Abstract

On-site waste treatment systems are a common alternative to traditional sewage infrastructure and often used by rural or isolated households in the US. Without proper maintenance, these systems dramatically reduce surface water quality. A potential solution for rural neighborhoods to ensure proper sewage treatment and maintenance is to connect all homes to a community sewage system. The challenge is that this conversion requires community-level buy-in, cooperation, and expense, but corresponding research is absent.

As a case study, we examine one neighborhood located along Bayou Lafourche in southeast Louisiana to understand household willingness to pay to convert to a community sewer system. Using an incentive compatible payment card elicitation, we find that household willingness to pay is $7.87-10.43 per month. This value depends on several factors, with the number of years lived in the subdivision, age of the respondent's septic system, and educational attainment associated with an increase in willingness to pay. The number of years the respondent has lived in Louisiana, the number of recreational activities the respondent participates in, experiences with sewage issues in the past, retirement status, and income all had negative effects on willingness to pay that were statistically significant.

Key words: Contingent Valuation, Community Sewage System, Payment Card, Hypothetical Bias

A major contributor to water quality is wastewater treatment. In the US, about one in five households commonly rely on onsite wastewater treatment systems (OWTS) for treatment (US Census Bureau 2006). Rather than pumping the sewage elsewhere for treatment, OWTS treat and dispose of sewage on-site, typically with one individual system per home. Common examples include septic tanks, cesspools, and drain fields. For decentralized rural and suburban communities, OWTS may be preferred compared to connecting to an existing nearby centralized sewage system because of the diseconomies to scale from a smaller customer base resulting in overall higher construction and maintenance costs (Pearson 2007). Properly maintained OWTSs can provide wastewater management that is comparable to centralized systems (USEPA 1997). When properly maintained, a customer with OWTS may have life-cycle costs 25% lower than a customer who relies on public sewage (Swann 2001). While such large savings may help explain the wide adoption of OWTS in rural areas, proper maintenance and inspection is costly and voluntary in the US. Homeowners may save money by avoiding maintenance, explaining why some homeowners fail to manage their OWTS.

Despite the wide acceptance and implementation of OWTS, there is growing concern that such systems, when not maintained, severely harm water quality (Day 2004; Harris 1995; Sidhu et al. 2013). An estimated 5%-40% of all OWTS in the US are malfunctioning to some degree, varying widely across locations (Swann 2001). According to the EPA, states do not regularly report this data and further do not have a uniform definition for “system failure”, thus explaining the wide range for failure rates (2002). In Louisiana, 170 waterways had elevated FC levels, with 103 of these reporting poorly maintained OWTS as the leading cause of impairment (Hindrichs and Cormier 2022). Measuring failure rates of OWTS is difficult because regulations and permits are typically locally administered and largely deal with planning and implementation of these systems, but not the maintenance and upkeep (Withers et al. 2014).

OWTS often fail at such high rates for several reasons. Homeowners are often unaware of proper maintenance routines and therefore neglect their systems, an issue that is exacerbated in more isolated or underserved communities (Fizer et al. 2018). OWTS failure is also caused by improper siting and installation, as many OWTS rely on sensitive biological and chemical processes whereby effluent from the system is released into surrounding soils for further treatment (Gunady et al. 2015; Beal, Gardner, and Menzies 2005). OWTS efficacy is also affected by other factors such as soil characteristics, moisture, and water level (Macintosh et al. 2011). OWTS may also be more susceptible to extreme weather events (Kohler, Silverstein, and Rajagopalan 2020). The number of repairs and the associated downtime prior to being fully functional for OWTSs significantly increased after the flood event. This suggests that with climate change coastal communities are especially vulnerable to improperly functioning septic systems (Cooper, Loomis, and Amador 2016; Yin et al. 2011).

From an economic perspective, homeowners may fail to maintain their OWTS because it adversely affects water quality, a public good (Mohamed 2009). Homeowners are behaving rationally to avoid the maintenance costs to their system, but hoping others will maintain theirs, thus ensuring good water quality. The result is that too many people free ride and the provision of the public good (water quality) is not guaranteed.

To improve water quality, efforts typically focus on repairs and maintenance to reduce the number of malfunctioning OTWS as well as educating owners on proper maintenance (Vedachalam, Hacker, and Mancl 2012; Gunady et al. 2015). Repairs are effective, but temporary since OWTS will inevitably need further maintenance in the future (Macintosh et al.

2011). A lack of monitoring or enforcement provides no incentive for homeowners to ensure proper maintenance. Education works to increase voluntary compliance and assumes that homeowners do not manage their OWTS because they do not understand the link between their OWTS and health and environmental issues.

To improve educational outreach efforts, Kohler recommends emphasizing long term household savings due to proper OWTS maintenance which reduces the risk of expensive emergency repairs rather than focusing on environmental benefits (2017). Connelly et al. (2023) find evidence of such savings of regular maintenance and that mandatory inspections increased maintenance. Without an enforcement mechanism, education and outreach is only as effective as the number of homeowners affected by and willing to voluntarily spend to properly maintain their OWTS. It also still requires maintenance per household, greatly increasing the effort necessary for neighborhood-level compliance.

Instead, proper sewage treatment across all households is more easily coordinated and achieved by converting houses from OWTS to a community sewage system (CSS), thus resulting in improved surface water quality (Daeger and Bosch 2021). CSS are well suited for rural communities consisting of less than 10,000 homes in which building or connecting to a centralized sewage system is prohibitively expensive. 92% of the small water systems in the US serve similar sized communities and so would be well suited for a CSS conversion (Pearson 2007). Converting all houses in a rural neighborhood to a CSS eliminates the need for individual maintenance per household. This system limits the ability to free ride because all households must connect to the system and pay to use it.

A major barrier to CSS adoption is the potential expense which cannot easily be compared to a set of benefits to understand efficiency. This would most likely be in the form of increases in water/utility bills as they would now account for sewage handling costs. Further, improvements to water quality may include a range of benefits that are enjoyed by different people at varying levels, so it is difficult to know all of the actual benefits enjoyed by the community, which in turn makes a benefit-cost analysis more difficult (Gramlich 1977; Jordan and Elnagheeb 1993). This is despite evidence that even the most costly projects tend to have a positive benefit-cost ratio (Hall and Lobina 2008).

The number of studies that seek to understand WTP for a CSS to improve water quality is sparse. Most WTP studies for improved sewage infrastructure take place in developing countries (Mani, Onishi, and Kidokoro 1997; Palanca-Tan 2015; Tudela-Mamani 2017; Van Houtven et al. 2017). Most economic studies of water quality improvements in the US emphasize recreational benefits or WTP to improve groundwater quality and do not deal with community sewage (Carson and Mitchell 1993; Elnagheeb and Jordan 1997; Lipton 2004; Van Houtven et al. 2017). As far as we know, no studies have examined WTP for CSS in the US, a relevant solution to many rural communities.

The purpose of this article is to understand WTP to install a CSS as means to improve water quality. We use a case study of residents in a single neighborhood along Bayou Lafourche in Lafourche Parish in southeast Louisiana. Bayou Lafourche provides drinking water and recreational benefits to over 300,000 people in surrounding areas, but many of its segments currently exceed Louisiana Department of Environmental Quality's (LDEQ) standards for primary exposure (swimming) as well as secondary exposure (boating and fishing) (Martinez et al. 2019). This poor water quality increases the risk of illness, increases water treatment costs, and harms aquatic wildlife (Watson 2006; Iverson et al. 2017; Swann 2001; Gunady et al. 2015). Additionally, while payment cards have typically been avoided to elicit WTP for public goods due to incentive incompatibility, we utilize a recently developed incentive-compatible payment card elicitation method from Vossler and Holladay (2018) to estimate WTP.

Methods

To ascertain the economic value of improved water quality via CSS, we conduct a survey of households located in a specific subdivision along Bayou Lafourche near Lockport (Lafourche Parish), Louisiana. This community was selected for several reasons in conjunction with LDEQ leaders. First, it has a proven record of poor water quality (LDEQ 2011, 2013). Second, (shown in Figure A1's aerial view), the neighborhood's 220 houses are closely packed and so are ideal for a CSS. Third, the neighborhood's adjacency to Bayou Lafourche means that proper sewage treatment would directly benefit water quality in the bayou. Lastly, using one neighborhood also increases the salience of the issue to residents, which in turn can be communicated to local authorities to make an informed decision.

Prior to eliciting WTP for CSS, we explained the proposed change and instructions for the elicitation. It began with a brief description of water quality challenges facing Bayou Lafourche and how a community sewage system may help, including an image of the system and benefits from past conversions in Louisiana, shown in Figure 1. This facilitates respondent comprehension of the good being valued as well as the incremental changes that may result from the conversion. To further check for attitudes towards water quality and comprehension of the description, we then asked to what degree respondents think sewage contributes to worsening water quality and how likely a community sewage system is to improve it.

An important decision of eliciting WTP using contingent valuation is choosing among several elicitation techniques, such as open-ended, payment card, or dichotomous choice. In terms of measuring WTP, PC is more preferable to dichotomous choice because it provides narrow interval on which the respondent’s true WTP falls, yielding more accurate WTP estimates during modeling (S.H. Yang et al. 2013). Conversely, single binary choice has become the standard because it is incentive-compatible for public goods (Johnston et al. 2017; Arrow et al. 1993). A technique is incentive compatible if the respondent has the incentive to truthfully reveal their actual WTP (Carson and Groves 2007). Public goods, such as water quality, are non-rival and non-excludable such that one person’s consumption does not prevent another’s consumption and no one person can be excluded from enjoying the good, even if they did not contribute to its provision. These characteristics make eliciting WTP for public goods while ensuring incentive-compatibility especially difficult.

Traditionally, PC is not an incentive-compatible method to elicit public goods because of the lack of an implementation rule which may make it unclear how responses will be interpreted. If the cost is fixed and known to the respondent, then the elicitation is not incentive compatible and the respondent may answer strategically by over or understating WTP (Brouwer, Brander, and Van Beukering 2008). For example, suppose a campaign for the provision of a public good like water quality relies on a certain threshold to be met before collecting. A respondent who wishes for the good to be provided may strategically overstate their WTP in the survey to ensure the fundraising begins, but then freeride on the actual donations of others (Carson, Groves, and List 2014). Vossler and Holladay (2018) and later Vossler and Zawojska (2020) show that by using a random price voting mechanism, making price uncertain to the respondent, eliciting WTP for a public good becomes incentive-compatible using a payment card (IC-PC) and yields estimates equivalent to a single binary choice.

Prior to elicitation, respondents watched a two-minute video including instructions[1] of the IC-PC mechanism, closely following the structure of Vossler and Holladay (2018). The video contained several elements to adhere to IC-PC: 1) the cost of converting to CSS is unknown, 2)the decision rule, conversion to CSS requires majority support within the community and if the majority vote yes, then everyone must connect, 3) compulsory payment, if approved, the amount would be added to the monthly water bill and replace any costs for their at-home sewage system.

Respondents are then asked a series of "yes" or "no" questions, each at a different price level from $.50 to $50 dollars per month to elicit their WTP to install a CSS, following the IC-PC format (see Figure 2). Using PC provides a narrower interval of the respondent's WTP compared to a single-binary choice, which only provides enough information to determine whether WTP is greater than or less than the bid amount selected. This advantage is especially important because of the small population being surveyed which cannot overcome the wide intervals with a large number of responses.

Beyond the elicitation, we follow several other best practices (Boyle 2017; Johnston et al. 2017). We consider Hypothetical Bias (HB), the difference between hypothetical and real WTP (Penn and Hu 2018), with hypothetical WTP typically being greater than real WTP. Specifically, we use the certainty follow-up question method (Blomquist, Blumenschein, and Johannesson 2009), which has been shown to be more effective than Cheap Talk at mitigating or eliminating HB (Penn and Hu 2022). Certainty follow-up is an ex-post correction method that typically addresses HB by taking 'yes' responses with comparatively low levels of certainty and recoding them to 'no', reducing the percentage of 'yes' responses at each price level. In our case, we ask a qualitative two-level certainty follow-up question (Blumenschein et al. 2008) ("probably sure"

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[1] Viewable at: lsu.qualtrics.com//CP/File.php?F=F_3gc5dF9GSGzA7b0. The paper version of the survey included the same information from the video in several paragraphs.

and “definitely sure”) for the highest amount they voted ‘yes’. “Probably sure” responses are recoded to ‘no’ and their maximum WTP decreases to the next highest amount they voted ‘yes’. If they answered “Probably sure”, we repeat the process a second time, asking for certainty at the next highest yes-level, repeating the same process. This allows us to report certainty-adjusted model results and WTP estimates to address HB.[2]

We also control for protest responses, respondents who misstate WTP in hopes of affecting the hypothetical policy decision, irrespective of the price. Protest responses reject the elicitation scenario for reasons unrelated to price and may answer strategically to deter project implementation. After the elicitation, respondents were asked to select from a list of factors that influenced their WTP. 13 respondents selected “I don’t think that is my responsibility to pay to reduce sewage contamination”, and thus were considered protest responses. Examples of valid, non-protest responses include “It was difficult for me to decide the highest amount I would pay” and “My utility bill is too high, and I am against any initiative that will increase it”. These responses are valid because they directly cite price as a reason for their WTP.

Another critical component of demand-revealing responses in CVM studies is consequentiality. Respondents must care about the issue and believe their response has the chance to affect outcomes (Carson and Groves 2007). We include two corresponding questions to measure the respondent’s perceived consequentiality. The first asks how likely the respondent believes it is that the survey data will be taken into consideration by the local government. The second asks to what degree the respondent believes that their responses will affect whether a CSS is built. Respondents may select “Very Good Chance”, “Some Chance, “Little Chance”, and “No Chance”. Eight respondents answered no chance for both questions with two more

[2] Only one certainty follow-up question was provided for the paper surveys, and it used a generic text asking how sure the respondent is that they would be willing to pay the amount selected. We follow similar logic, with the highest “yes” response recoded to “no” if the individual selected “probably sure”.

answering no chance for either question, for a total of 12 respondents believing that they survey is not consequential based on both questions. Due to the limited sample size, respondents who viewed the survey as inconsequential or gave a protest response were not excluded from the analysis. Inconsequentiality and protest responses tend to have a downward effect on estimates for WTP and marginal effects (Interis and Petrolia 2014).

Beyond the elicitation for CSS and its associated questions, the survey also contained several other relevant questions. Its first section asked general questions such as how long the participant has lived in the area and participation in outdoor recreation. The second section focused on experiences related to potential sewage issues in Bayou Lafourche as well as the age, maintenance and expenses of their OWTS. It continued with attitudinal questions of water quality in Bayou Lafourche. The next section contained the WTP elicitation as well as certainty follow-up, protest, and consequentiality questions. It concluded with demographic information. Summary statistics and descriptions of variables used in the analysis from these various sections appear in Table 1. A full version of the survey administered may be found in the appendix as figure A2.

Survey Development and Implementation

In developing the survey, we conducted several interviews and qualitative survey pretests including focus groups of stakeholders in the area. Groups involved include Barataria-Terrebonne National Estuary Program, Lafourche Parish Water District, and Louisiana Rural Water Authority as well as residents of the area (excluding residents of the neighborhood of our study). In the past, such groups have conducted projects and workshops in the area to increase OWTS maintenance and cooperation with these local authorities.

To maximize participation in the survey, respondents were contacted following the Dillman tailored survey design approach (2014), resulting in four total waves of mailings in Fall 2022. These waves consisted of an initial letter to notify residents of the survey, a second mailing including a link to take the survey online (via Qualtrics), and another two waves including the same link as well as a paper version that respondents could mail back at no cost. The three initial waves were mailed out approximately 14 days apart with the fourth wave mailed out a month after the previous. Each household in the neighborhood received a unique access code to take the survey to ensure one response per household. A yard sign reminding households to take the survey was at the entrance to the neighborhood for part of the study. As well, the cover letter notified respondents that a $2 donation per response would be made to a local charity (The Bayou Community Foundation)[3].

Analysis

Following Haab and McConnell (2002), we use the random utility model to explain a household's WTP for CSS. Random utility theory specifies that the utility function of household *i* is shown in eq (1):

$$U_i = (Y_i, \boldsymbol{X}_i, \varepsilon_i) \quad (1)$$

Where the utility of household *i* is a function of observable components including *Y*, their income, a vector of other factors $\boldsymbol{X}$ that may affect WTP, and ε_i, an unobservable component known to the individual, but not the researcher. The household will agree to pay their WTP so long as their utility U_{i*} after the payment is exceeds their utility in the status quo, U_i, shown in eq (2).

$$U_{i*} = (y_i - WTP_i, \boldsymbol{X}_i\ , \varepsilon_i) \geq U_i = (Y_i, \boldsymbol{X}_i\ \ \varepsilon_i) \quad (2)$$

[3] A separate experiment on the fourth wave provided a $2 bill as an incentive, the focus of a separate study.

When deciding to vote ‘yes’ or ‘no’ for a given price level, the household is deciding between their utility functions U_{i*} and U_i. The former represents utility after voting ‘yes’ when they are required to pay their WTP while the ladder is their utility in the status quo as explained in the random utility model from eq (1). So long as the reduction in utility after paying their WTP is offset by improvements to other values that explain their utility, the household will vote ‘yes’ and thereby prefer U_{i*}. Otherwise, the respondent will opt for the status quo in which their utility is greater than if they were forced to pay and connect.

We use interval regression to estimate the maximum WTP for CSS, a maximum likelihood technique often used in conjunction with PC elicitations (Gutierrez-Castillo et al. 2022; Tian, Yu, and Holst 2011; S.-H. Yang et al. 2012). Based on the theoretical framework, we can construct the econometric model to understand that for household *i* that chooses a maximum WTP amount t_b, the probability that their true WTP lies between t_b and t_{b+1} can be defined in eq (3):

$$Pr(choose\ t_b) = Pr(t_b \leq\ WTP_i < t_{b+1}) \tag{3}$$

Where t_b is the bid amount selected by the respondent and represents the lower bound estimate for WTP while t_{b+1} is the next highest bid amount representing the upper bound on WTP. The model assumes a normal distribution for WTP so that $WTP_i = x'_i\beta + \varepsilon_i$, where *x* is the vector of explanatory variables, β is the vector of parameters to be estimated, and ε_i is an error term. Assuming the error term is normally distributed with a mean of zero and variance σ^2 then eq (4) may be used

$$Pr(choose\ t_b) = \phi\left(\frac{t_{b+1} - x_i'\beta}{\sigma}\right) - \phi\left(\frac{t_b - x_i'\beta}{\sigma}\right) \tag{4}$$

Taking the log-likelihood of eq (4), we can use maximum likelihood to estimate β. Using the coefficients from these model results, mean WTP is calculated using eq (5).

$$WTP = \alpha + \sum(\beta\bar{x}) \qquad (5)$$

Where α is the constant, β are the parameters estimated from the interval regression, and $\bar{x}$ is the mean value of explanatory variables selected for econometric analysis.

We include several explanatory variables captured in the survey to understand WTP, described in Table 1. *Neighborhood Years* and *Louisiana Years* tell how long the respondent has lived in Nolan Toups and Louisiana, respectively. *Rec Count* is the number of recreational activities enjoyed with activities considered including fishing, swimming, boating, water sports, and duck hunting. This variable measures the recreational value that residents gain from Bayou Lafourche.

We include several variables related to sewage and the homeowner's OWTS. *Minor Smell* and *No Issues* explain the respondent's experiences with sewage related issues with the former indicating whether the respondent has experienced a minor sewage smell in the past five years and the latter indicating that the respondent has not experienced any sewage related issues in the same time frame. *Concerned* and *Notice Change* explain the respondent's perception about water quality based on a five-point likert scale question. *Concerned* tells how concerned the respondent is about water quality in the Bayou while *Notice Change* explains how much of a change the respondent has noticed in water quality since living near Bayou Lafourche. *Expense100* is the amount the respondent has spent on their septic system in the past five years measured in \$100's. *Septic Age* is the reported age of the home's OWTS. Respondents are able to select options for 1-2 years, 3-4 years, 5-7 years, 8 or more years, and 'I don't know' with responses being recoded to the midpoint of the interval and 'I don't know' responses being recoded to ten since this is likely indicative of them having an older system.

We also incorporate several demographic characteristics. *Income1000, Bachelor*, and *Retired* represent demographic characteristics that affect WTP. *Income1000* is the household's income from 2021 in $1,000's, *Bachelor* indicates whether the highest level of education is at least a bachelor's degree and *Retired* indicates whether the respondent is retired or not. *Income* was also collected like the variable *Septic Age* and recoded values to the midpoint of intervals selected. Further, eight respondents did not answer *Income1000* and so were replaced with the sample mean. Finally, *Consequential* measures how likely the respondent believes it is that the local government will take survey results into consideration when deciding to build the CSS.

Results

Of the 219 households that were contacted, 59 responded. Excluding respondents who failed to answer most of the survey, the number of useable responses is 51, a response rate of about 23%. Summary statistics of sample characteristics appear in Table 1.

Respondents lived in Nolan Toups and Louisiana for an average of 26.5 and 56.9 years, respectively. Nearly 30% of respondents did not answer the number of years lived in Louisiana and thus were replaced with either the mean number of years in Louisiana for the sample or the number of years the respondent has lived in Nolan Toups, whichever is greater. *RecCount* has a mean of 2.7, meaning that Nolan Toups residents partake in about 3 recreational activities.

In terms of Sewage issues households face, 70% reported having *No Issues* with their system over the past five years. Importantly, this is reported issues; homeowners may be unaware of issues with their OWTS. Among those who had experienced sewage related issues, the most reported issue was a *Minor Smell* among 30% of the respondents. Responses to variables *Concerned* and *Notice Change* indicate that, on average, respondents tend to neither agree nor disagree with statements about water quality in Bayou Lafourche either being a concern or having changed since they've lived near the bayou.

The average reported amount spent on regular maintenance and repairs of OWTS over the last five years (*Expense100*) was $470. This is a useful benchmark to compare against the cost of converting to a CSS. The average reported *Septic Age* was 7.6 years. This is likely an underestimation due to the assumptions made when converting the survey responses to numerical values as previously discussed. Further, 10% respondents indicated that they do not know the age of their septic system indicating that the system is likely much older. *Expense Year* indicates that, on average, the last year in which respondents paid for regular maintenance or repairs was 6.41 years ago with 16% reporting having never paid for any work on their individual, at-home sewage system. Louisiana Department of Health recommends a OWTS inspection every six years and getting the system pumped at least every eight years (LDH 2021). These results emphasize the potential ignorance or free-rider problem of homeowners either unaware or incentivized to avoid paying for OWTS maintenance (Mohamed 2009).

Moving onto the demographic questions, we can see that the average reported household income was $78,800 for 2021. Roughly 20% of respondents have a bachelor's degree or more and over 40% are *Retired*. Finally, the average value of 2.5 for *Consequentiality* indicates respondents believe there is some to little chance their response will be taken into consideration.

Model results of the interval regression shown in (Eq) 6 appear in Table 2. Model I includes the unadjusted model without additional covariates. In this model, we find that the average household WTP is $10.43 per month. Using a certainty adjustment to correct for hypothetical bias, WTP decreases to $7.87. This certainty-adjusted estimate is nearly a whole price level from the IC-PC lower than the original estimated WTP, indicating that the follow up questions were effective at reducing HB.

Model II runs the interval regression with the explanatory variables discussed above and features a smaller sample size at 44. Despite efforts to maintain the sample size, seven respondents were excluded for failing to answer at least one question used in the analysis. Using the parameter estimates from model II in conjunction with Eq. 6, we can obtain new estimates for WTP. Using the raw responses, WTP is $9.57. Upon applying a certainty correction to mitigate potential hypothetical bias, mean WTP is $7.52[4]. After adjusting for certainty, we see a general trend of variables losing significance.

As the number of years the resident lived in Nolan Toups increases by one, their WTP is predicted to increase by $0.49 ($0.38 after adjusting for certainty). Reported septic age had a statistically significant positive effect on WTP at a 0.01 certainty level. As septic age increases by one year, WTP for a CSS increases by $3.5, or $2.47 after adjusting for certainty. This is reasonable because a person with an older system may end up paying more for repairs and maintenance over its life, and so would be more willing to convert to a CSS. Individuals who had attained a bachelor's degree had a significantly higher WTP, more than $9 more than those without. This result is only marginally significant with certainty adjustment as the marginal effect of a bachelor's degree falls to $3.59). This significance is expected as higher educational attainment may improve other factors further allowing for a higher WTP.

The number of years the respondent lived in Louisiana had a statistically significant negative effect on WTP, with a one-year increase lending to a $0.32 reduction in WTP ($0.26 after adjusting for certainty). Recreational participation saw a similar relationship with an

[4] When running the model excluding protest respondents and those who viewed the survey as inconsequential, WTP estimates increase to $13.09 and $10.34 before and after adjusting for certainty. The results of this model may be provided by the author upon request.

additional recreational activity decreasing WTP by $1.3 or $1 before and after adjusting for certainty. On the one hand this may be counterintuitive since those who use the bayou for recreation may have a greater benefit from an improvement in water quality. Conversely, respondents who already recreate in Bayou Lafourche believe that the water is clean enough already and so are not willing to pay for further improvements.

Experiences with sewage-related issues also had a statistically significant negative impact on WTP, with respondents who reported a minor sewage smell having a WTP that was $7.73 lower than those who had not, and those who reported no issues having a WTP that was $14.25 lower than those who had reported any issue. *Minor Smell* gains significance after adjusting for certainty as the marginal effect on WTP of reporting a minor smell decreases to 6.80. The marginal effect of Reporting no sewage related issues does not lose significance after adjusting for certainty, however it does decrease to $10.98. Before adjusting for certainty, income has a negative effect on WTP with a $1000 increase in income corresponding to a 0.09 reduction in WTP. However, this variable is no longer statistically significant after adjusting for HB. Finally, retirement status has a significant negative impact on WTP with retired respondents having a WTP that is $17.69 lower than those who are not, with the marginal effect falling to $10.38 after adjusting for certainty.

Conclusion and Discussion

Numerous OWTS are failing in the US and connecting to traditional municipal sewage systems is infeasible in many circumstances. CSS are an alternative opportunity for improving water quality in rural neighborhoods. Our estimates for WTP indicate community support for a CSS at a price level of $10.43 per household, with a more conservative measure indicating WTP is $7.87 per household. Factors that have a statistically significant positive impact on WTP include years lived in Nolan Toups, reported septic age and educational attainment. Factors that have a negative effect on WTP include years lived in Louisiana, the number of recreational activities enjoyed thanks to Bayou Lafourche, experiences with sewage-related issues, income, and retirement status.

While CSS conversions are a more long term solution, LDEQ highlights the importance of continued efforts to educate the public about proper sewage maintenance and ways that they can contribute to a cleaner Bayou Lafourche (LDEQ 2013). In the spring 2023, we conducted an informational workshop with the community to educate residents on water quality challenges facing Bayou Lafourche as well as ways to improve water quality. The workshop was hosted by LDEQ, and respondents took our survey before and after the workshop with goal of understanding the effects of information interventions on WTP.

In the US, more than 20% of homes rely on individual septic systems (US Census Bureau 2006) with 50% of these users residing in rural areas where connecting to municipal systems is less affordable. The census further shows how 46% of these houses that rely on septic tanks are in the Southern Region of the US. The concentration of coastal communities in this region, like those in Southeast Louisiana, and the spread-out nature of systems make them more inclined to face issues with septic systems (Cooper, Loomis, and Amador 2016; Finn 2022).

Our study aims to provide a framework that may be used in future studies to help better understand people's WTP for clean water. By using best practices, we establish a format that may be used in future studies for the nonmarket valuation of other public goods. Further, our study will serve to improve understanding of the benefits associated with improving water quality through the development of CSS. In the future, similar studies may further adapt the IC-

PC to elicit WTP for public goods. We also identify factors that are significant in estimating WTP for CSS.

In the status quo, it is difficult to estimate marginal benefits of improving water quality. This is largely because whatever studies do exist each have their own definitions for just about every facet of the project. The lack of a uniform way of measuring water quality or valuing the changes that are made in water quality makes it difficult to identify the benefits of a particular project. Through the framework that we establish in our methods, we allow for future projects to be more homogenous in the way that they measure and convey costs and benefits.

While our estimates for WTP can be used to inform policy decisions on whether a CSS is feasible in Nolan Toups or not, a range of benefits result from improved water quality. Although there is no project planned for Nolan Toups, similar septic-to-sewage conversions in the region have seen success in improving water quality in the past. Based on our WTP estimates alone, it is unlikely that any formal BCA would result in the conversion to a CSS. Future studies should focus on other types of benefits that will result from the conversion to help decide if the project is efficient.

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Tables

Table 1: Variable Description and Summary Statistics of Sample (n=51)

Variable Name	Mean (SD)	Variable Description
Neighborhood Years	26.5 (16.6)	Number of years lived in neighborhood
Louisiana Years[1]	56.9 (17.1)	Number of years lived in Louisiana
Rec Count	2.7 (1.6)	Number of recreational activities participated in (0-6), based on fishing, swimming, boating, water sports, and duck hunting
Minor Smell	0.3 (0.4)	1 if reported a minor sewage smell in the past five years, else 0
No Issues	0.7 (0.5)	1 if reported no sewage related issues in the past five years, else 0
Concerned[S]	3.6 (1.2)	"I am concerned about the water quality near Bayou Lafourche"
Notice Change[S]	3.0 (1.1)	"I've noticed a difference in the water quality since I've lived near Bayou Lafourche. "
Expense100	4.7 (13.4)	Amount (per $100) spent on septic system in the past five years
Septic Age	7.59 (2.2)	Reported age of the septic system in years
Expense Year	6.41 (7.42)	Years from 2023 when the respondent reported last expense on sewage
Income1000[2]	78.8 (42.1)	2021 household income ($1000)
Bachelor	0.2 (0.4)	1 if they attained a bachelor's degree or more, else 0
Retired	0.4 (0.5)	1 if retired, else 0
Consequential	2.5 (1)	Believe there is ____ chance that responses will be taken into consideration by local government 1: No, 2: Little, 3: Some, 4: Very Good

[1]: replaced missing values with mean for four respondents
[2]: replaced missing values with mean for eight respondents
[S]: Likert statement, measured from 1 (Strongly Disagree) to 5 (Strongly Agree)

Table 2: Interval Regression Model Results

	Model I		Model II	
Variable Name	**Mean WTP**	**Certainty-Adj. WTP**	**Unadjusted**	**Certainty-Adj.**
Constant	10.43*** (1.108)	7.87*** (0.854)	21.343*** (6.394)	9.046* (4.944)
NolanToups			0.493*** (0.097)	0.376*** (0.072)
Louisiana+			-0.322*** (0.092)	-0.259*** (0.070)
Rec Count			-1.296* (0.731)	-1.006* (0.555)
Minor Smell			-7.734* (4.11)	-6.799** (3.121)
No Issues			-14.253*** (4.658)	-10.997*** (3.552)
Concerned			-1.785 (1.375)	-0.515 (1.045)
Notice Change			-0.501 (1.415)	0.363 (1.070)
Expense100			0.036 (0.089)	-0.030 (0.068)
Septic Age			3.501*** (0.811)	2.473*** (0.619)
Income1000+			-0.086*** (0.031)	-0.021 (0.024)
Bachelor			9.068*** (2.612)	3.592* (1.981)
Retired			-17.687*** (4.006)	-10.378*** (3.048)
Consequential			0.643 (1.249)	0.911 (0.952)
WTP (95% CI)	10.43 (8.47, 12.85)	7.87 (6.34, 9.74)	9.57 (7.70, 11.45)	7.52 (6.12, 8.94)
AIC	312.255	300.330	245.997	239.441
N	51	51	44	44

Standard errors reported in parentheses; *, **, and *** indicate a p-value less than 0.1, 0.05, and 0.01, respectively; +Missing Values replaced with the mean

Figures

Bayou Lafourche is the main source of drinking water and supports many industries and outdoor recreation along its corridor stretching from Donaldsonville to Lafourche parish. However, the water in the bayou is negatively impacted by runoff from on-site home sewage treatment systems. The Louisiana Dept. of Environmental Quality (LDEQ) estimates that as many as 50% of total on-site systems in the region are failing. The LDEQ also indicates that fecal coliform concentration in Bayou Lafourche exceeds the standard set by the Clean Water Act. Thus, there is an urgency to improve water quality.

Furthermore, businesses along Bayou Lafourche are already regulated to ensure they do not contribute to deteriorating water quality.

Connecting properties using on-site sewage systems known as community sewer systems is a long-term solution to improve water quality in Bayou Lafourche. A small community sewer system connects to each property and may serve anywhere from 20 to 200 households.

Nolan Toups would need a community sewage system with a footprint about the size of a typical single-family home, pictured below.

LDEQ has found that water quality in other Louisiana communities that have installed community sewer systems has significantly improved and a similar improvement is expected in Nolan Toups if installed. A neighborhood in Belle Rose further north along Bayou Lafourche gained these benefits once it installed a community sewer system in 2015.
The benefits of installing a community sewer system include:

- Convenience: The homeowner's expense and hassle of maintaining their home's sewage treatment system and the risk of overflow or other problems is eliminated.
- Safer conditions: Virtually no chance of being exposed to raw sewage, reducing the risk of illness that may occur from recreating in or near water
- Better drinking water: Cleaner water in Bayou Lafourche means less expense and fewer chemicals to make drinking water safe
- Improved water quality: virtually no sewage odor or reduced gray/black coloring in the water; improves habitat for fish.

Figure 1: Community sewage description

Should the Nolan Toups subdivision introduce a mandatory fixed fee of $_____ to every Nolan Toups households' *monthly* water bill, for the foreseeable future, to fund the proposed community sewage system for the subdivision? This hypothetical fee would replace any costs or maintenance you currently pay for your septic tank.

If the fee is...	I vote "Yes"	I vote "No"
50¢	○	○
$1	○	○
$2	○	○
$3	○	○
$5	○	○
$7	○	○
$10	○	○
$15	○	○
$20	○	○
$35	○	○
$50	○	○

Remember, the cost of this project is ***uncertain*** *at this time, which is why we're asking how you would vote for several possible amounts. This way, when the construction and maintenance costs are known, and the necessary monthly fee is calculated, we will know the percentage in favor and against at each amount.*

Figure 2: Incentive compatible-payment card elicitation

Appendix

Figure A1: Map of Nolan Toups

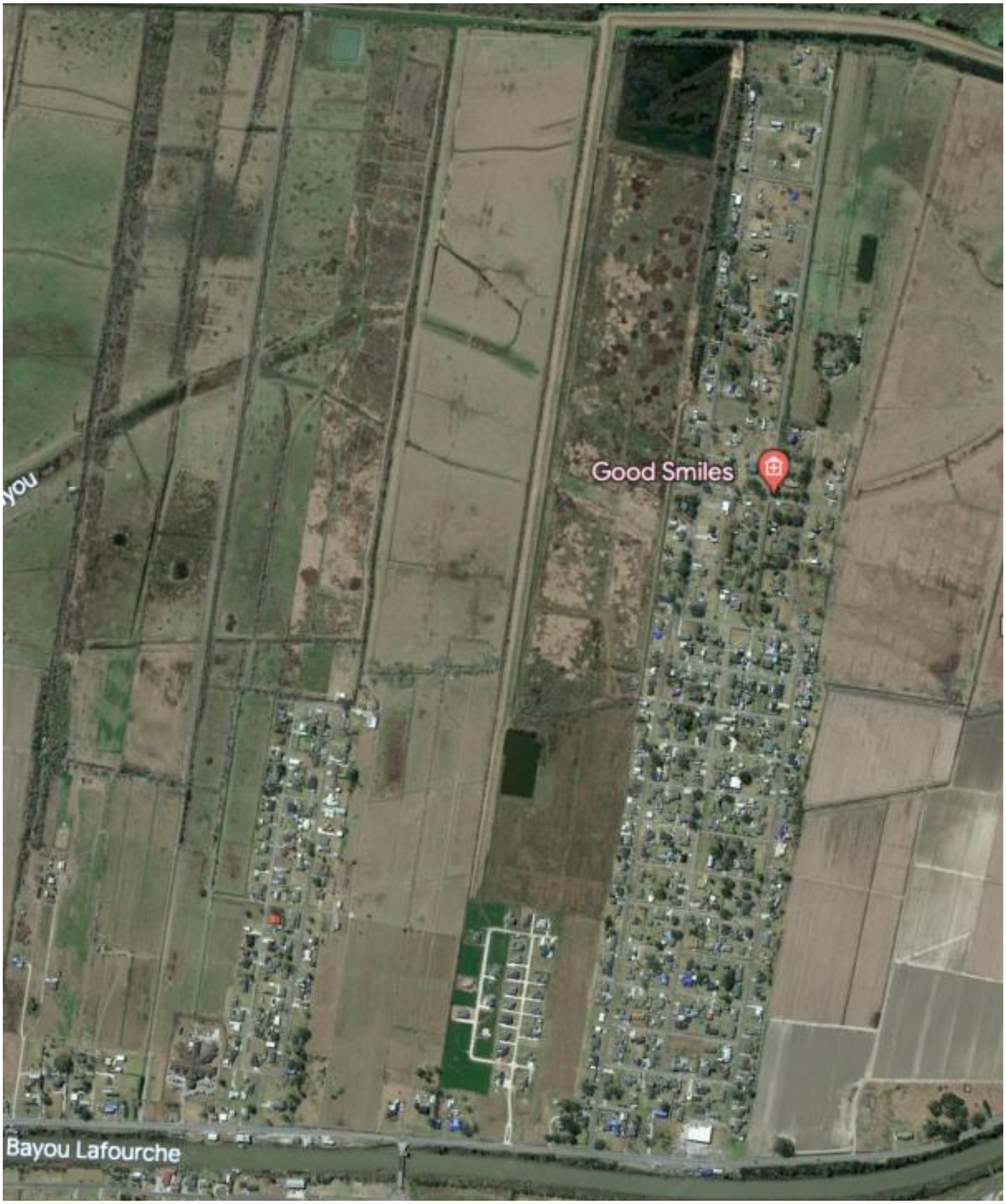

Figure A2: Survey (paper version)

Section 1: Introduction

---

1. To verify your residency in Nolan Toups, please provide the five-digit access code provided on the cover letter inviting you to participate in this survey.

   ____

2. How many years have you lived in…?

   Nolan Toups Subdivision ___________
   Lafourche Parish ___________
   Louisiana ___________

3. In the past 20 years, which of the following recreational activities have you participated in? (*Select all that apply)*

   ☐ Fishing
   ☐ Swimming
   ☐ Boating
   ☐ Other
   ☐ Duck Hunting
   ☐ Watersports (skiing, jet skiing, wakeboarding, etc.)
   ☐ Other (*please specify*):
   ____

As best we understand, all of the homes in Nolan Toups subdivision rely on individual sewage treatment systems. The next few questions are about your home's sewage treatment system and related sewage issues you may have faced.

4. About how old is your home's individual sewer system? (*Please select one)*

   ☐ Less than a year old
   ☐ 1-2 years old
   ☐ 3-4 years old
   ☐ 5-7 years old
   ☐ 8 or more years old
   ☐ I don't know

5. In the past 3 years, which of the following issues/ problems have you faced? (*Select all that apply)*

   ☐ No issues
   ☐ Intense Sewage Smells
   ☐ Minor sewage smells
   ☐ Raw Sewage Smells
   ☐ Sewage Backups
   ☐ Pets coming in contact with sewage
   ☐ Children coming in contact with sewage
   ☐ Suspected health issues from sewage exposure
   ☐ Other (*please specify*): ____________________________

6. As best you can recall, what were your expenses in each of the past five years (including supplies and services for regular maintenance or emergency) for your home's sewage treatment system? *(Write $0 if you didn't have expenses)*

   2021: $__________________

2020: $___________________
2019: $___________________
2018: $___________________
2017: $___________________

☐ I didn't have any expenses for my home sewage system in the past five years. The last year I had expenses for my home's sewage treatment system was: ________

7. Please indicate how much you agree or disagree with the following statements:

	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
I'm concerned about the water quality near Bayou Lafourche.	☐	☐	☐	☐	☐
I've noticed a difference in the water quality since I've lived near Bayou Lafourche.	☐	☐	☐	☐	☐
Since I was a kid, water quality near Bayou Lafourche has gone down.	☐	☐	☐	☐	☐
I no longer eat fish I've caught in Bayou Lafourche due to health risks.	☐	☐	☐	☐	☐
I have reduced watersports in Bayou Lafourche to reduce health risks.	☐	☐	☐	☐	☐

Section 2: Community Sewers

Bayou Lafourche is the main source of drinking water and supports many industries and outdoor recreation along its corridor stretching from Donaldsonville to Lafourche parish. However, the water in the bayou is *negatively impacted* by runoff from on-site home sewage treatment systems. The Louisiana Department of Environmental Quality (LDEQ) estimates that as many as 50% of total on-site systems in the region are failing. The LDEQ also indicates that fecal coliform concentration in Bayou Lafourche exceeds the standards set by the Clean Water Act. Thus, there is an urgency to improve water quality.

Furthermore, businesses along Bayou Lafourche are already regulated to ensure they do not contribute to deteriorating water quality.

Connecting properties using on-site sewage systems known as community sewer systems is a long-term solution to improve water quality in Bayou Lafourche. A small community sewer system connects to each property and may serve anywhere from 20 to 200 households.

LDEQ has found that water quality in other Louisiana communities that have installed community sewer systems improved significantly, like in the Belle Rose Neighborhood further north along Bayou Lafourche in 2015. Similar improvements are expected in Nolan Toups if installed.

The benefits of installing a community sewer system include:

- **Replacement**: the homeowner's expense and hassle of maintaining their home's sewage treatment system and the risk of overflow or other problems is eliminated.
- **Safer conditions**: virtually no chance of being exposed to raw sewage, reducing the risk of illness that may occur from recreating in or near water.
- **Better drinking water**: cleaner water in Bayou Lafourche means less expense and fewer chemicals to make drinking water safe.
- **Improved water quality**: no sewage odor, reduced gray/black coloring of water, and improves fish habitat.

8. Based on what you've read above and your own experience, to what extent do you believe that

	None at all	A little	Moderately	A lot	A great deal
Sewage contributes to declining water quality in Bayou Lafourche	☐	☐	☐	☐	☐
A community sewer system can improve water quality in Bayou Lafourche	☐	☐	☐	☐	☐

Section 3: Your Support of Community Sewer System

Please carefully read the passage below for instructions on how to answer the next set of survey questions

This survey hopes to measure how much Nolan Toups Residents like or dislike the idea of installing a community sewer system. It is **exploratory**, meaning that information will be communicated with the local government to assess **community support** for sewage treatment and water quality enhancement projects, but nothing is planned. Each Nolan Toups Household should consider what they would be willing to pay for a community sewage system to improve water quality in Bayou Lafourche. A community sewage system is only feasible if a majority of households want to connect. If the majority of households choose to connect, then the community sewer system is built, and all Nolan Toups Households must connect to it. All households would pay a certain amount per month to connect to and maintain the sewer system in the form of a fee added to their monthly water bill.

The cost of the proposed community sewer system for Nolan Toups is uncertain, so the monthly amount needed to pay for it is unknown. For this reason, we will show you a list of amounts, and ask you to vote "**Yes**" or "**No**" for each amount. This way, if cost information were to become available, we would know the percentage in favor and against the proposal at each monthly amount. Because the project cost is uncertain, the range of potential monthly fees is wide. Be sure to consider how much, if anything, you are willing to pay before voting. Each row represents a vote to install a community sewage system at that corresponding price level.

Start with the row labeled **"$0.50**". Mark the box next to "**Yes**" if you vote yes to add $0.50 to every Nolan Toups Household's monthly water bill to pay for the proposal. Otherwise, vote "No". Move onto the row for $1, repeating the same process as you move down the list. Be sure to keep in mind other ways that you may prefer to spend the money.

9. Should the Nolan Toups subdivision introduce a mandatory fixed fee of $_____ to every Nolan Toups household's *monthly* water bill, for the foreseeable future, to fund the proposed community sewage system for the subdivision? (*Please vote on each amount independently)*

	I vote "Yes"	**I vote "No"**
$0.50	☐	☐
$1	☐	☐
$2	☐	☐
$3	☐	☐
$5	☐	☐
$7	☐	☐
$10	☐	☐
$15	☐	☐
$20	☐	☐
$35	☐	☐
$50	☐	☐

Remember, this project's cost is currently ***uncertain****, which is why we're asking how you would vote for several possible amounts. This way, when the construction and maintenance costs are known, and the necessary monthly fee is calculated, we will know the percentage in favor and against at each amount.*

Section 6: Your Reasons for your Votes

We'd like to ask a few questions about your "votes" in the previous question.

10. For the highest amount you voted "Yes", how sure are you of your response?

☐ Definitely Sure ☐ Probably Sure

11. Which of the following reasons influenced your votes: *(Select all that apply)*

☐ I believe that my utility bill is too high already and against any initiative that will increase it.
☐ I don't think it's my responsibility to pay to reduce sewage contamination.
☐ I believe that funding this project is well worth it to me.
☐ I would like to see this project completed, but I cannot afford to pay much for it.
☐ It was difficult for me to decide the highest amount I would pay.
☐ I do not have enough information on this issue to make a comfortable decision.
☐ I'm not worried about sewage contamination and water quality.
☐ I didn't read the information on the proposal carefully.
☐ Other (*please specify*): ____

12. To what degree do you believe that the responses from you and other participants about support for a community sewer system will be taken into consideration by local government? (*Select one)*

☐ Very good chance ☐ Some chance
☐ Little chance ☐ No chance

13. To what degree do you believe that the responses from you and other participants about support for a community sewer system will affect whether a community sewage system is built? (*Select one)*

☐ Very good chance ☐ Little chance
☐ Some chance ☐ No chance

Section 7: Demographic Information

Please tell us more about yourself. Remember, we will ***never*** share your answers.

14. What is your occupation? *(Select all that apply)*

☐ Part-time ☐ Self-employed
☐ Full-time ☐ Disability
☐ Student ☐ Homemaker
☐ Retired ☐ Other (*please specify*): ________________________

15. What is your marital status?

☐ Married
☐ Widowed
☐ Divorced/Separated
☐ Single/never married

16. What is your highest level of education obtained? *(Select one)*

☐ Less than high school
☐ Some high school
☐ High school graduate (incl. GED)
☐ Some college, no degree
☐ Associate's degree
☐ Bachelor's degree
☐ Graduate/professional degree

17. What is your race? *(Select all that apply)*

☐ White
☐ Black or African American
☐ Asian
☐ Native Hawaiian or Pacific Islander
☐ Native American/Alaska Native
☐ Other

18. Are you of Hispanic, Spanish, or Latino origin?

☐ Yes
☐ No

19. What year were you born? ___________

20. Including yourself, how many people live in your household?

Adults (18 or older): __________
Children (17 or younger): __________

21. What was your total household income in 2021? *(Select one)*

☐ Less than $10,000
☐ $10,000 to $14,999
☐ $15,000 to $24,999
☐ $25,000 to $34,999
☐ $35,000 to $49,999
☐ $50,000 to $74,999
☐ 75,000 to $99,999
☐ $100,000 to $149,999
☐ $150,000 to $199,999
☐ $200,000 or more

22. Please provide your email if you would like to see a one-page summary of the results. Also, check the box if you’d like a receipt of the donation to the Bayou Community Foundation emailed to you.

    Email: ____

    ☐ *Yes, please send me a receipt of the total donation to the* ***Bayou Community Foundation****.*

23. Please feel free to express any comments, questions, or concerns you may have in the space below.