants that can form beneficial relationships with host plants (Bulgarelli et al., 2013).

Using a technology called endophyte-assisted phytoremediation, endophytes can be added to plants to help improve phytoremediation capabilities and decrease phytotoxicity. One of the primary barriers to phytoremediation is park managers' belief that park users prefer a grass-only park and would oppose the introduction of shrubs into the area. Park managers, who are the primary decision-makers for park planning and cleanup, were approached with the suggestions to utilize endophyte-assisted phytoremediation to clean up remaining contamination. They declined using the technology, stating that park users prefer the open spaces. The purpose of the present study was to explore park users' acceptability of phytoremediation at Gas Works Park and to identify factors that might contribute to supporting or failing to support a phytoremediation project at the park.

Existing literature illustrates the negative effects of exposure to PAHs, as well as the effectiveness of endophyte-assisted phytoremediation, and provides some insight into the factors that may influence phytoremediation acceptability. Risk, knowledge, trust, values, ownership and participation, and landscape preference have been shown to play a role in social acceptability and may be important factors involved in phytoremediation acceptability.

1.2 Endophyte-Assisted Phytoremediation of PAHs

1.2.1 Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic aromatic hydrocarbons (PAHs) are organic contaminants common to fuel combustion and manufacturing sites and can remain in soil and sediments long after operations have ceased. PAHs are of particular concern due to the fact that they are slow to degrade and pose serious health and environmental hazards (Kathi & Khan, 2011). Most notably, they are known to be carcinogenic, teratogenic, and systemically toxic.

Research with lab animals has shown that birth defects, immune system suppression, and multiple forms of cancer are common consequences of exposure to PAHs (Armstrong et al., 2004; Boffetta et al., 1997; Henner et al., 1997; Germaine et al., 2009). Though no conclusive studies have been performed on humans, there is evidence to suggest that PAH exposure likely has similar effects (ATSDR, 1995). Epidemiological studies support this evidence, indicating that heavy long-term exposure to PAHs is associated with increased risk of lung, skin, bladder, and gastrointestinal cancers, as well as cataracts, kidney and liver damage, and skin inflammation (Armstrong et al., 2004; Boffetta et al., 1997; Boström et al., 2002; Polycyclic, 2009). Naphthalene in particular contributes to the breakdown of red blood cells if ingested in large amounts. Short-term effects of high levels of exposure include eye irritation, nausea, vomiting, diarrhea, and confusion (Polycyclic, 2009).

1.2.2 Traditional Remediation Methods

Given the highly toxic nature of PAHs, several strategies have been developed to remediate PAH-contaminated soil. Standard methods for doing so include capping, excavation to another site, incineration, air sparging, chemical treatments, and bioremediation (Doty, 2008; Henner et al., 1997; Kaimi et al., 2007; Wilson & Jones, 1993).

Traditional remediation methods, though generally effective at removing contamination, carry with them numerous negative consequences. For one, all of the methods mentioned above are expensive. In some cases contaminated soil is not ‘cleaned’ but rather moved elsewhere or simply covered up. Through excavation to another site, contaminated soil is collected and brought to another location (Wilson & Jones, 1993; Henner et al., 1997). This just relocates or postpones the problem. The method also requires large amounts of fuel to truck contaminated soil over long distances, which then worsens problems of air pollution and resource use.

Some other drawbacks are air pollution, input of chemicals such as surfactants or acids, and the introduction of new contaminants to the site (Gan et al., 2009; Henner et al., 1997). Incineration can create new air pollutants, as well as residual ash that requires hazardous waste disposal (Riser-Roberts, 1998). Air sparging is limited to use with a unique set of contaminants and unique soil conditions. It also carries with it the possibility of releasing contaminants into the air (EPA, 2012). Chemical treatments sometimes require the introduction of new contaminants to the site and can result in creation of dangerous intermediate metabolites (Rubio-Clemente, Torres-Palma, & Peñuela, 2014).

Bioremediation involves using microbes to break down pollutants into less toxic substances. Though it is potentially less problematic than other traditional remediation methods, it still requires the use of surfactants and co-metabolites, is time consuming, and sometimes creates intermediate metabolites that can be more dangerous than the original contaminants (Gan et al., 2009; Doty, 2008; Straube et al., 2003; Henner et al., 1997; Wilson & Jones, 1993; Werner & Brauch, 1988).

In addition to some initial bioremediation and air sparging efforts early on in the cleanup process, the remediation strategy of choice at Gas Works Park has been capping. Usually considered to be a temporary remediation strategy (Henner et al., 1997), capping is not well suited as a permanent solution to contamination. Consequently, there have been multiple efforts to “re-cap” the soil at Gas Works Park, as the existing cap occasionally thins due to heavy foot traffic. A more permanent and more effective solution would be beneficial and may reduce or eliminate the need for future capping projects.

1.2.3 Phytoremediation

Phytoremediation is the use of plants to naturally remove contaminants from soil, sediment, surface water, and groundwater (Doty, 2008; Kathi & Khan, 2011; Soleimani et al., 2008). This remediation method is versatile and can be used to clean up a wide variety of both organic and inorganic contaminants.

Phytoremediation is advantageous over other, more traditional, remediation strategies for a variety of reasons. Phytoremediation does not require excavation and relocation of soil, thereby removing the need for additional disposal sites and minimizing ecosystem disturbance (de-Bashan et al., 2012). In addition to being far less expensive than other methods, it is also more aesthetically pleasing, stabilizes soil and contaminants, and offers additional environmental benefits such as animal habitat and carbon sequestration (Kang, 2014; Doty, 2008).

Phytoremediation is especially well-suited to locations with diffuse contamination, such as former manufacturing sites where pollutants have been released into the air and deposited in the surrounding soil (de-Bashan, 2012).

Phytoremediation has been shown to be an effective strategy for remediating PAHs, which are a primary contaminant of concern at Gas Works Park. Research indicates that remediation of PAHs can be greatly enhanced through phytoremediation using many different types of plants (D'Souza et al., 2015; Técher et al., 2012; Meng, Qiao, & Arp, 2011; Liste & Alexander, 2000). Hultgren and colleagues (2010) tested the ability of Willow plants to remediate PAHs from soil contaminated with creosote. The researchers found that willow was effective at degrading phenanthrene and pyrene, with a greater percentage of contaminants degraded from the soil than in soil without plants. Research by da Cunha and colleagues (2012) supports the effectiveness of phytoremediation using willow to remove up to 98% of PAHs from

contaminated soil. Results from research conducted by Yergeau and colleagues (2014) indicate that, when exposed to PAH-contaminated soil, willow plants display an increase in the expression of genes that degrade hydrocarbons. Together with the fast growth and high transpiration potential of willow, these findings suggest that willow can be a beneficial phytoremediation tool.

There are multiple forms of phytoremediation, including phytoextraction, phytostabilization, phytovolatilization, and phytodegradation. Through phytoextraction, also called phytoaccumulation, the contaminant is taken up by the plant and stored in its tissues (Boonyapookana et al., 2005). This is a common form of phytoremediation for inorganic contaminants, which cannot readily be broken down by plants. When phytoextraction occurs, the plant itself becomes contaminated, and the tissues need to be harvested and disposed of to prevent contact with humans or wildlife and to completely remove the contaminant from the ecosystem (Pivetz, 2001). Phytoextraction is more effective than excavation since the contaminated plant mass is considerably less than the mass of the contaminated soil, and the overall soil quality is enhanced by the plant exudates.

Through phytostabilization, contaminants are contained within the soil and prevented from moving elsewhere (Mendez & Maier, 2008). The plants also stabilize the soil itself, further reducing the spread of contamination via erosion and subsequent runoff (Pivetz, 2001). Similar to phytostabilization, phytovolatilization does not remove contaminants from the environment. Instead, pollutants are dispersed into the air and diluted, which minimizes the negative impacts of more concentrated contaminants (Ghosh & Singh, 2005).

Phytodegradation involves the uptake, metabolization, and degradation of pollutants within the plant itself. When taken up, the contaminants are broken down within the plant and

rendered partially or completely inert (Newman & Reynolds, 2004; Pivetz, 2001). The primary advantage of phytodegradation is that contaminants can be removed from the environment completely and do not have to be transported to another location or dealt with in another manner. Most relevant to the proposed study is the effectiveness of phytoremediation, and specifically phytodegradation, for cleaning up petroleum-contaminated soils, like those at Gas Works Park (Soleimani et al., 2008).

There are some potential drawbacks to phytoremediation. These include phytotoxicity, limited uptake and slow degradation of contaminants, and volatilization of pollutants (Li et al., 2012; Khan & Doty, 2011). These shortcomings can limit the effectiveness of phytoremediation as a tool. It is therefore valuable to find ways to minimize drawbacks to phytoremediation so as to optimize the efficiency and effectiveness and improve overall environmental health.

1.2.4 Endophyte-Assisted Phytoremediation

Endophytes are non-pathogenic bacteria found within the tissues of healthy or symptomless plants and can form beneficial relationships with their host plant (Bulgarelli et al., 2013; Schenk, Carvalhais, & Kazan, 2012; Phillips et al., 2008; Soleimani et al., 2010). Some of the most notable benefits of endophyte-assisted phytoremediation are decreased plant stress and improved ability to take up and degrade contaminants from soil (Khan & Doty, 2011). One challenge with remediation of PAHs is their phytotoxicity, in which exposure to the contaminants the plants are intended to remediate can result in damage to and death of the plants (Doty, 2008). Plant-endophyte partnerships can help to mitigate the toxic effects of contaminants. Additionally, the use of endophyte-assisted phytoremediation can lead to an even greater improvement in decontamination of polluted areas (Bisht et al., 2014; Doty, 2008; Khan & Doty, 2011; Germaine et al., 2009).

The addition of endophytes to grasses has been shown to increase uptake and tolerance of PAHs (Khan & Doty, 2011). Andreolli and colleagues (2013) found similar effects in poplar trees, which showed increased remediation of PAHs and decreased toxicity with the addition of the endophyte *B. fungorum* to roots. The researchers found that inoculation of poplar trees led to increased uptake and exudate production, protective effects on roots, and greater phytoremediation efficiency. Inoculated trees had significantly greater efficiency in PAH remediation, with up to 99% of PAHs removed from the soil by the end of the experiment. Endophytes may also have the added benefit of reducing transpiration of contaminants into the atmosphere, which is a commonly cited concern associated with phytoremediation (de-Bashan et al., 2012). The most well-studied PAH degrading bacteria are *Burkholderia*, *Pseudomonas putida*, and *Pseudomonas stutzeri* (Kang, 2014).

Plants can be inoculated with endophytes that occur naturally in other plants. For example, researchers have shown that pea plants inoculated with *Pseudomonas putida* isolated from poplar trees had increased ability to degrade naphthalene (Germaine et al., 2009). Weyens and colleagues (2013) tested the effects of adding endophytes to willow and found that the addition of *Burkholderia* sp. and *Pseudomonas* sp. improved the ability of the willow to degrade toluene. Adding PAH-degrading endophytes to willow could be extremely beneficial, as willow have high biomass, grow relatively quickly, and could efficiently remediate contaminants (Dhankher et al., 2011).

Specific to phenanthrene, research indicates benefits of the addition of a natural microbial symbiont of poplar, *Pseudomonas putida* PD1, to willow and grasses. Addition of the endophyte was shown to protect the plants against phytotoxicity of the PAH and to significantly improve the ability of willow and grasses to remove phenanthrene from soil (Khan et al., 2014).

Inoculating willow with PAH-degrading endophytes is a promising strategy for remediation of PAH-contaminated soil.

1.3 Social Acceptability

Despite being an effective, inexpensive, and safe remediation tool, phytoremediation is not widespread. In some locations this may partly be due to lack of familiarity with the method, or assumptions that stakeholders are disapproving of phytoremediation. No matter how sound the science, it can be difficult to put phytoremediation into practice without approval by stakeholders (including community members) and project managers (LaChapelle & McCool, 2005; Wolfe & Bjornstad, 2002). Consequently, social acceptability assessments are a valuable tool in determining the potential viability of phytoremediation projects.

The introduction of new technologies and management options are embedded in a socio-political context that is unique to each community. That context determines, in part, which technologies become controversial and which are socially acceptable (Gupta et al., 2011). There are a number of factors that can come into play in terms of influencing social acceptability. Risk perception is a key component, along with values, ownership, and trust (Shindler et al., 2004; Wolfe et al., 2002). Gaps in public knowledge and awareness of existing remediation efforts can also influence acceptability (Poumadère et al., 2011). Furthermore, each site and community is unique, bringing with it a different set of considerations and making it important to do an assessment of social acceptability and situational factors for each proposed site. Various factors that may contribute to social acceptability are discussed below.

1.3.1 Risk

A major component of risk perception is the frequent discrepancy between expert knowledge and public beliefs about potential hazards. More often than not it seems, experts and the public differ in their opinions on the severity of a particular risk (Slovic et al., 2005). Much of this may be due to experts' tendency to rely on the scientific component of risk, and a preference for looking at risk assessments from a purely factual perspective (Covello & Sandman, 2001). Also relevant are differing interpretations of definitions of risk. Risk is technically defined as the probability or frequency with which a harmful event is going to occur, combined with the consequence of the event (Mazur & Curtis, 2006; Mazur & Boterrill, 2004). To many, and to experts in particular, risk refers to expected annual mortality, while the public tends to view risk as meaning something different, such as a general feeling of danger or potential health impacts (Sandman, 1987). Because risk perception is socially constructed, definitions and responses will vary based on the culture and the individual (Mazur & Boterrill, 2004).

Some common themes pervade the literature on risk. These include the roles of knowledge (Covello & Sandman, 2001; Johnson, Sandman, & Miller, 1992), trust (Covello & Sandman, 2001; Mazur & Boterrill, 2004; Mazur & Curtis, 2006), risk/benefit analysis (Slovic, Peters, Finucane, & MacGregor, 2005; Slovic, Peters, Finucane, & MacGregor, 2004; Mazur, 1985), and risk-as-feelings (Whitmarsh, 2008; Slovic et al., 2005; Loewenstein et al., 2001; & Zajonc, 1980).

Knowledge

The relationship between knowledge and risk perception is complex. Knowledge of potential risks is generally considered to be necessary in order to make an assessment of risk. Presumably, one needs to know about the potential threats in order to make an effective decision about the potential risk of the decision (Covello & Sandman, 2001). However, there is evidence that knowledge of risk severity may not significantly predict the degree of perceived risk (Wildavsky & Drake, 1990).

It is a common belief among risk professionals that if the public is given knowledge about actual risks, public risk perception will go down, especially if actual risks are relatively small (Johnson et al., 1992). However, there is evidence that risk perceptions may have relatively little to do with knowledge of actual risk or perceptions of how well risk is being managed by governing bodies (Johnson et al., 1992). Grasmück and Scholz (2005) found that neither self-estimated knowledge nor actual knowledge accurately predict risk estimation. Their research indicates that high levels of self-estimated knowledge are associated with low perceived levels of risk, despite actual risk. Actual knowledge was not shown to be significantly correlated with any risk variables. Beyond knowledge of the existence of risk, information about risk severity may also have little to do with risk perception. People are often alarmed by risks that are not deadly, and are not frightened by more extreme risks (Sandman, 1987).

In fact, evidence suggests that *any* technical risk information that is shared with the public may lead to an increase in perceived risk (Johnson et al., 1992). This is particularly the case when the public is outraged and when they believe that risk is high. In this case, providing more information about risk, even if it is about the risk being minimal, often does little to minimize outrage and perceived risk (Covello & Sandman, 2001). Presumably, the effect is

strong even if prior knowledge about risk is lacking. If the public believes that visiting a location or engaging in an activity carries little to no risk and they then learn that there are potential risks associated with those things, they may be more likely to have increases in risk perception.

Additionally, complete knowledge of existing risks is not always necessary nor sufficient, as sometimes decisions need to be made to avert an environmental or health crisis before the full magnitude and likelihood of it occurring is even known (Covello & Sandman, 2001). In this case, general perceptions of a situation may be the determining factor. This does not mean all facts should be ignored, but rather that possibilities should be assessed, weighing potential pros and cons. Knowledge is almost certainly relevant in terms of risk perception. However, it is important to consider that knowledge may play less of a role than is commonly believed and cannot entirely predict assessments of risk among the public. It is important to look into other potentially relevant factors as well.

Trust

Remediation of contaminated public land poses a unique situation, as trust plays a role in both previous and future remediation efforts. Trust in those who performed previous remediation efforts and trust in the effectiveness of those remediation efforts may affect trust in future remediation strategies. Trust in an agency is an important part of risk assessment for a hazard a person has little knowledge about (Brunson & Shindler, 2004; Winter et al., 2004; Siegrist & Cvetkovich, 2000). Some researchers even suggest that trust in institutions is the most powerful factor for predicting risk perceptions (Wildavsky & Drake, 1990). More specifically, trust that previous responsible parties have sufficiently cleaned up a landscape may influence risk perception and acceptability of future remediation projects (Bickerstaff, 2004; Renn, 2004).

Additionally, trust in the individuals or agencies who are in charge of implementing a new remediation project will likely affect acceptability of that project (Siegrist & Cvetkovich, 2000).

Trustworthiness of those supplying technical risk information can influence the impact of the information and consequently the perception of risk (Johnson et al., 1992). Industry is seen as more credible when stating that risk is high and environmental problems are dangerous. Whereas environmental organizations and environmentalists are seen as more credible and trusted when they say the risk is low (Johnson et al., 1992). For this reason, it is important to consider the source of information and how that source might impact public perceptions.

Trust generally does not influence risk perceptions in isolation, but instead interacts with other factors. For example, Siegrist and Cvetkovich (2000) found that when people are knowledgeable about a potential hazard, trust does not affect risk assessment. The assumption being that, if an individual has a great deal of knowledge about a topic, they do not need to rely on information from others to make assessments about safety. Consequently, whether or not they trust the organization would be largely irrelevant.

Analysis and Risk-as-Feelings

Risk analysis takes into consideration logic and scientific deliberation in assessment of a situation (Slovic & Peters, 2006). Risk and benefit perceptions are widely seen as influencing acceptability of management options (Gupta et al., 2011). Use of a risk/benefit analysis assumes that each potential option has some good and some bad features, which add to and detract from utility respectively (Mazur, 1985). With that, it is assumed that the positives and negatives should at the very least be in balance, so that the positives can offset the negatives (Mazur, 1985).

Benefits of new management options and technologies are often communicated frequently and clearly, but the technologies can also come with risks. The public, if unfamiliar with the new technology, may find the potential risks to outweigh possible benefits (Gupta et al., 2011). In reality, risk and benefit are positively correlated, with high risk often co-occurring with high benefit. However, the public frequently view the two as negatively correlated, assuming that high risk is associated with low benefit and low risk with high benefit (Slovic & Peters, 2006; Slovic et al., 2005). By this logic, it would be beneficial to emphasize the benefits of a desirable technology, as doing so would theoretically simultaneously lower risk perception (Slovic et al., 2005).

While risk analysis represents a cognitive aspect of risk assessment, risk perception is also informed by an affective component. The affective component is likely as influential as cognitive components, if not more so, in terms of overall risk assessment and behavior. Overall, the process of weighing pros and cons is a relatively inefficient strategy for assessing the appropriateness of a particular solution. It is more efficient to create a mental shortcut, or an overall affective impression, of a situation or setting (Slovic et al., 2005).

Cognitive and affective assessments of risk differ in terms of how they develop. Affective, or emotional, reactions are informed largely by the vividness and proximity of potential consequences and personal experience with outcomes (Loewenstein et al., 2001; Whitmarsh, 2008). Unlike cognitive evaluations, which take probability into account, affective responses to risk are minimally affected by probability (Loewenstein et al., 2001). Cognitive and affective judgments also differ in terms of the amount of control one has over them. Because they are largely insensitive to objective information, affective judgments are more heavily ingrained and less subject to change as more information comes in (Zajonc, 1980). In fact, they

tend to be relatively irrevocable, due to the fact that they are virtually immune to persuasion. Consequently, it is extremely challenging to predict attitudes, decisions, and judgments using cognition-based solutions (Zajonc, 1980).

1.3.2 Values

Overall in the United States, there is a widespread concern for environmental issues. However, concern does not always translate to behavior, potentially due to the need for sacrifice or inconvenience related to the steps required for conservation (Thompson & Barton, 1994). The discrepancy between those who do and do not engage in proenvironmental behavior may be explained in part by differences in values related to the environment; specifically anthropocentrism and ecocentrism.

Anthropocentrism refers to a concern primarily for human welfare, and an assumption that the environment should only be protected because of the ways it can serve humans and fulfill human needs. Ecocentrism refers to a concern for all forms of life, asserting that nature is valuable for its own sake, and that the environment should be protected even if that protection requires some sacrifice (Nordlund & Garvill, 2002; Kortenkamp & Moore, 2001; Bjerke & Kaltenborn, 1999; Thompson & Barton, 1994).

Ecocentrism and anthropocentrism are both associated with a desire to preserve the environment, but the motivations for doing so differ (Thompson & Barton, 1994). Research has shown positive correlations between ecocentrism and proenvironmental behavior, independent of other environmental values (Thompson & Barton, 1994). One possible reason for this finding is that environmental conservation sometimes requires sacrifices in terms of human-centered values. Those high in anthropocentrism may not be willing to make such sacrifices, whereas ecocentrics may be more likely to do so because they see intrinsic value in the environment and

view preserving it as worth sacrificing some material quality of life (Thompson & Barton, 1994). In a study assessing remediation preferences on private residential land, Weber and colleagues (2001) found that environmental benefits were the most important factor influencing preferences for bioremediation, before aesthetics and cost.

The effects of environmental values extend beyond preferences for environmental action. They can come into play far before any actions are proposed and can affect whether or not a problem is even recognized. Specifically, there is a positive effect of ecocentrism (and not anthropocentrism) on awareness of an environmental problem (Nordlund & Garvill, 2002). Ecocentrism and anthropocentrism are both orientations toward the environment, but ecocentrism is a stronger motive for acknowledging environmental issues and for engaging in proenvironmental behavior. It is also worth noting that anthropocentrism and ecocentrism are not mutually exclusive. There is, in fact, a positive correlation between the two (Bjerke & Kaltenborn, 1999), and the values are measured and assessed based on the level of the individual value itself.

It is not clear whether phytoremediation would fall under proenvironmental behavior in terms of the effects of ecocentrism and anthropocentrism on acceptability. The present study explores the role of environmental values on social acceptability of phytoremediation and may help to tie this together with the research on proenvironmental behavior.

1.3.3 Ownership and Participation

Ownership is another key component of social acceptability. Ownership of a plan arises when community members are involved with agencies and management institutions in the planning process. It operates within the context of dialogue and knowledge to facilitate increased acceptability of and commitment to management decisions (LaChapelle & McCool, 2005).

Ownership is also important with regard to power relations and the associated effects on community acceptance, and interacts closely with power to challenge conventional ideas about control. It allows participants to have a voice both in the definition of the problem and in the outcome of the issue, contributing to a reallocation of authority (LaChapelle & McCool, 2005). Through stakeholder ownership of a project, alternate forms of knowledge are recognized, and power over outcomes is more distributed (LaChapelle & McCool, 2005).

Public participation is a vital component of ownership. Involvement of the public in the planning process is beneficial not only for the community, but also for the leaders and project managers. Knowledge of public concern and opinion provides project managers with a stable framework from which they can work to align with public preferences or address concerns (Yankelovich, 1991). In this vein, it is beneficial for managers to view public participation as a process of mutual learning and understanding, as opposed to simply an opportunity to inform the public about what will happen. The public has a great deal of insight and perspective that is unique to a situation and community, meaning participants can likely offer as much knowledge to managers as managers can offer to them (Shindler et al., 2004).

Specific to remediation of contaminated land, Feldman and Hanahan (1996) found that public participation was one of the primary concerns cited by residents near a contaminated site. They postulated that a desire for public involvement was related to distrust toward authorities and stated a belief that threats to health and environmental well-being are largely due to lack of citizen involvement and political accountability. Other researchers state the importance of public participation in remediation efforts, citing community groups' distrust of political processes and consequent role in forcing the cleanup of contaminated sites (Rowe & Frewer, 2000; Freudenberg & Steinsapir, 1991). When the public is involved in decision-making related to

remediation options, acceptance of the chosen options can increase, which can promote overall improvements in the success of remediation (Balasubramaniam, Boyle, & Voulvoulis, 2007).

Public participation is also valuable because resource management options are rarely a matter of objective science. It is important to incorporate sound scientific and economic principles, but those factors seldom are all that is necessary to determine the best course of action. Rational decisions based on technical-scientific models generally do not incorporate public input, making it difficult to gain social acceptability (Shindler et al., 2005). Early incorporation of public concerns, values, and ideas is a critical component in garnering public support for management decisions and can go a long way toward increasing enjoyment and acceptability of the landscape (Atauri et al., 2000; Poumadère et al., 2011; Shindler et al., 2004; Wolfe et al., 2002).

Historically, there has been somewhat of a rift between expert approaches and approaches based on public participation. The ‘expert’ paradigm asserts that only trained professionals can assess landscape value and beauty, which is done via objective assessment of the landscape (Brown & Brabyn, 2012). The assumption is that there exist universal parameters of landscape quality, which are based on pre-existing models of aesthetics and perception (Brown & Brabyn, 2012; Daniel, 2001). Tveit (2009) rejects the idea that experts are the only ones who can accurately assess landscapes, saying that professionals can work to accommodate preference of the public and need to pay attention to the effects of landscape change on aesthetic preference and enjoyment.

More recently, researchers have called for the integration of these two strategies as a way to both optimize landscape management and improve public perception of landscape management and changes (Tveit, 2009; Atauri et al., 2000; Daniel, 2001). The socio-cultural

(non-expert) paradigm states that landscape changes should be informed by communal decision-making processes instead of direct assessment by experts, with an emphasis on negotiation (Daniel, 2001). It is possible to combine the expert and socio-cultural paradigms to create a more balanced approach that integrates expert knowledge and community input. The goal would be increased acceptability and a more balanced, less extreme management outcome. Atauri and colleagues (2000) stress that it is critical to factor in the preferences of those who use the landscape, not just those who manage it. A primary focus is on the interaction between physical features and how individuals interact with those features and the landscape as a whole (Daniel, 2001; Wherret, 2000; Zube et al., 1982)

1.4 Landscape Preference

The term landscape is commonly thought of as referring to an outdoor environment as perceived by a person using that environment (Arriaza, Cañas-Ortega, Cañas-Madueño, & Ruiz-Aviles, 2004). In reality, landscape encompasses the visual appearance-based aspects of an area, as well as psychological responses to the features that make up the landscape.

By nature, phytoremediation almost always requires some sort of change in landscape due to the addition of vegetation used for remediation. It is therefore critical to consider landscape preference when assessing the social acceptability of phytoremediation in public spaces. If phytoremediation is to be implemented with maximum acceptability in a heavily used public location, it becomes important to coordinate landscape changes in a way that is consistent with user preferences, and ideally to match those preferences with the areas within the park that contain the highest levels of contamination.

Previous research provides insight into which landscape features tend to be more and less desirable to viewers. The presence of water appears to be a feature that is universally considered

to be aesthetically positive (Atauri, Bravo, & Ruiz, 2000; Brown & Brabyn, 2012; Kaltenborn & Bjerke, 2002; Wherrett, 2000; Ulrich, 1986). Vegetation also has been found to have a positive effect on preference, with lush vegetation and trees seen as particularly desirable in park settings (Atauri et al., 2000; Buhyoff et al., 1984; Ulrich, 1986). Ulrich (1986) found that landscapes consisting of empty grass-covered expanses garnered low preference ratings, with a significant increase in ratings when scenes included plants. Similar findings are reported by other researchers, who found that landscapes with dry land and minimal vegetation are more likely to be rejected (Brown & Brabyn, 2012; Arriaza et al., 2004; Atauri et al., 2000). Similarly, Arriaza and colleagues (2004) found that a greater degree of ‘wildness’ is generally seen as having a positive effect on landscape appearance. Research by Weber, Kowarik, and Säumel (2014) suggests that the presence of roadside vegetation improves landscape approval, whether the vegetation is ‘wild’ or cultivated. There is also research indicating that landscape preference in urban areas increases with tree density, particularly when trees are added to a previously barren landscape (Jiang et al., 2015), in addition to research showing preference for forested scenes and benefits associated with forest proximity (Kaplan & Austin, 2004).

Many of the landscape factors discussed above can be summed up as contributing to ‘visual quality’. Simply put, people want the landscape to be aesthetically pleasing, which is a joint product of visual features and emotional responses to the landscape. Part of this is related to the ‘naturalness’ of a landscape, which is often strongly correlated with greater perceived landscape quality (Matsuoka & Kaplan, 2008; Daniel, 2001). Some research indicates that purely ‘natural’ landscapes are not always preferred over those that are ‘man-made’. Preferences have been found for landscapes that integrate ‘natural’ and ‘man-made’ features (Hadavi, Kaplan, & Hunter, 2015).

Constructed landscape features can provide information about the landscape, such as historical uses, the nature of the land, and present suitable uses. Human constructed features have a unique impact on landscape assessment, with buildings regularly judged as less desirable than 'natural' landscape features such as trees, vegetation, and water (Ariazza et al., 2004; Kaltenborn & Bjerke, 2002; Ulrich, 1986; Mudrak 1982/1983). When a landscape already has human constructed features, landscape assessments are more positive when vegetation is present (Ulrich, 1986). There may, however, be some caveats to negative ratings of constructed features. In a location where human-made features are a focal point and represent an historic background, those features may be positively-evaluated by land users. Arriaza and colleagues (2004) report that in this case, constructed features contribute to increases in the perceived visual quality of a scene. Kaltenborn and Bjerke (2002) address this idea to some degree with finding that, as long as human influence is in balance with natural elements, it may be appreciated and more widely accepted.

Not surprisingly, landscapes with a judged threat are rated as less desirable, regardless of other aesthetic variables (Ulrich, 1986). Ulrich discusses the role of clear hazards such as steep cliffs and uneven ground in predicting lower landscape desirability. It is unclear whether less visible and less tangible threats such as below-ground contamination have a similar negative effect on landscape preference.

Atauri and colleagues (2000) found that the types of activities people engage in while utilizing a space can affect perceptions of the space and preferences for its management. Specifically, recreation and more open landscapes are especially valuable in large cities where open spaces are limited and are at a premium (Payne, Mowen, & Orsega-Smith, 2002; Atauri et al., 2000). There is also evidence that the location in which park users reside can have an effect

on preferences for the type of landscape. For example, researchers have found that those who reside in urban areas are more likely to prefer parks that are more developed, whereas those who live in more rural areas prefer more “wild” environments (Schroeder, 1983).

Lastly, some research suggests a potential role for demographic variables in predicting landscape preferences. Zube and colleagues (1983) found that natural landscapes with more vegetation density are preferred among young and middle-aged adults, but not among elderly adults. Similarly, research by Tahvanainen and colleagues (2001) suggests that preferences for natural forest settings decrease with age. One potential caveat is that young parents may prefer landscapes that are less dense, as dense vegetation is often viewed as a potential threat to safety (Bjerke, Østdahl, Thrane, & Strumse, 2006; Özgüner & Kendle, 2006). Education level may predict vegetation preferences as well, with research indicating that higher levels of education are associated with preferences for moderate to dense vegetation, versus little to no vegetation (Bjerke et al., 2006).

1.4 Rationale

Research into the social acceptability of phytoremediation is lacking. This includes assessments of landscape preference, risk assessment, values, and aspects of phytoremediation. Landscape preference, though inherently connected to phytoremediation, has not been explored as a component of phytoremediation acceptability. However, many of the principles of social acceptability and landscape preference research can be incorporated into an exploration of the acceptability of endophyte-assisted phytoremediation in a public recreation setting. Landscape change not only relates to visual quality and recreation, but also has a component of human

safety and environmental conservation. This is particularly true at a site that contains toxic pollution and is regularly altered in order to limit public exposure to contaminants.

Gas Works Park is unique in its history, location, and layout. Because of the type of contamination, community use and perceptions of the landscape, and the uniqueness of the park itself, Gas Works presents an ideal site for exploring phytoremediation acceptability. The gas structures provide information about the history of the park, which could mean that previous research findings regarding the undesirability of man-made structures (Ulrich, 1986), may not be applicable to the Gas Works Park landscape. This might be the case especially if respondents associate the structures with heritage values (Brown & Raymond, 2007) and if the structures are viewed as being in balance with natural elements (Kaltenborn & Bjerke, 2002). The history of Gas Works Park may also play a role in the acceptability of landscape change. The park has gone through many closures and transformations as managers and regulatory agencies work to improve safety and decrease contamination. It may be the case that park visitors, especially those who are familiar with the ongoing changes, will be more accepting of phytoremediation because they have already accepted that the park is in near-constant flux.

It is also important to take into consideration the unique role of phytoremediation on landscape preference. Phytoremediation involves more than simply adding vegetation to the park landscape, as the primary goal of adding the plants is contaminant removal. As a result, the fact that plants are being used to make the park cleaner may result in notably different landscape preference outcomes than would simply adding plants to the landscape without the added benefit of cleanup.

The present study takes findings from the social acceptability and landscape preference research and applies them to the exploration of phytoremediation implementation options in a

popular historic park setting. The results of this research will contribute to the existing literature and provide information about the values and preferences unique to phytoremediation. Finally, the research outcomes can be used to inform management decisions for remediation and landscape options at Gas Works Park.

1.5 Research Questions

1. Will park users be accepting of phytoremediation at Gas Works Park?
2. What are park users' landscape preferences at Gas Works Park and how might they affect phytoremediation acceptability?
3. Do the types of activities park users engage in influence their acceptance of phytoremediation at Gas Works Park?
4. Do park users' values predict their acceptance of phytoremediation at Gas Works Park?
5. Do park users' perceptions of contamination-related risk at the park predict their acceptance of phytoremediation at Gas Works Park?
6. Do park users' concerns about phytoremediation predict the acceptability of phytoremediation at Gas Works Park?

Chapter 2: Methods

2.1 Research Design

A mixed-methods approach was used for this research. In mixed methods research, components of quantitative and qualitative research are combined within a single study (Johnson, Onwuegbuzie, & Turner, 2007; Johnson & Onwuegbuzie 2004). A mixed-methods approach allows for capitalization on the benefits of both qualitative and quantitative methods while minimizing disadvantages (Cresswell et al., 2003; Johnson & Onwuegbuzie, 2004). This approach is a practical way to combine methods into a workable research paradigm.

Mixed-methods research is inherently flexible, and there is no one single criterion for definition, nor particular way to conduct a study (Johnson, Onwuegbuzie, & Turner, 2007). It is distinct from mixed-model research, which combines quantitative and qualitative research throughout each stage of research. In mixed-methods approaches, distinct stages are developed for qualitative and for quantitative strategies (Johnson & Onwuegbuzie, 2004).

The present study began with a qualitative stage, the results from which were analyzed independently and were used to inform development and administration of the quantitative stage. In the first phase of the study, focus group interviews were used to explore emerging themes in discussion of activities, landscape preferences, and phytoremediation options at Gas Works Park. In the second phase, surveys were administered to a larger segment of the population. The qualitative and quantitative methods were integrated at the beginning of the quantitative phase, as survey questions were developed based on findings from focus group interviews. They were also integrated at the end of the study in the discussion of findings from both phases.

2.2 Focus Groups

2.2.1 Target Population and Participant Selection

The target population consisted of members of the communities surrounding Gas Works Park, as well as community groups with members that frequently use the park. Participants were composed of a convenience sample and were recruited from existing groups in the target communities. Members of the Wallingford and Fremont community councils were recruited at community council meetings. Participants were also recruited through posts to the Wallyhood blog in Wallingford and from local activity groups that use Gas Works Park for recreation. The community council participants were told about the project in person, and all other groups learned about the focus groups through online posts to public forums. All participants were from the immediate area surrounding Gas Works Park and had visited the park on multiple occasions.

The focus groups were relatively homogenous in participant composition. Given the nature of the study and the composition of the community and stakeholder group, this was intentional. The goal was to find participants who use the park and reside in the surrounding community, which inherently led to a relatively homogenous participant pool. That saturation was reached relatively early in the process is unsurprising, as park users and community members could be expected to have similar concerns and thoughts about the fate of the park.

2.2.2 Procedures

Solicitations for participation were posted to local blogs, community bulletins, and email lists from community groups, local activity organizations, and the Fremont weekly events email. Participant recruitment also occurred at community group meetings, where the project was introduced and discussed, and during which interested group members were asked to sign up to

participate in focus groups. Focus group meetings were held in public spaces in Wallingford and Fremont. These included the Good Shepherd Center, the Fremont Public Library, and Mosaic Coffee House. Space reservations were free, except for at the Good Shepherd Center where room rentals cost twenty dollars per hour. Focus groups were approximately 1-2 hours in length and consisted of 4-7 participants each. The relatively small group sizes were beneficial, as they allowed for more in-depth discussion of topics and promoted greater participation of all group members. Focus groups were recorded using a voice recording device and subsequently transcribed and analyzed for content.

A total of four focus groups were conducted. Saturation was used as a primary measure to determine the appropriate number of groups, along with the suggestion by Morgan and Kreuger (1998) that the typical number of focus groups be between three and five. Saturation is reached when no new data is being introduced by focus group participants (Strauss & Corbin, 1990). By the third focus group, no new information or ideas were being presented by participants. A fourth session was held to ensure that ideas were adequately explored. Again, no new ideas were introduced, indicating that saturation had been reached, and the focus group component of the research project concluded at that point.

All focus groups were moderated, transcribed, and analyzed by the researcher. This allowed for analysis of the data with knowledge of the group setting, nuances, and any dynamics that were noted during the focus group. It was also helpful in allowing the moderator to stray somewhat from the questioning route when focus group conversation went in directions that were valuable but not directly related to the predetermined questions.

Focus groups were semi-structured and a questioning route was used to provide a general framework and flow to the sessions. The questions themselves and the order in which they were

addressed were flexible and were adapted to the participants of each group. Further, the questioning routes were informed by focus group analyses, and questions were added, removed, or changed when it seemed appropriate and beneficial to do so based on previous conversations. Discussion guides were designed such that more general questions were introduced first, with inquiries becoming more specific to the research question as the focus group progressed. See Appendix I for an example of a questioning route.

2.2.3 Data Analysis

Each focus group was transcribed within one week after it was completed. Brief analyses were then conducted and used to refine questions and approach for the subsequent focus groups. Consequently, some preliminary analyses were completed as research was being conducted.

Focus group recordings were transcribed using ExpressScribe and analyzed using NVivo 10 research software. Thematic analysis was used to analyze the data from focus group interviews. Thematic analysis involves exploration across data sets to find identifiable themes or patterns of meaning that describe or organize observations of a phenomenon (Braun & Clarke, 2006; Boyatzis, 1998; Aronson, 1994). It is beneficial in its flexibility, which is particularly useful when conducting an exploratory study where many responses and themes cannot be anticipated in advance (Braun & Clarke, 2006). Thematic analysis is well suited to mixed-methods research because the focus is on identification and analysis of patterns that can be used to develop a theory and/or can contribute to further research strategies (Braun & Clarke, 2006).

The data for this project were analyzed using a primarily inductive approach, with the addition of some deductive analysis. Through thematic analysis, the entire data set is used to identify underlying themes. Both deductive and inductive analyses can be performed using thematic analysis. Analysis of data from the present study was conducted primarily in one chunk

after all data was collected. Additionally, some preliminary analysis was conducted after each focus group, and questions were modified in each of the subsequent focus groups to accommodate for those preliminary findings.

Analysis was conducted according to the steps outlined by Braun and Clarke (2006). The first step in thematic analysis is familiarization with the data. This began with transcribing focus group recordings. Next, meaningful chunks were identified and initial codes were generated and applied to those excerpts. Those codes were then sorted and combined into broader themes, which were refined and named for final analysis and interpretation of the data.

Because research on the social acceptability of phytoremediation is very limited, this study had a largely exploratory component, which made an inductive approach appropriate. Using NVivo software, common, recurring themes were identified and coded throughout the transcripts for all focus groups. Taking excerpts from the transcripts, statements were grouped into common themes and then the themes were used to develop an idea of the most common concerns, preferences, suggestions, and other issues raised by focus group participants.

For the deductive component, data was coded for any themes related to existing theories of social acceptability and landscape preference and how they relate to landscape management. Visual landscape features, in particular, were identified for deductive analysis, as existing literature indicates the importance of landscape features in landscape preference and acceptability.

Following analysis of the recordings, focus group data were used to inform the development of surveys, which were distributed to a larger segment of the population of park users.

Human Subjects

Extensive conversations with Human Subjects Division (HSD) led to the determination that this research project did not require review by the IRB. This applied to both focus group and survey components. However, focus group participants were asked to sign informed consent forms that provided them with information about the research project and informed them of the fact that the focus groups would be recorded. See Appendix II for an example of the consent form.

2.3 Surveys

2.3.1 Target Population and Participant Selection

The sampling frame consisted of visitors to Gas Works Park. Park users were chosen as the target audience due to initial motivations for the research study and park managers' prior statements regarding user preferences. One of the managers' primary concerns was that park users would be unhappy with the addition of shrubs to the park landscape. As a result, it was important to survey park users to explore preferences and evaluate the acceptability of phytoremediation and any associated landscape changes. Participants ($N = 114$) for this study were visitors to Gas Works Park.

2.3.2 Data Collection

Systematic sampling techniques were employed using an intercept survey. Participants were recruited on weekends and weekdays in the morning, afternoon, and evening, in an attempt to sample from a variety of park visitors. All sampling was conducted during the months of August and September. The researcher stood at the entrance to Gas Works Park for three to four

hour periods of time and asked every third individual who entered the park to sign up to complete the survey. Potential respondents were asked to write their name and contact information on a sheet of paper. A total of 238 email addresses were collected. There were not any festivals or events taking place at the park during the sampling times, so individuals who visit the park solely or primarily for festivals were not included in the survey.

Links to the online survey were sent out within one week of participant sign-up. As suggested by Dillman and colleagues (2007) three follow-up messages were used to increase responses from participants who did not complete the survey after initial contact. Follow-up notices were sent out after two weeks, three weeks, and four weeks. Because the survey was web-based and the email setting is commonly associated with less attentive reading behavior, cover letters were kept brief (Dillman et al., 2007). An incentive was offered, providing each person who completed the survey with entry into a drawing to win a \$25 Amazon.com gift card.

2.3.3 Survey Measures

Surveys were composed primarily of 5-point Likert scales that assessed values, activities, knowledge of park history, risk perception, concerns associated with phytoremediation, and preferences of park visitors. The scales ranged from ‘never’ to ‘very frequently’, ‘strongly disagree’ to ‘strongly agree’, and ‘not concerned at all’ to ‘very concerned’. Scales to assess values were derived from Thompson and Barton’s (1994) scales for ecocentrism (valuing nature for its own sake) and anthropocentrism (valuing nature for the benefit it can provide to humans). Scales for acceptability of phytoremediation, perception of risk, and concerns about phytoremediation were designed uniquely for this study and are specific to Gas Works Park and associated contamination. There were also demographic questions, as well as open-ended

questions to assess frequency of visits, length of time living in Seattle, and space for additional comments. See Appendix III for a sample of the full survey.

Phytoremediation Acceptability

The acceptability of phytoremediation was assessed using a series of 12 questions. A definition and description of phytoremediation was given immediately prior to the question section. Included were questions about whether phytoremediation is or is not a good idea at Gas Works Park, whether or not the addition of shrubs would be desirable, and whether the use of phytoremediation technologies would make Gas Works Park a more desirable place to visit. Of the initial 12 questions, nine were used to develop an overall rating for acceptability. For the overall score, questions about landscape preferences were omitted, as these questions did not directly assess opinions about phytoremediation acceptability. Additionally, there was one open-ended question, which was not included in the composite score. For the overall acceptability rating, higher scores indicate greater acceptability and lower scores indicate lesser acceptability. Scores for each of the nine questions were averaged to create a composite score for the variable 'Acceptability' ($\alpha = .87$). Negatively worded questions were reverse-scored prior to averaging.

Risk Perception

The risk perception subscale consisted of 10 items, Respondents were asked about the amount of risk they felt was associated with visiting Gas Works Park. Questions asked directly about whether they believed Gas Works Park is safe for visitors, level of concern about residual effects of contamination on the environment and children, confidence that previous cleanup efforts have been effective, and about whether their knowledge of contamination influences their

decision to visit the park. Scores for each of the 10 questions were averaged to create a composite score for the variable 'Risk Perception' ($\alpha = .82$). Negatively worded questions were reverse-scored prior to averaging.

Concern

The scale for assessing concern included questions about levels of concern regarding different potential sources of issues associated with phytoremediation. The questions were derived from focus group data and represented issues that focus group participants brought up as potential problems with phytoremediation. These include maintenance, removal, effectiveness, plants being in the way, plant size, genetic modification (GMO plants), safety, use of new technology, and use of microbes. "Other" was included as a 10th option and offered a space to write out other concerns. Scores for each of the nine different sources of concern were averaged to create a composite 'concern' score ($\alpha = .87$). This score can be viewed as an overall level of concern associated with the implementation of phytoremediation at Gas Works Park. Additional value may come from viewing each of the sources of concern individually so as to explore ways to address and minimize potential concerns among the population of park users.

Values

The values assessment was included in part due to the common recurrence of a "values" theme in focus groups. Scales were designed to assess levels of anthropocentrism and ecocentrism and were based on scales by Thompson and Barton (1994). Eight items were averaged to create the composite 'ecocentrism' score ($\alpha = .83$). Eight items were averaged to create the composite 'anthropocentrism' score ($\alpha = .40$).

Demographic Variables

The final part of the survey contained an assessment of demographic variables. There were multiple choice options for age, income, and education level. There were seven categories for age, five categories for income, and six categories for education level. Gender was assessed using an open-ended question. All respondents either self-identified as female or male, or chose not to answer the question.

2.3.4 Data Analysis

Statistical Package for Social Sciences (SPSS) software 19.0 was used for all descriptive and inferential analyses of survey data, and an alpha level of 0.05 was adopted for all hypothesis tests. To evaluate the direct relationships among risk, concern, and values with phytoremediation acceptability, bivariate zero-order correlations were computed. To test the unique contributions of risk, concern, ecocentrism, and anthropocentrism to explaining phytoremediation acceptability, after controlling for demographic characteristics, multiple linear regression with sequential predictor entry was employed. For ease of results interpretation, metrical predictors were standardized into z-scores and binary predictors effect coded prior to model entry. (Assumptions of linearity, normality, and homoscedasticity were examined and found tenable for the analysis.)

Response Rate

238 individuals signed up to complete the survey and were sent an email with a link to a Survey Monkey survey. The survey had 146 total respondents, with 21 respondents who left the survey almost entirely blank. An additional 11 participants completed most of the survey but

neglected to answer a small number of questions. There were 114 respondents with complete data available for analysis, for a total response rate of approximately 47.9%.

Chapter 3: Results

3.1 Focus Group Results

3.1.1 Overview of Themes

Six major descriptive themes emerged from focus group transcripts and interactions among group participants. These were knowledge, safety, major concerns, trust, landscape, and environment. Each theme is discussed individually, according to the theme itself. Direct quotes from participants are included to further illustrate these themes. Participants are anonymous and quotes are not attributed to specific respondents.

Knowledge

As a theme, knowledge (of contamination and phytoremediation) was extensive, frequent, and intense. It was mentioned in each of the 4 focus groups, and multiple times in each group. In every group, there was intense discussion about existing knowledge of park history and contamination, as well as about finding ways to increase phytoremediation knowledge. Overall, knowledge and concern about contamination appeared to be relatively minimal, and comments amongst participants indicated that they were either unaware of existing contamination or were not concerned about it. Based on focus group analysis, there were three primary reasons for apparent lack of knowledge or concern about contamination. These reasons were true lack of awareness of contamination, “choosing” to be unaware, and being aware of but unconcerned about potential risks.

For some, there appeared to be an overall absence of knowledge about park history and contamination, as suggested by a participant who stated, “But I’m sure there’s also a contingent

that is unaware, despite the fact that there's a- industrial buildings there. They probably still haven't put the two pieces together and realized that it's sitting on a hazardous waste site." Other participants within the same group agreed with this statement and mentioned that they had not previously thought about pollution or potential risks associated with visiting the park. Some of this lack of knowledge might be attributable to the fact that many residents are relatively new to the city and unaware of park history. It could also be related to levels of trust in those responsible for park management and cleanup, as discussed later.

While many individuals truly do not have a good idea of the park history and contamination, some participants expressed the idea that there is a component of "choosing" to possess knowledge. As one participant stated, "People often times will glance over it and just enjoy the park." This indicates that visitors may have some idea of the possibility of contamination, but choose to overlook that knowledge in favor of enjoying the park and sidestepping the need to worry. Another participant said, "I guess intuitively I kind of imagined it might have been contamination associated with that, but I hadn't heard anything about it." This statement implies that the respondent relies on others for information about safety and chose not to worry about potential contamination until she heard something about it from another person.

The above statements about "choosing" to ignore knowledge about risk also give an idea of the affective impression some park users may have developed about the park. When the overall impression is positive, cursory knowledge about potential risks does not seem to have much of an impact on overall perceptions. Instead, it seems that feelings might be overriding knowledge about how park history might negatively affect safety in some way.

Finally, there appears to be a contingent of park users who are aware of history and contamination but choose to use the park anyway and assume any risks, as suggested by another participant, who stated:

I'm an environmental person as well, so when there's standing water like that in the little valley by the hill and stuff like that I sort of wonder what's in it. But it doesn't usually stop me from using it.

This participant also spoke about bringing his children to the park on a regular basis, despite being skeptical about potential contamination. Here, knowledge ties into risk as a factor influencing risk/benefit analysis and, consequently, overall risk analysis. The respondent talked about being knowledgeable about potential risks and alluded to the risk/benefit analysis he performed when deciding to bring his children to the park. In this case, it seems that the benefits outweigh any potential costs associated with visiting the park for this individual. Part of his decision could potentially be attributed to the fact that he does not know exactly what the risks are. He knows only that there is some possibility for contamination based on park history and his educational or informational background. That there is still some ambiguity about contamination might make it easier for park visitors to view risks as relatively low, especially in comparison to the notable perceived benefits of visiting Gas Works Park.

Overall, as far as knowledge is concerned, existing contamination does not appear likely to affect participants' use of the park. Despite there being a contingent who are knowledgeable about contamination, the overarching trend amongst focus group participants was a tendency to overlook or 'forget' about contamination, or to continue using the park even when aware of

potential risks. Throughout all of the focus groups, there was not one participant who said that they avoided the park because of contamination or indicated they would change their park-visiting behavior based on new knowledge of contamination.

Discussion of knowledge also arose with regard to information about phytoremediation itself. Participants were unfamiliar with phytoremediation technology and its effectiveness. They also discussed lacking knowledge about the type of willow shrubs that would be used, generally assuming that ‘willow’ referred to large weeping willow trees before learning more about the plants and the phytoremediation process. There was a great degree of interest in phytoremediation and a clear hunger for more knowledge about the process, as evidenced by the high number and intensity of questions about phytoremediation, and readily offered suggestions for ways to implement the technology.

The inclusion of informational plaques to tell park users about phytoremediation was a common suggestion, with the implication amongst focus group participants that more knowledge about phytoremediation could contribute to improved acceptability of the technology, both for themselves and for other park users. Focus group participants expressed a great deal of enthusiasm for including a scientific educational component to accompany the implementation of phytoremediation. One participant suggested finding ways to provide information about phytoremediation along with details about the history of the park itself:

People love the history of the park, too. And the signs and stuff have sort of broken down over time. There’s still a few there. But, you know, even information about why it’s polluted in a certain area.... and some sort of semi-technical information about what’s in the ground and... how it’s being cleaned up.

Tying new information about phytoremediation into discussions of park history was a popular idea in focus groups and provided some insight into the importance of the park history to visitors. Part of this may be attributable to the uniqueness of Gas Works Park and the importance of incorporating any new management plans into that uniqueness. Further, the history of the park can provide some information as to the potential risk for contamination. Though many park users do not make the connection automatically, pointing out the history and the pollution could help tie the two concepts together. As mentioned by focus group participants, highlighting that connection could promote acceptability of phytoremediation. Optimally, phytoremediation would be well integrated with existing structures, and informational plaques would provide information about the overall benefits of phytoremediation and why remediation is necessary due to the unique park history.

Safety

Safety was another common issue, with concern about the pollutants arising primarily following discussions about knowledge of existing contamination. For this reason, safety is addressed separately from knowledge. Safety refers specifically to participants' safety assessments of existing contaminants at the park. Prior to learning about existing contamination, most respondents had not been concerned about safety issues. There was a general desire to talk more about the topic once they learned about the history of the park, at which point participants talked extensively about safety. Some of this could be due to the fact that most were unfamiliar with existing contamination, or had not given it much thought up to this point.

Despite some initial apparent concern, respondents really didn't seem too worried about potential negative impacts of visiting the park. One participant commented on being aware of potential risk but not worrying about it:

It's something that I've always known about but I, I still go down there. I still really enjoy the park. There's a lot of waste and crazy stuff out... you know, it's a pretty park. I never think, 'oh, you know, this is flesh-eating grass' or anything.

This statement reflects the idea that there's so much contamination everywhere that some people do not care too much about contamination specific the park. A common mentality seemed to be that "it's just a drop in the bucket" and going to the park is worth the exposure. This also lends to the idea that appearances can really influence risk perception. Gas Works Park is covered in green grass and overlooks a lake. It does not look like a contaminated site, so people often do not perceive it as such. It is also possible that people are reluctant to consider Gas Works Park to be a dangerous location because they greatly enjoy the park and are hesitant to change traditions and behavior associated with visiting it.

Similarly, there seemed to also be the perception that other issues are more important and deserving of attention and resources:

[I'm] not super concerned about contamination from the park. I just found out there's a huge combined sewer overflow right next to the park, which is nice to know about. So that far surpasses any of the contamination coming out of the park I think.

Different people may have different priorities so far as safety and contamination exposure are concerned. This particular respondent frequently swims with family members in the lake and stated that they ignore the signs warning people not to swim around Gas Works Park. His statement reflects a belief in a hierarchy of things to worry about, and soil contamination appears to be low on this individual's list. It may be the case that he perceived the absolute risk of soil contamination to be very low, or perhaps issues that greatly impact water quality and safety are more important to him than those that impact soil. It is also possible that swimming is a highly valued activity for this particular family, so issues that impact the safety of swimming in the lake are of primary importance.

Major Concerns about Phytoremediation

Several concerns arose with regard to implementing phytoremediation at Gas Works Park. The most common were GMO/Organic, maintenance and removal of vegetation, effectiveness of phytoremediation, and disruption of activities. The same topics came up in each focus group, but discussion was neither frequent nor intense.

Statements related to GMO and organic were grouped together for analysis, as discussion of GMO and organic plants always arose together and the two concepts were consistently intertwined. Further, some participants weren't able to identify the difference between the two terms. Genetic modification and organic growing were of concern to participants and were mentioned spontaneously in every focus group. Common questions from participants were related to the endophytes and the plants themselves. One participant asked about the phytoremediation-enhancing microbes, saying, "And those are natural endophytes, right? Nothing funny happened to them in the lab before they get applied?" This statement reflects a

common concern that came up in focus groups, and there was a general distaste for anything that hinted at the possibility of genetic modification.

Organic growing was another concern. One participant asked if the phytoremediation process was organic. When pressed a little bit as to what was meant by “organic”, the participant responded with “I don’t know, whatever organic means.” Comments like this one provide an idea as to participants’ concerns about topical issues. They may know that organic is important to some people, and therefore cite organic as important to them as well, despite not really knowing what the term ‘organic’ means.

Concerns around maintenance had less to do with logistics about planting, and more to do with who will keep up with maintenance once the shrubs are planted. Removal was a particularly strong concern, and the issue was raised more frequently than were concerns about other components of maintenance. In every focus group, participants asked about removal strategies and whether there would be stumps remaining. These questions reflect overarching concerns about landscape, both with regard to visual preference and recreation. Some worried that any leftover stumps would be an eyesore, while others expressed concern that remnants of phytoremediation would continue to hinder field-based activities even after the shrubs themselves were gone.

An unanticipated but persistent concern was related to removing plants that park users have grown to like. One park user talked about the potential for plant removal to be alarming to visitors, saying, “My guess is that people wouldn’t let, assuming they’re nice and people enjoy them, they would be sad when it’s cut down. It would be kind of a little bit traumatic for folks that got used to them.” Concern over taking out shrubs to which park users had become attached was one of the strongest and most-frequently cited concerns about utilizing phytoremediation

strategies at the park. It would be important to give park users information about the longevity of plantings at the beginning of a phytoremediation project. This way, visitors would know in advance that the shrubs would be temporary and might be better prepared for their removal in the future.

There were also some concerns about the willow itself. This was a much less common issue and concern was expressed in only one focus group, with a participant stating,

Other things that fewer people might worry about that I'd be curious about would be, you know, exactly what kind of willow it is, where it comes from. Is there any chance this could be invasive? Is it a host for other pathogens? Stuff like that.

In subsequent focus groups, questions were added to inquire about possible concerns related to the willow plants. However, participants in these groups stated that they would not be worried about the plants themselves and would even be accepting of non-native or hybrid plants if those shrubs would be more efficient soil remediators. To account for those park users who would be worried about the plants, informational plaques, as mentioned above, could be a useful tool in providing information to reduce fears about the willow.

Finally, there were some concerns about the effectiveness of phytoremediation if it were to be implemented. The following statement reflects trepidation among some respondents who seemed skeptical of the long-term effectiveness of phytoremediation:

What if we plant some trees and they're there for however long. A couple years, a few years. And that's completely cleared out, but maybe 3 years down the road, for whatever

reason, it seeps up again? Then that area that we remediated, it poses another risk and we'd have to remediate again.

Concerns about effectiveness are not surprising given the history of remediation at Gas Works Park and repeated capping efforts. The fact that phytoremediation is seen as a new technology may also influence safety and trust perceptions. If people are unfamiliar with phytoremediation, they may see it as unpredictable and hesitate to place much confidence in the technology. It is understandable that park users would want to be sure that undertaking a major project would truly be effective in the long term. Some concern about effectiveness could also be related to trust, another prominent theme throughout focus groups.

Trust

Discussions about trust arose with regard to both the current safety and the effectiveness of phytoremediation for cleaning the park. Concerns about current safety may reflect a lack of trust in the managers and officials who were responsible for past remediation efforts and who have deemed Gas Works Park safe for the public.

Some respondents expressed concerns about the potential ineffectiveness of previous remediation efforts and the current safety of the park:

Another thing that comes to mind is that, you know, if I lived here for a while and assumed that, since, one they turned it into a park, and two, there have been more remediation efforts like the capping, I would have probably thought 'Ah they did some stuff and took care of it.' And then, if I heard now they might want to do more stuff, I

would assume that uh, not assume, but I would realize oh it wasn't all taken care of, then I might start to worry.

The idea here being that these individuals placed trust in authorities to clean the park completely, and they are faced with the possibility that their trust was violated. Because assumptions about safety are being violated, that could translate to concerns about phytoremediation, as evidenced by the following statement by another participant from the same focus group: "On the one hand, I'd be relieved that you're doing something. On the other hand, I'd worry that, oh if these other things didn't fix it, will this fix it?"

Effectiveness and communication of past cleanup efforts may influence acceptability of future cleanup efforts, including phytoremediation. This could be the case even if phytoremediation were to be undertaken by a different group than that which performed previous conventional remediation efforts. Given knowledge of previous remediation efforts, participants offered suggestions for ways to increase trust and potentially improve acceptability of large-scale phytoremediation at Gas Works Park.

It might be a good idea, instead of doing it large scale, to do like a little patch and having it be tested. And say 'look at this little patch and how much better it is. You could have the entire park like that.' And that might be an easier sell.

Taking it even further, one participant stated: "Maybe you could test little sites, like to prove that it could actually be done. That the toxins could be removed to such a level that it would be safe to grow food." This was an interesting notion, because the participant seemed to

be suggesting that in order to be safe for park users, the land should be clean enough to grow food. Other participants in the same focus group did not agree that successful remediation required the ability to safely grow food in the soil. It appears that the removal of carcinogenic contaminants would be enough to satisfy most park users. Of note, participants were not asked for ways to convince others; these recommendations were spontaneous and reflected the overall enthusiasm of focus group participants for the implementation of phytoremediation

As mentioned above, there were some concerns about any potential risks associated with phytoremediation itself. There sometimes arose the idea that phytoremediation sounded too good to be true, with a participant saying, “I mean it sounds very beneficial so I guess my only question is, is it harmful to people in any way or pets?”

Participants were somewhat wary of trusting this new, apparently beneficial, technology and wanted to be sure that it would not carry any major downsides. If such perceptions are common among community members, this presents a bit of a challenge in terms of showing that phytoremediation is a safe and effective strategy. However, it also provides a glimpse into the mentality about cleanup organizations and strategies in general. People may be primed to be skeptical about claims of effectiveness and risk, especially at a park where safety proclamations are regularly undermined by the repeated need to fix the soil.

Landscape

Landscape was a major theme in each of the focus groups. This is not surprising, given that phytoremediation would have a noticeable impact on the park landscape, which is a primary concern for park users. Unique concepts arose regarding varying details about park use and layout and resulting ideas about the potential for implementing phytoremediation. Included in

conversations about landscape were discussions of where shrubs should and should not be planted, as well as discussions of temporary versus permanent plantings.

Potential impacts to the view of the lake and the city skyline were a prominent topic. The view of the city and the lake from Gas Works Park was important to participants in every focus group. It was the only feature about which participants were unanimously adamant that it be preserved. Some even cited the view as the primary reason for the popularity of the park, making statements such as, “People love Gas Works because of the open space and the view of Rainier and the center, Seattle, or the space needle.” Another participant suggested that maintaining the view is the only thing that would matter in terms of acceptability, saying, “I think as long as you preserve the view at the top of the hill I do not think people would have a problem with it. Planting trees isn’t a conflict of interest.”

Kite hill is an identifying landmark within Gas Works Park, and a primary location from which park users can view the city. As such, it was the focus of some interest and potential concern related to willow planting:

I know that there’s a lot of events that take place there. And like this huge mount right here [pointing to kite hill], kids love to roll down it and things like that. So, when it comes to maybe in this area right here [northern strip/open field], it’s kind of its own little natural hilly amphitheater. If there were to be some [shrubs] around here, would it take away as it grows and matures, could the leaves actually take away from the view of maybe a concert or something?

This participant's statement makes it clear that, at least to some park users, the view of other areas within the park is as important as the view of the lake and the city from the park. It became evident that it is important to preserve views from kite hill of the city and of other locations within the park. The desire to preserve the view from and recreation associated with kite hill would be one reason for phasing the plantings in some areas.

Another suggestion was to plant willow in areas that already have vegetation. In this case, the willow could serve as a replacement for existing vegetation. Overall, the change to the landscape would be minimal and would not affect the open spaces. Several respondents suggested planting willow near the water:

I think plantings, like along the water. Like if you're trying to keep it from going into the water, things like that. I think that would be, there's already kind of blackberry, you know, mess down there now. You could probably plant a nice strip along there.

This sentiment was echoed several times throughout the different focus groups. The water line was cited as a desirable location to plant willow. There are already (invasive) Blackberry plants there, so the change to the landscape would be negligible. In fact, some participants identified the existing blackberry plants as "ugly" and potentially dangerous, so removing them in favor of willow may be considered a net positive from both an aesthetic and a remediation perspective.

Others suggested planting locations based on topography:

So there's a lot of places to plant, and maybe the other thing that'd be interesting is maybe looking at the wetter areas. 'Cause I think, for me, those are kind of the scarier areas. So, like, the bottom of the, below the hill where there's all that dead [grass] usually because it's all at the bottom there.

Planting in the low, wetter areas may be advantageous because the current state of the ground makes it an undesirable place to spend time currently. The willow would place fewer restrictions on recreation if activity in those locations is limited anyway. Planting in lower areas would also help to preserve the view from kite hill of other areas in the park and would be advantageous of those areas have higher levels of contamination. Additionally, if park users see those areas as 'scary', as suggested by the above comment, implementing phytoremediation in those places may be more acceptable as a way to clean up the land.

Recreation was also seen as important, with respondents making statements such as:

I mean, there's a big field right as you go in. That's used constantly for ultimate Frisbee, or kickball seems to be the big thing there these days. So you obviously couldn't plant in the middle of that without a big problem.

This statement reflects what was a relatively common sentiment in focus groups. That being that recreation, or the activities that participants engage in at the park, play a role in their perceptions of how the landscape should be managed and where willow should or should not be planted. Consequently, many suggestions for planting locations were based on recreation spaces.

One suggestion was to plant willow in areas that were ‘out of the way’ or in areas of the park that are more marginal:

You could plant sort of, you know, islands or barriers like around the fenced area. That could be planted, there’s certainly plenty of areas to plant. You know, for an area sort of the size of this room [approximately 15 X 30 feet]. Different places or border or something like that. Um, but the open spaces pretty much need to stay open for the users.

As illustrated by this participant’s comment, it was important to a lot of people that areas used for recreation stay open. Another participant said, “Large contiguous stretches of grass are probably very important to people.” Upon further discussion, participants indicated that there could be some “wiggle room” when talking about planting in the open spaces. This seemed to be the case especially when participants learned about the idea that the plantings could be temporary. Respondents indicated that park users might be able to deal with the loss of the open spaces if that loss would not be permanent. Some even saw the potentially temporary nature of the plants as a major selling point for phytoremediation:

I think really pushing the idea that it’s temporary and it’s gonna be so beneficial and environmental and if it’s, you know, truly is an excellent cleanup of the site.... It’s a no-brainer and it should be done. It almost sounds like it is criminal if it’s not done.

This is an interesting idea, as it appears to be in direct opposition to other participants’ statements that removal could be ‘traumatic’ for people. However, there may be ways to

combine temporary and permanent plantings in a way that would optimize park layout and cleanup. Perhaps the decision of whether or not to remove the shrubs would be based on the location within the park. Participants provided ideas for ways to implement a combination of permanent and temporary willow plantings. Here, location was considered critical:

And maybe do it both ways. Maybe the ribbon along the water is permanent and that's just the way it is. And then you do some test areas around the fenced in towers or something and just say 'this is a temporary test in a different area' or something like that. I mean, you could potentially do both, but I think especially along the water leaving 'em would probably be better.

It might be easier for park users to accept willow shrubs in the open spaces if they are temporary. Whereas, in locations that are not as highly prized for their openness and recreational utility, more permanent willow plantings may be desirable.

Many seemed relatively indifferent as far as the importance of open spaces, and some people even talked about the desirability of having natural landscape components other than just grass: "I have kind of a bias towards having interesting landscaping and plants and trees. I like going places, parks, where there is that kind of an environment rather than just wide open lawns." Another individual suggested creating interesting landscape features such as mazes. These comments represent somewhat of a minority opinion, but a valuable one nonetheless. The diversity in opinions and preferences might show that people are pretty resilient as far as acceptability of landscape change. Based on conversations within focus groups, it seems unlikely that individuals who currently use the park would stop visiting if willow shrubs were planted.

History was also important to focus group participants. History was discussed primarily as a component of landscape, as the remaining features served to remind park users and focus group participants of the previous function of the landscape. The park structures were brought up in every group, and always as a positive aspect. Even when the decision to leave gas manufacturing structures was seen as somewhat perplexing, the overall sentiment was that the structures make a positive addition to the park:

I thought it was really curious that they left a lot of that machinery and the pipes and everything in place as kind of integrated into the park the way it is now. I thought that was really interesting and kind of an attractive idea.

In all focus groups, participants talked about the fact that they enjoyed seeing the structures at the park. At no point did any participants talk about the structures as a negative landscape feature. The structures tell about the history and make Gas Works Park unique, setting it apart from other open spaces within the city.

Generally speaking, focus group discussions reflected the fact that Gas Works Park has a diverse landscape and that there are a large number of values that park visitors attach to different aspects of the landscape. Planting willow shrubs in a way that would please all park visitors from a landscape perspective would be a challenge. However, participants offered numerous suggestions for ways to optimize user acceptability and remediation effectiveness in a way that would work with the park. Respondents also seemed generally resilient to landscape changes.

Environment

Discussion about environmental factors, such as benefits to wildlife and waterways, was rather limited. Focus group participants were mostly concerned about potential health effects and landscape impacts. Those who did address environmental concerns were very enthusiastic about the benefits, going so far as to say that using phytoremediation to help the environment is a “no-brainer”. The following statement by a participant gives a good indication of the level of concern for the environment:

Really pushing the environmental-ness of it will really get folks to take a look at it and to agree. And, I mean, they've been talking about Gas Works being so contaminated for so long and nothing's really been done about it that I'm aware of.

In this case, the participant expressed not only her own desire to protect the environment, but also her belief that others hold the same environmental values and would be swayed by arguments that highlight environmental benefits. The second part of her statement also gives an indication of trust levels and might offer some insight into the way trust in managers could influence perception of management and acceptability of alternative remediation strategies such as phytoremediation. Specifically, there was a perception amongst some of the focus group participants that nothing has really been done to permanently clean the park and that perceptions of phytoremediation could consequently be even more positive.

Capping

On a final note, participant responses were noted with regard to knowledge and perceptions of the current capping project, which commenced in September of 2014. At the very end of the focus group, participants were asked if they were aware of the planned capping project. No one had heard of it, and everyone was visibly frustrated. Immediately, respondents suggested that if the capping is going to happen anyway, phytoremediation might as well be implemented.

Much of the frustration seemed to stem from participants' feelings that they weren't involved in, or even informed about, new plans for capping. They seemed to feel blindsided, which amplified anger associated with the new project, and expressed a desire to have been included in the decision-making process. Subsequent increases in enthusiasm for phytoremediation may be partly attributable to the fact that these participants were being asked for their opinions and were involved in conversations about potential phytoremediation projects.

There are some other potential reasons for increased enthusiasm for phytoremediation upon learning about the capping project. For one, the fact that a capping project would need to be implemented seemed to make it clear to participants that there was still contamination that needed to be addressed. Additionally, capping is seen as ugly, and respondents made comments about shrubs being more visually appealing than capping. Some said that if it's going to be ugly anyway, they might as well just use phytoremediation as well, as there is less of a need to maintain aesthetic values.

Focus group findings indicate an overall positive perception of phytoremediation at Gas Works Park. Participant statements suggested that knowledge of history and contamination at the

park was quite limited. Similarly, perceptions of risk associated with visiting the park were very low, with all participants stating that they did not worry about safety issues associated with exposure to contaminants when visiting. There were some concerns about phytoremediation itself. These were primarily related to genetic modification and the potential for shrubs to interfere with preferred activities. Specifically, the view was seen as a critical component to maintain, and some individuals were adamant that recreational spaces be left open. A few respondents also expressed concern that park users would become attached to plants and would be upset if the plants were to be removed. Acceptability of phytoremediation at the park could potentially be hindered by park users' lack of trust in the effectiveness of previous remediation efforts. Despite potential problems associated with trust, participants were enthusiastic about the potential for using phytoremediation at Gas Works Park, due to both health and environmental benefits.

3.2 Survey Results

3.2.1 Descriptive Statistics

Table 1 summarizes the descriptive statistics for demographic variables. The average age of respondents was approximately 31 years (range 18 to 60+ years). The sample had a relatively high level of education, with more than half (61.7%) of respondents reporting having completed at least an undergraduate. Additionally, there were more female (55.2%) than male (42.4%) respondents.

Table 1*Sample Demographic Characteristics*

	N	%(n)
<i>Age</i>	122	
18-20		8.0% (10)
21-29		52.0% (65)
30-39		20.8% (26)
40-49		8.8% (11)
50-59		8.0% (10)
60 or Older		2.4% (3)
<i>Income</i>	118	
Under \$19,999		19.2% (24)
\$20,000-59,999		28.0% (35)
\$60,000-99,999		19.2% (24)
\$100,000-139,999		11.2% (14)
\$140,000 or Over		16.8% (21)
No Answer		5.6% (7)
<i>Education</i>	123	
Some High School		1.6% (2)
Graduated from HS/GED		3.2% (4)
Some College		21.6% (27)
Graduated from College		41.6% (52)
Some Graduate School		4.8% (6)
Graduate or Professional Degree		27.2% (34)
<i>Gender</i>	123	
Female		55.2% (69)
Male		42.4% (53)
No Answer		2.4% (3)

3.2.2 Correlations

Means and zero-order correlations were computed for subjects with complete data. For simplicity, all demographic characteristic variables were dichotomized into dummy coded variables using a median split prior to computing correlations as well as the subsequent regression analysis. Correlations were then used to ensure no multicollinearity would be present in the regression analysis, as well as to examine the direct, one-to-one relationships between both outcome and predictor variables prior to all variables being entered into the model

simultaneously together. As can be seen in Table 2, there were no extraordinarily high correlations between predictors that would indicate a collinearity problem or interfere with subsequent multiple regression results (all r 's < 0.90, cf. Field, 2005).

Table 2

Descriptive Statistics and Zero-order Correlations for Variables used in Analyses

Measure	<i>M</i>	<i>(SD)</i>	1.	2.	3.	4.	5.	6.	7.	8.	9.
<i>Outcome</i>											
1. PhytoAccept	4.16	(0.59)	--								
<i>Block 1 Predictors</i>											
2. Education (1=high)	0.73	(0.45)	-0.01	--							
3. Income (1=high)	0.50	(0.50)	0.10	0.20*	--						
4. Gender (1=female)	0.56	(0.50)	0.16	-0.01	-0.02	--					
5. Age (1=older)	0.39	(0.49)	0.17	0.19*	0.51**	0.05	--				
<i>Block 2 Predictors</i>											
6. Risk	2.83	(0.67)	0.23*	-0.16	0.01	-0.03	0.19*	--			
7. Concern	2.54	(0.84)	-0.16	-0.17	-0.05	0.07	-0.08	0.20*	--		
8. Ecocentrism	3.85	(0.69)	0.43**	0.10	0.17	0.00	0.12	0.38**	-0.01	--	
9. Anthropocentrism	2.56	(0.41)	-0.13	-0.07	-0.09	-0.09	0.08	-0.06	0.11	-0.25**	--

Note. N=114 Respondents with complete data. PhytoAccept = phytoremediation acceptability rating scale (1-5); Education coded 1=high, 0=low; Income coded 1=high, 0=low; Gender coded 1=female, 0=male; Age coded 1=older, 0=younger; Risk = level of rating scale (1-5); Concern = level of rating scale (1-5); Ecocentrism = level of rating scale (1-5); Anthropocentrism = level of rating scale (1-5)

* $p < .05$, ** $p < .01$

More importantly, the correlations showed that, while none of the demographic variables were significantly correlated with phytoremediation acceptability, both risk and ecocentrism exhibited significant positive correlations with the outcome (higher levels of both are associated with higher levels of phytoremediation acceptability). This said, the correlation between the two predictor variables themselves, at $r = 0.38, p < .01$, indicates that they share more variance with each other than they do with the outcome and thus there is the potential that neither will uniquely predict the outcome when entered together into the regression model. Finally, it is notable that neither concern nor anthropocentrism had a significant direct relationship with phytoremediation acceptability.

3.2.3 Regression Analysis

Evaluating Regression Assumptions

Standard linear regression analysis assumptions were examined for tenability. The P-P plot created to assess normality of the dependent variable residuals (phytoremediation acceptability) displayed good observed vs. expected value fit for normality. Homoscedasticity and linearity were assessed using a scatterplot comparing the predicted values with their residuals; the plot showed no increase or decrease in spread as predicted values increased, nor were any curvilinear patterns present; together this indicates that these two assumptions are tenable as well. Finally, independence would appear tenable in this case, since the process for subject recruitment ensured that no family members or groups were systematically invited to participate in the survey.

Regression Model Results

Regression results are displayed in Table 3. For the regression, scores for phytoremediation acceptability (the outcome), as well as risk, concern, ecocentrism, and anthropocentrism (focal predictors), were averaged across their scale items, respectively, to create composite scale scores (descriptive statistics are reported in Table 2). Subsequently, the composite scores for the focal predictor variables (risk, concern, ecocentrism, and anthropocentrism) were standardized, and demographic variables effect coded for ease of results interpretation. The social acceptability scale, which was composed of 8 items, each based on a 5-point Likert scale, was left in its original units.

Multiple linear regression analysis with sequential predictor entry was conducted to assess whether risk, concern, ecocentrism, and anthropocentrism (focal predictors; Block 2) would uniquely predict phytoremediation acceptability after controlling for education, income, gender, and age (demographic characteristics; Block 1). The decision to use these specific variables was informed by focus group findings, research interest, and information from previous studies indicating that certain variables may predict proenvironmental behavior. Table 3 shows the results from the hierarchical regression.

Table 3*Multiple Linear Regression Analysis on Phytoremediation Acceptability*

	Block 1					Block 2				
	R^2_{change}	R^2_{total}	R^2_{adj}	b	sr^2	R^2_{change}	R^2_{total}	R^2_{adj}	b	sr^2
<i>Model Fit</i>	0.07	0.07	0.03			0.21 ***	0.28 ***	0.22		
<i>Coefficients</i>										
Intercept (Mean PhytoAccept)				4.17					4.18 ***	
Education (1=High)				-0.04	0.00				-0.05	0.00
Income (1=High)				0.03	0.00				0.00	0.00
Gender (1=Female)				0.10	0.03				0.11 *	0.03
Age (1=Older)				0.06	0.02				0.05	0.01
ZRisk									0.08	0.01
ZConcern									-0.12 *	0.03
ZEcocentrism									0.21 ***	0.10
ZAnthropocentrism									-0.01	0.00

Note. N=113 Respondents with complete data. Block 1 F-change test $df = 4, 109$; Block 2 $df = 4, 105$. PhytoAccept = phytoremediation acceptability rating scale (1-5); Education coded 1=high, -1=low; Income coded 1=high, -1=low; Gender coded 1=female, -1=male; Age coded 1=high, -1=low; Risk = level of rating scale (1-5); Concern = level of rating scale (1-5); Ecocentrism = level of rating scale (1-5); Anthropocentrism = level of rating scale (1-5)

* $p < .05$, ** $p < .01$, *** $p < .001$.

The results of the analysis show that Block 1, where all demographic variables were entered into the model simultaneously, did not account for significant variation in phytoremediation acceptability, $R^2 = 0.07$, $F(4, 109) = 1.99$, $p > .05$. The second block, however, where risk, concern, ecocentrism, and anthropocentrism were entered, did account for significant variation in acceptability above and beyond demographic characteristics (21% additional variance), $F_{\text{change}}(4, 105) = 7.62$, $p < .001$. Moreover, in the final model with all predictors entered, only concern and ecocentrism were significant unique predictors of phytoremediation acceptability. Concern had a unique negative effect, with an estimated mean decrease of 0.12 points on phytoremediation

acceptability for respondents who were one standard deviation higher than average in concern, whereas ecocentrism's effect was positive, with an estimated mean increase of 0.21 points on phytoremediation acceptability for respondents who were one standard deviation higher than average in ecocentrism.

Chapter 4: Discussion and Conclusions

4.1 Discussion

4.1.1 Perceptions of Phytoremediation at Gas Works Park

Focus groups and surveys were used to assess phytoremediation acceptability at Gas Works Park. Focus groups were primarily exploratory and gave insight as to the conversations that park users are having about the park itself and about phytoremediation at the park. Surveys were designed to develop a quantitative assessment of phytoremediation acceptability. The survey assessment consisted of a series of questions developed primarily based on focus group findings.

Perceptions of phytoremediation were overwhelmingly positive. Responses from focus groups and surveys both indicated that park users would be accepting of the use of phytoremediation at Gas Works Park. Focus group participants, after asking numerous questions about the process and effectiveness of phytoremediation, indicated very strong support for phytoremediation implementation at the park. Enthusiasm for phytoremediation was especially high when participants learned of the new capping project.

Reactions to news of the capping project were strong, and knowledge of the project appeared to influence overall perceptions in a couple of ways. The first was that, if managers are starting a new capping project, it means that previous remediation was not complete, going to the park is dangerous, and managers might not be completely honest with the public about the hazards and the effectiveness of current remediation strategies. The second was a sentiment that if the park is being torn up anyway, shrubs may as well be planted there as well to clean it up. In both cases, these reactions contributed to increases in preferences for phytoremediation

implementation. Overall, participants appeared to have quite a positive view of phytoremediation and to think it would be beneficial to implement such a strategy at Gas Works Park. Some participants felt very strongly about the benefits of using phytoremediation, even saying that to not implement it “would be criminal”.

It is possible that perceptions of capping and of phytoremediation may be related to ownership and participation. Focus group participants were unhappy about the capping project, in part because they felt that they were not informed about the project or involved in the decision-making process. In contrast, participants were directly involved in discussions about phytoremediation and the potential for implementing the technology in Gas Works Park, which may have led to greater acceptability of phytoremediation. Such an explanation would be consistent with Balasubramaniam and colleagues’ (2007) findings that acceptance of remediation options can increase when the public is involved in decision-making.

There was some skepticism about the purported effectiveness of phytoremediation. Some focus group participants felt that there had to be a catch because phytoremediation seemed too good to be true in some ways. The skepticism may stem in part from concerns about the lack of effectiveness of previous remediation efforts. Some individuals suggested that they felt a somewhat ‘duped’ by those who imply that contamination has been removed. Even with this skepticism, the perception of phytoremediation was positive.

Survey responses also indicated a strong level of acceptability for phytoremediation at Gas Works Park. The question that specifically asked whether phytoremediation should be used at the park had exclusively neutral and positive responses. There was not a single response out of 114 indicating lack of agreement with the idea that phytoremediation should be used at the park. Other measures of acceptability were also markedly positive, and the composite score for

phytoremediation acceptability had a mean rating of 4.16 (out of 5). This indicates a relatively high level of acceptability of phytoremediation at Gas Works Park. It is important to note that the high mean score for composite ratings of phytoremediation acceptability may have an effect on statistical results. That most people were accepting of the phytoremediation plan results in a ceiling effect, meaning that little variance is left for predicting outcomes using regression. It is valuable to keep this in mind when interpreting the regression model in terms of the ability of independent variables to predict phytoremediation acceptability.

4.1.2 Landscape Preference

Preferred Locations for Phytoremediation

Preferred locations for the addition of shrubs to the park were influenced heavily by perceptions of a few distinct features. The most common request was that the shrubs not block the view of the lake and the city. This is not surprising, given that Gas Works Park has one of the most iconic views of the city and the view is a key component of the park. It is also consistent with previous findings that water is seen as a positive landscape component (Atauri et al., 2000; Brown & Brabyn, 2012; Kaltenborn & Bjerke, 2002; Wherrett, 2000; Ulrich, 1986). Many sightseers and festival/celebration attendees visit the park solely because of the view that is offered. Preserving the view would not be a challenge given the elevation of the primary park viewpoints and the height of the shrubs. Managing shrubs through pruning would be a viable way to ensure that desired height is maintained.

Another suggestion was to replace existing blackberry bushes with willow shrubs. This has a number of benefits. The first is that the view would not be impacted, as the willow could be maintained to grow no higher than the blackberry shrubs grow now. Blackberry shrubs likely have to be maintained presently to prevent them from spreading to other areas of the park.

Maintenance of the willow shrubs would consequently not be too big of a challenge, as the maintenance would change to a different plant in the same location. Some respondents were worried about potential toxins in blackberries picked from the shrubs, so replacing the plants with willow would minimize perceived risks of exposure to contaminants. Another advantage is that willow would be replacing an invasive plant, potentially increasing the perceived benefits of willow in that particular location.

Kite Hill was the only location that was unanimously cited as a place where willow should not be planted. There was one exception, being that planting willow on kite hill would be acceptable during the time that it is closed off for capping anyway. Given that capping is scheduled to end within the next few months, planting on kite hill would probably not be feasible. However, this input is useful in the case that any capping projects need to take place in the future.

Finally, some participants suggested creating interesting landscape features, such as a maze, with the shrubs in the open areas. The idea being that the shrubs could offer an interactive feature, providing a way to increase knowledge about phytoremediation and allowing the vegetation to be perceived as well-integrated and enjoyable, rather than an area of the park that is rendered unusable.

Recreation

Focus group responses indicated that the activities park users engage in have some bearing on phytoremediation acceptability and landscape preference. Participants who play field-based team sports such as soccer, ultimate Frisbee, and kickball expressed concern about shrubs in open spaces and frequently requested that those areas be left for recreation purposes. There

was a spread between those who wanted the entire space left alone, and those who felt it would be ok if only part of the space remained. Overall, it became clear that acceptability would be higher if the park retained some open space at all times.

Those same participants who requested that open spaces be retained were also quick to suggest areas in which phytoremediation *should* be implemented at the park. Commonly suggested locations were in place of blackberry bushes on the water line, around the fenced area surrounding the gas works structures, or in the wetter areas that were seen as potentially more dangerous and contaminated. Similarly, participants who talked about visiting the park on walks and for sightseeing were mostly concerned about the view, and indicated that they would be happy to see phytoremediation strategies used at the park as long as the view is preserved. These findings suggest that activities might not predict acceptability as a whole, but rather influence perceptions about the way phytoremediation should be implemented.

Structures

In focus groups, there was extensive discussion of the history of the park, with participants expressing enjoyment of the constructed features. This finding was consistent with research by Arriaza and colleagues (2004), who found that positively evaluated constructed features contribute to increases in perceived visual quality of a landscape, particularly when they represent a historic location. Together with the findings by Ulrich (1996) that constructed features are perceived more positively when natural features are present as well, it makes sense that respondents might view the addition of shrubs to the park as an overall benefit. Integration of natural features with constructed features that are already rated positively appears to be considered as a net positive for park visitors who participated in focus groups.

Several participants suggested installing plaques that tell about the history of the park and the phytoremediation cleanup project. This would tie in with the historical component of the park, about which respondents were very enthusiastic. Doing so would also provide benefit in terms of giving more historical information and information about the benefits of phytoremediation and the potential risks of current contamination.

4.1.3 Preferences for Permanent vs. Temporary Planting

There were somewhat differing views regarding the length of time shrubs should be left at the park. Some respondents liked the idea of permanently adding willow, while others felt that the shrubs would only be acceptable if they were temporary. Ultimately, preference for temporary vs. permanent plantings depended to a large degree on the location itself. For example, focus group participants suggested long-term or permanent plantings along the water line where the view would not be negatively impacted. Additionally, participants felt that willow along the water line could be beneficial in terms of preventing some runoff from flowing into the adjacent lake.

Temporary, or phased, plantings were considered to be more desirable in open spaces within the park. This would allow for recreation activities to continue while phytoremediation was in effect, and may contribute to continued acceptability among a wider range of park users. There were some concerns about park visitors getting attached to the willow and becoming upset once it is removed. However, those concerns should be balanced with those of people who might be frustrated by willow shrubs blocking recreational spaces, particularly in a city where recreational spaces are limited (Payne et al., 2002; Atauri et al., 2000). Focus group participants suggested using plaques to provide information about phytoremediation and park history. These plaques could also include information about the temporary nature of a phytoremediation project,

which may help to prepare park users for shrub removal and reduce disappointment if they do become attached to the plants.

Overall, park users seemed to be relatively flexible in their preferences for and acceptability of varying landscape and phytoremediation options. Though seemingly outraged by the new capping project, focus group participants were quick to look for new solutions, and indicated that they still plan to use the park. Such a response is encouraging and suggests resilience to a wide variety of park management strategies. Respondents volunteered a number of ways to increase the acceptability of phytoremediation at Gas Works Park, which indicated that they felt strongly enough about the positive impacts of phytoremediation that they were immediately enthusiastic about finding ways to implement the strategy and make it attractive to other park users.

4.1.4 The Role of Values in Phytoremediation Acceptability

In focus groups, there were frequent indications that participants hold both ecocentric and anthropocentric values. Some participants suggested that the environmental benefits of phytoremediation be emphasized, indicating ecocentric values and suggesting that participants believed others would respond positively to messaging that targets ecocentrism. There was also extensive discussion of aesthetics and recreation spaces, which may suggest importance of some anthropocentric values. The importance of recreational activities was brought up multiple times in focus groups, indicating that recreation is important to park users and may play a role in phytoremediation acceptability.

In support of exploratory focus group findings, surveys indicated that ecocentrism predicts phytoremediation acceptability, with higher levels of ecocentrism associated with a greater degree of phytoremediation acceptability. Anthropocentrism, however, was not a

significant predictor of phytoremediation acceptability. These results are consistent with previous research findings that ecocentrism is a predictor of pro-environmental behavior (Thompson & Barton, 1994). It may be the case that phytoremediation is associated with pro-environmental attitudes and could be thought of as a type of pro-environmental behavior.

It is possible that anthropocentrism was not a significant predictor of phytoremediation acceptability in part because respondents did not feel that implementing phytoremediation would require much in the way of sacrifice. As discussed previously, anthropocentrism negatively predicts pro-environmental attitudes and behavior primarily when such behavior is associated with having to make some sacrifice (Thompson & Barton, 1994). Perhaps the sacrifices associated with phytoremediation at Gas Works Park are viewed as minor enough that they do not outweigh the potential benefits of phytoremediation. Additionally, those high in anthropocentrism may focus to some degree on the human benefits of phytoremediation and consider those as an advantage.

It is important to note that the findings regarding both values and acceptability may be region-specific, as Seattle residents are known for holding largely pro-environment views. This is a good argument for further research in other, less ‘pro-environment’ parts of the country and world. In addition, surveying individuals in locations that may be less accepting of phytoremediation may produce more variation in phytoremediation acceptability ratings and consequently may provide more information about the possible roles of predictor variables such as risk and anthropocentrism.

4.1.5 Risk Perception and Phytoremediation Acceptability

Risk perception was low among focus group and survey respondents. Focus group participants expressed little to no knowledge of existing contamination or any associated risk.

Only two focus group participant openly admitted to knowing about the risk of contamination, and those individuals stated that their knowledge did not impact their decision to visit the park. Notably, there was not a single focus group respondent who expressed concern about contamination or allowed knowledge of risk to affect their decision to visit the park.

Descriptive analyses suggest that overall risk perception was moderate, with a mean of 2.83 for the composite risk variable. Correlational analyses of the survey results showed that there was a direct effect between risk and acceptability. However, risk was also correlated with ecocentrism and concern and shared more variance with those two predictor variables than with phytoremediation acceptability (dependent variable). Ultimately, concern and ecocentrism were uniquely predictive of phytoremediation acceptability, and risk perception was not a unique predictor.

Existing theories on risk perception may offer some insight regarding reasons for lower levels of risk perception at Gas Works Park. For one, it is possible that park users see the benefits of the park as outweighing risks. This idea is supported by statements by some participants, who said that they were aware of contamination but did not worry about it. Potentially, these participants performed some sort of analysis, weighing the pros and cons of visiting Gas Works Park, and decided that the advantages outweighed any potential disadvantages. Even if the analysis was somewhat cursory, the positives seemed to offset the negatives, as described by Mazure (1985).

However, risk/benefit analysis did not appear to be the only factor related to risk perceptions and phytoremediation acceptability. As suggested by some researchers (e.g., Loewenstein et al., 2001; Whitmarsh, 2008; and Zajonc, 1980), overall perceptions of risk and consequent behavior may be driven largely by affective evaluations of a situation as a whole

rather than by cognitive analyses of the different components of risk and benefit. Consistent with findings by Slovic and colleagues (2005), participants seem to create mental shortcuts in assessing park risk. Weighing individual risks and benefits is an inefficient strategy, so park users may simply create a positive overall affective impression of the park and choose not to consider risks each time they visit.

A couple of focus group participants talked about risk/benefit analysis of visiting the park, but most respondents spoke about having generally good feelings about the park. They talked about it being pretty and about not thinking of it as contaminated. Respondents also spoke about fond memories or about enjoyment associated with attending festivals and events. It may be the case that many visitors to Gas Works Park have a positive affective impression of the park, and do not take the time and cognitive energy to calculate all potential advantages and disadvantages of spending time there. Some focus group participants alluded to such attitudes, stating that they either didn't think about contamination or visited the park despite knowing that contamination risk might be an issue.

Surveys didn't directly address affective vs. cognitive sources of risk perception. However, that risk was not a significant predictor of phytoremediation acceptability may potentially be an indication that risk perception doesn't notably affect behavior or perceptions of cleanup. Further research in this area would be valuable as a way to delve deeper into the basis of risk perceptions at contaminated sites and how those perceptions might influence phytoremediation acceptability.

There is also evidence that people have a tendency to minimize or deny the existence of risks that they know little about or feel are out of their control (Renn, 2004; Sjöberg, 2000). Park users are likely relatively unfamiliar with the risks associated with PAH contamination, as

indicated by focus group and survey findings. As a result, they probably do not have much knowledge about ways to reduce PAH risk. According to Wolfe and colleagues (2002), this would lead those individuals to minimize potential risks.

Finally, contamination at Gas Works Park is not visible, which could lead park visitors to easily overlook or minimize risks, and consequently might contribute to low risk perception among respondents (Bickerstaff, 2004; Renn, 2004). Findings from focus groups offer some support for the notion of visibility affecting risk perception. Participants talked about not being able to see the contaminants and noted that they thought of Gas Works Park as ‘just a pretty park’. Others talked about seeing some areas with dead grass and standing water and being most worried about potential issues there. Also consistent with these theories, focus group and survey participants said that they had not seen signs warning of contamination at Gas Works Park, which may contribute to decreased knowledge about contamination and consequently to lower perceptions of risk. Surveys were supportive of this explanation in that overall perceived risk was low, and most respondents indicated that they had not seen signs warning of contamination.

4.1.6 Concerns about Phytoremediation

Findings related to concerns about phytoremediation indicate a relatively low level of overall trepidation about the remediation technology. This is not surprising, given the positive response to the idea of phytoremediation implementation at the park, as discussed above. Some concerns were voiced in focus groups, with participants mostly looking for explanations or more information about phytoremediation in general.

Survey results showed that the degree of concern was not predictive of phytoremediation acceptability. This may be in part because respondents do not have much knowledge about phytoremediation and consequently do not have experience with which to compare their concern.

It may also be related to the high level of interest in and acceptability of phytoremediation. It makes sense that strong support for the technology might be accompanied by a relatively low level of concern for associated issues. As mentioned previously, Slovic and colleagues (2005, 2006) found a similar effect, with high perceived benefits associated with lower perceived risks.

Lastly, trees are almost universally seen as positive. One focus group respondent stated that “planting trees isn’t a conflict of interest.” According to Buhyoff, Gauthier, and Wellman (1984), it is well accepted that people like trees. This is consistent with findings from studies exploring landscape preferences in urban areas, in which researchers found a consistent preference for landscapes containing trees (Hadavi et al., 2015; Jiang et al., 2015). Even though the willows planted at Gas Works Park would be shrubs rather than trees, respondents indicated that the vegetation would be desirable and expressed minimal concerns about implementing phytoremediation, as long as it was done in the right locations.

4.2 Limitations

This study had a number of limitations. The survey relied entirely on self-report, which carries with it the potential for social desirability bias. Social desirability bias occurs when a respondent reports socially desirable behavior despite not actually behaving in that manner (Grimm, 2010; Kreuter et al., 2008). This is a potential limitation of both interview and survey research. It is possible that focus group and survey participants in this study responded in a way that they felt was socially acceptable rather than expressing their actual beliefs and behavior. Research indicates that self-administered surveys, such as those sent via email, produce lower bias than do surveys administered by the interviewer (Kreuter et al., 2008), suggesting that social acceptability bias may have been diminished to some degree in the survey component of this study.

Respondents who participated in the focus groups and agreed to complete the survey may have had a particularly strong interest in the park and potential outcomes there. Specifically, this study may have drawn participants who wanted to learn more about phytoremediation. Consequently, results may not reflect the views of the entire population of Gas Works Park visitors. Additionally, all survey participants were those who continue to visit Gas Works Park. As such, any individuals who may have ceased visiting the park due to possible safety concerns were not included in the study. This may have had an effect on discussions and ratings of risk perception and associated behavior in particular. Future studies would benefit from including individuals who used to visit the park but no longer do so.

Composite scores for the ‘anthropocentrism’ variable had low reliability, which may have impacted the results from statistical analysis. That anthropocentrism was not significant could potentially be attributed in part to the low reliability of the scale.

The study could benefit from a larger sample size collected over a longer period of time. Subjects were recruited over a two-month period, thereby potentially limiting participant diversity in terms of seasonal- and weather-based activities. Future studies would benefit from data collected over a longer period of time, ideally at varying points throughout the year.

4.3 Suggestions for Future Research

This study was exploratory, and findings could be used to inform future research on the topic of the social acceptability of phytoremediation. For one, the study was specific to a unique location and to one particular type of contamination. It would be valuable to conduct a study on phytoremediation acceptability in a different region, a different type of location (rural or suburban instead of urban), and with different types of contamination. Specifically, it would be

of interest to conduct a study assessing the social acceptability of remediating inorganic contaminants.

It would also be interesting to further explore the role of concern (with phytoremediation itself) and to explore different ways of assessing risk perception associated with existing contamination. Concern may be greatly affected by type of contamination, as phytoremediation of inorganic contaminants would likely pose more risks and would require more intensive cleanup and management since the pollutant would conceivably be more bioavailable than would phytoremediation of organic contaminants that involves degradation of the pollutants. Similarly, risk associated with contamination could be impacted by landscape components, the location of the site itself, and the social environment surrounding it.

The results of this study suggest that values are an important predictor of phytoremediation acceptability. Future studies could explore different ways of assessing anthropocentrism and ecocentrism. One possibility would be to use more refined and in-depth scales to assess each value. Perhaps an entire survey could be designed just to assess these components so as to further explore their role, and potentially to elucidate possible relationships between phytoremediation acceptability and overall proenvironmental attitudes and behavior.

4.4 Conclusions

Evaluations of phytoremediation at Gas Works Park were overwhelmingly positive. Respondents were particularly amenable if the shrubs could be tied in with existing features. They also indicated that it would be important to maintain the view of the city and some open recreational spaces within the park. Participants also suggested that phytoremediation be implemented along with plaques that provide information about the process and benefits of phytoremediation and about the history of the park.

Values were an important component of phytoremediation acceptability, with ecocentrism as one of the only two variables that significantly predicted acceptability. This is consistent with past research, which shows that ecocentrism is positively associated with proenvironmental behavior. The finding may indicate that phytoremediation acceptability can be considered a subset of proenvironmental attitudes and behavior.

One notable observation was focus group participants' enthusiasm for the use of phytoremediation. Without any prompting for suggestions, participants volunteered ideas for ways to promote phytoremediation and increase acceptability. Enthusiasm was particularly strong once participants learned about the new capping project at the park. Overall, this study suggests that phytoremediation would be well received at Gas Works Park, and that measures could be taken to improve acceptability of implementation.

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Appendix I: Sample Focus Group Questioning Route

Opening Question: What would you be doing if you weren't here right now?

How often do you visit Gas Works Park?

Why is Gas Works Park important to you?

What other parks do you visit?

What activities do you participate in at the park?

Please talk about the history of Gas Works Park.

- Are you aware of contamination at the park?

Have you talked with family and friends about park contamination?

Do you feel that your activities at Gas Works Park put you at risk for exposure to contamination?

- Are you concerned about risks associated with contamination at Gasworks Park?

What are your thoughts about previous cleanup efforts at the park?

Have you heard about phytoremediation? Please explain.

Are you aware of the natural ability of bacteria to degrade pollutants?

What are your thoughts about using phytoremediation at Gas Works Park (using willow shrubs)?

Of all the things we discussed, what is the most important to you?

Is there anything else you would like to say about the park or phytoremediation?

Appendix II: Focus Group Consent Form

Consent Form

Study Title: Assessing the Social Acceptability of Endophyte-Assisted Phytoremediation

Researchers:

Ellen Weir

Dr. Sharon Doty

Graduate Student

Associate Professor

School of Environmental and Forest Sciences

School of Environmental and Forest Sciences

Ellenf3@uw.edu

(206) 714-7142

You are invited to be part of a research study that will explore park visitors' viewpoints on landscape management at Gas Works Park. You have been selected as a potential participant because of the insight that you may be able to provide on this particular subject. We ask that you read this form and ask any questions you may have before agreeing to be in the study.

Background Information:

The purpose of this study is to explore park visitors' viewpoints on phytoremediation, contamination, and landscape management at Gasworks Park. By participating in this focus group, you will have the opportunity to express your views and opinions on phytoremediation and landscape management. This will help determine the feasibility of phytoremediation as well as help to guide the development of landscape plans at Gasworks Park. This portion of the study involves holding focus groups with park visitors and community members to provide knowledge about the opinions of park users and apply that knowledge to the decision-making process.

Procedures:

If you agree to participate in this study, we will ask you to do the following things:

- Engage in a focus group of six to ten people where you will be asked questions regarding your thoughts on phytoremediation and landscape preference at Gasworks Park.

The focus group sessions will be audio recorded and those recordings will be transcribed. If your name is mentioned during the focus groups, your name will be omitted from the transcription. The entire session is anticipated to take between 1.5 and 2 hours.

Confidentiality:

Focus group participants will be informed that the statements of other participants are considered confidential information and should not be shared outside of the group. Information that would make it possible to identify you will not be included in any report or publication that may result from this study and the audio-records will be destroyed upon completion of the study. Information will be stored securely and only researchers will have access to the records.

Risks of being in the study:

There are no anticipated risks to participating in this study. The purpose of the focus groups is to obtain information about park visitors' and community members' views on phytoremediation and landscape preference. While focus group participants are informed that the statements of other participants are considered confidential, it is possible that statements from the focus group might be discussed outside the group and traced back to you. This study does not involve discussion of sensitive material. Therefore, we do not anticipate risks associated with the disclosure of comments.

Benefits of being in the study:

By participating in this study, you will have the opportunity to express your views on phytoremediation and landscape preference, which will help inform practices at Gasworks Park. Your participation will also help guide the design of a survey for park visitors.

Voluntary nature of the study:

Participation in this study is voluntary. Your decision whether or not to participate will not affect your current or future relations with the University of Washington. If you decide to participate, you are free to not answer any question or to withdraw at any time without affecting those relationships.

Contacts and Questions:

The researcher conducting this study is: Ellen Weir. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact Ellen at (206) 714-7142 or ellenf3@uw.edu.

Printed name of study staff obtaining consent	Signature	Date
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Subject's statement

This study has been explained to me. I volunteer to take part in this research. I have had a chance to ask questions. If I have questions later about the research, I can ask one of the researchers listed above. If I have questions about my rights as a research subject, I can call the Human Subjects Division, of the University of Washington, at (206) 543-0098. I will receive a copy of this consent form.

Printed name of subject	Signature of subject	Date
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Appendix III: Gas Works Park Survey

Do you live in the Seattle area? _____

If yes, how long have you lived there? _____ years _____ months

In the past month, how many times have you visited Gas Works Park?

Rarely	Once a Month	Every Two Weeks	Once a Week	At Least Two Times Every Week
1	2	3	4	5

Please indicate how often you engage in the following activities at Gas Works Park:	Never				Very Frequently
1. Running	1	2	3	4	5
2. Walking	1	2	3	4	5
3. Picnicking	1	2	3	4	5
4. Flying Kites	1	2	3	4	5
5. Playing sports	1	2	3	4	5
6. Sight-seeing	1	2	3	4	5
7. Attending festivals and events (e.g., 4 th of July, Solstice Festival, etc.)	1	2	3	4	5
8. Organized group activities (e.g., acro-yoga, meetup group events, etc.)	1	2	3	4	5
9. Playing with your kids	1	2	3	4	5
10. Walking your dog	1	2	3	4	5

Are you familiar with the history of Gas Works Park? Yes ___ No ___

Who do you believe was responsible for cleanup of contamination at Gas Works Park?

Please indicate how much you agree with the following statements:	Strongly Disagree				Strongly Agree
1. I believe that those responsible for cleaning up Gas Works Park did a satisfactory job.	1	2	3	4	5
2. I am worried about residual contamination at Gas Works Park.	1	2	3	4	5
3. I am concerned about continuing health effects of Gas Works Park pollution.	1	2	3	4	5
4. There are not any negative environmental effects associated with Gas Works Park contamination.	1	2	3	4	5
5. I believe that Gas Works Park is safe for park visitors.	1	2	3	4	5
6. I am concerned about continuing environmental effects of Gas Works Park pollution.	1	2	3	4	5
7. I am concerned about the safety of Gas Works Park for children.	1	2	3	4	5
8. Knowledge of park contamination influences my decision to visit Gas Works Park.	1	2	3	4	5

Have you heard of phytoremediation before? Yes ___ No ___

Phytoremediation is the use of plants to clean up contaminated land, soil, sediment, air, and water. The chemicals that remain under the soil cap at Gas Works Park are called polycyclic aromatic hydrocarbons (PAHs). PAHs are pollutants that can cause cancer birth defects with too much exposure. Though mostly covered by the cap, these chemicals can occasionally seep up through the soil, especially during times of heavy foot traffic. Planting willow shrubs would help with the permanent removal of some remaining toxins.

Phytoremediation could be used at Gas Works Park to remove toxic chemicals that remain 1-2 feet under the soil. Willow shrubs would be monitored for removal of contaminants and would likely need to remain in the soil for 1-2 years. If used, this process could occur all at once or in phases, whereby some areas of the park would be planted with shrubs and others would remain open. Shrubs could then be removed from planted sites and new shrubs could be planted in different areas, ensuring that some locations within the park would remain open and free of shrubs. Additionally, microbes would be added to the plants to help the plants with detoxification. Symbiotic partnerships between the plants and microbes would help with greater removal of contaminants from the soil. Willows could be pruned annually to keep them short and bushy.

Below is a photo of the type of willow that could be used to clean up the soil at Gas Works Park:



Please indicate how much you agree with each of the following statements:	Strongly Disagree				Strongly Agree
1. Phytoremediation at Gas Works Park is a good idea.	1	2	3	4	5
2. Phytoremediation would be a good addition to other remediation strategies at Gas Works Park.	1	2	3	4	5
3. Shrubs would make a good addition to the landscape at Gas Works Park.	1	2	3	4	5
4. Phytoremediation at Gas Works Park should be phased, so only some areas of the park have plants at a time.	1	2	3	4	5
5. Phytoremediation at Gas Works Park should be permanent, so the park always has shrubs.	1	2	3	4	5
6. Phytoremediation would make Gas Works Park a more desirable place to visit.	1	2	3	4	5

7. Phytoremediation is NOT an appropriate cleanup method at Gas Works Park.	1	2	3	4	5
8. Phytoremediation at Gas Works Park would be beneficial to the environment	1	2	3	4	5
9. Phytoremediation at Gas Works Park would improve safety to park visitors.	1	2	3	4	5
10. Phytoremediation would make Gas Works Park a less attractive place to visit.	1	2	3	4	5

Please indicate how concerned you would feel about the following factors if shrubs were planted at Gas Works Park for phytoremediation:	Not at all Concerned				Extremely Concerned
11. Maintenance	1	2	3	4	5
12. Removal	1	2	3	4	5
13. Effectiveness	1	2	3	4	5
14. Location of plants (plants would be in the way)	1	2	3	4	5
15. Size of plants	1	2	3	4	5
16. Safety	1	2	3	4	5
17. Homelessness	1	2	3	4	5
18. GMO plants	1	2	3	4	5
19. Use of new technology	1	2	3	4	5
20. The use of microbes	1	2	3	4	5

Please indicate how much you agree with each of the following statements.	Strongly Disagree				Strongly Disagree
1. We are approaching the limit of the number of people the earth can support.	1	2	3	4	5
2. Technology can overcome any environmental problems.	1	2	3	4	5
3. Humans have the right to alter nature to satisfy wants and desires.	1	2	3	4	5
4. Maintaining economic growth is more important than protecting the natural environment.	1	2	3	4	5
5. Humans have the right to reduce the number of species on earth in order to promote economic development.	1	2	3	4	5
6. Science forms the basis for solving environmental problems.	1	2	3	4	5
7. There are limits to industrial growth.	1	2	3	4	5
8. Present levels of industrial activity need to be reduced	1	2	3	4	5
9. Nature is a storehouse of resources for humans to use.	1	2	3	4	5
10. Conserving natural resources is unnecessary because alternatives will always be found.	1	2	3	4	5
11. Natural resources should be used primarily to provide for basic needs rather than material wealth.	1	2	3	4	5
12. Humans should adapt to nature rather than modify it to suit us.	1	2	3	4	5
13. A change in basic values is necessary in order to solve environmental problems.	1	2	3	4	5
14. Humans should live in harmony with the rest of nature.	1	2	3	4	5
15. Human interference with nature often results in disastrous consequences.	1	2	3	4	5

16. Humans have the right to control the rest of nature.	1	2	3	4	5
17. Humans are not part of nature.	1	2	3	4	5
18. Humans are presently interfering too much with the natural environment.	1	2	3	4	5
19. There is a limit to the number of people the earth can support.	1	2	3	4	5
20. People should have respect for the rest of nature.	1	2	3	4	5
21. The natural environment has value within itself regardless of any value humans may place on it	1	2	3	4	5
22. Humans have moral obligations to other humans.	1	2	3	4	5
23. Humans have moral obligations to other animal species.	1	2	3	4	5
24. Humans have moral obligations to plants and trees.	1	2	3	4	5
25. Humans have moral obligations to the nonliving components of nature (e.g., rocks)	1	2	3	4	5
26. Present generations of humans have moral obligations to future humans.	1	2	3	4	5
27. Satisfaction and high quality of life are more important than material wealth.	1	2	3	4	5

Are you familiar with plans to close part of the park for several months to complete a new capping project on kite hill?

Yes ___

No ___

Demographics

What is the highest level of education you have completed?

- Some High School
- Graduated from High School/GED
- Some College
- Graduated from College
- Some Graduate School
- Graduate or Professional Degree

Please indicate your total household income before taxes for last year:

- Under \$19,999
- \$20,000 to \$59,999
- \$60,000 to \$99,999
- \$100,000 to \$139,999
- \$140,000 or over

Please indicate the number of people in your household: _____

What is your gender? _____

Which category below includes your age?

- | | | |
|--|--------------------------------|--------------------------------------|
| <input type="checkbox"/> 17 or Younger | <input type="checkbox"/> 30-39 | <input type="checkbox"/> 60 or older |
| <input type="checkbox"/> 18-20 | <input type="checkbox"/> 40-49 | |
| <input type="checkbox"/> 21-29 | <input type="checkbox"/> 50-59 | |