The value of restoring urban drains to living streams

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Abstract. Many urban streams have been cleared of native vegetation and converted to open drains resulting in a loss of ecological and aesthetic function. There is a growing recognition of the importance of these functions and work is being done to restore urban drains and create fully functioning wetland ecosystems ("living streams"). Such restoration work involves substantial cost, and it is important to know if the benefits generated from "living streams" are greater than restoration costs. This paper presents a detailed economic analysis of an urban drain restoration project in Perth, Western Australia. Controlling for other factors, we find homes within 200m of the restoration site increased in value by 4.4% once the restored area became fully established. When we compare benefits to cost we find that, with real discount rates of 5%, 7%, and 9%, project benefit–cost ratios are 2.6, 2.5, and 2.2, respectively. We then show that current institutional arrangements in Western Australia make it difficult to implement urban drain restoration projects, even when project benefits are greater than project costs. The paper concludes by identifying changes to governance arrangements that would allow value enhancing restoration projects to be undertaken.

Keywords: Stream restoration; Water Sensitive Urban Design; Economic valuation; Hedonic Pricing Method; Governance

JEL codes: Q51, Q58, R22

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1 Introduction

Water Sensitive Urban Design (WSUD) is a land planning and engineering design approach that integrates the urban water cycle into urban design (Wong and Brown 2009). Important elements of WSUD include improving and securing water supply; protection of groundwater systems; and management of stormwater and wastewater. WSUD can provide benefits that are easily quantified, such as additional water supply (Brown and Farrelly 2009); and benefits that are not easily quantified, such as mitigating environmental degradation, improving aesthetic appeal, and recreational benefits (Morison and Brown 2011). WSUD concepts have been promoted for over two decades, but adoption has been relatively limited. There are various possible reasons for this (Leonard et al. 2014), one of which is the lack of *ex post* assessments of WSUD projects that demonstrate project benefits have been greater than project costs.

Significant work has been undertaken on methods that can be used to rank different WSUD projects and identify, *ex ante*, the projects likely to deliver the greatest overall benefit to the community (e.g., Pannell 2015). The *ex post* evaluation literature is, however, limited. *Ex post* evaluations of WSUD projects are important for several reasons. First, *ex post* evaluations provide clear evidence of project effectiveness, and as such are an important tool in demonstrating WSUD is an economically viable concept that delivers improvements in overall community welfare. Second, *ex post* evaluations provide a check on the validity of the assumptions made when the project was originally proposed. Third, the information generated through *ex post* evaluations is an important input into new *ex ante* WSUD project ranking exercises.

Embedding the idea of systematic *ex post* evaluations of WSUD projects is also important in more nuanced ways. For example, if proponents understood that WSUD projects would be subject to rigorous *ex post* evaluations, it may result in proponents investing more heavily in the initial research phase to ensure that they put forward the very best projects.

Conceptually, *ex post* project evaluation is simple -- sum total project costs and subtract these costs from total project benefits to determine the project net benefit -- but it can be difficult to operationalise. Specific issues that are likely to appear as part of an *ex post* WSUD project evaluation include consideration of environmental benefits that do not have a clear market price; valuing the contribution of volunteer labour; apportionment of overhead and administration costs of organisations undertaking projects; the appropriate time lag to consider when calculating benefits; identification of an appropriate counter-factual scenario, and uncertainty in benefits.

The practical difficulty of undertaking comprehensive economic valuations means that few WSUD projects have been evaluated. Further, the evaluations that have been completed have been relatively simple; have mostly relied on rules of thumb to infer benefits; or have discussed benefits in a qualitative manner only (Gordon-Walker, Harle and Naismith 2007; Roseen et al. 2011; Royal Haskoning DHV 2012; USEPA 2007).

However, even with WSUD-specific comprehensive economic evaluations that show a clear business case (i.e. benefits outweighing costs), there exist significant barriers to change and institutional inertia to implementing such projects (Brown 2005; Wong 2006). Such impediments exist partly because of the complex existing institutional and regulatory structures that are used to manage urban water infrastructure. For example, in a comprehensive review of sustainable water management hurdles, Brown and Farrelly (2009) identified the top three barriers as: uncoordinated institutional frameworks; limited community engagement, empowerment, and participation; and limits of the regulatory framework. Thus, to overcome the implementation hurdles, governance and institutional reforms will be required.

This paper provides an analysis of the benefits and costs of a particular WSUD intervention: the restoration of an urban drain to a more natural state. Through this process the paper illustrates how many of the challenges involved in an *ex post* evaluation of a WSUD project can be addressed. We then discuss the issue of drain restoration projects more generally, and outline barriers to their adoption in Western Australia. Practical suggestions for changes to institutional arrangements that would remove barriers to the implementation of value-enhancing WSUD projects are also provided. Specifically, it is shown that setting main-drainage service charges on some measure of residential property values is an appropriate second-best policy option for matching drain restoration project costs to beneficiaries; and that a minor change to the operating licence conditions of the water utility would create an institutional environment that would remove a substantial WSUD implementation barrier.

2 Case study background and context

Detailed information on the study area and the historical pollution issues in the catchment can be found in Swan River Trust (2012) and SERCUL (2014). Here we provide just sufficient information to make the nature of the restoration project understandable. The Bannister Creek catchment is a highly modified system covering 23 square kilometres in the suburbs of Canning Vale, Lynwood, Ferndale, and Parkwood in metropolitan Perth, Western Australia. Across the catchment there is a mix of residential housing, commercial property, and light industry. Bannister Creek is a tributary of the Canning River, and prior to European settlement the creek was part of a linked wetland system. In 1979 the creek was straightened, deepened, and incorporated into the main drain network of the State water utility (Water Corporation)

During the 1980s and 1990s, urbanisation in the area led to an increase in impermeable area; which, combined with the loss of the wetland system and riparian vegetation; nutrient rich runoff from urban lawn and gardens; and runoff from industry, created erosion and pollution problems in the catchment. Additionally, during high-rainfall events, the rapid increase in the volume and speed of water surging through the now straightened and steeply banked Banister Creek main drain had become a public-safety risk.

In response to the pollution, erosion, and public safety issues, the local community established a volunteer group that became known as the Bannister Creek Catchment Group (BCCG). The BCCG was the catalyst for many projects aimed at improving the catchment, including a project to rehabilitate a section of the Bannister Creek main drain to a “living stream” that would, in addition to the flood-mitigation function of the existing main drain, also provide local amenity benefits, improve water quality in the catchment, and slow the flow velocity of the system during high-rainfall events. The first stage of the restoration project, which is the section we evaluate, was completed over the period 2000-2002, and involved work on a 320 metre section of the main drain.

The restoration work involved giving the creek a more natural shape, with meanders, riffles, fringing sedges, gentle sloping banks, and thick vegetation on the banks. The earth works involved to reshape the existing steep banks were substantial, and erosion control matting was used to stabilise the stream banks. The transformation from traditional main drain to living stream can be seen in Figure 1, which tracks the evolution of the area through time. The overall project design is consistent with what is now seen as best practice (Department of Water and Swan River Trust 2007).

Figure 1 Aerial photographs of Bannister Creek Living Stream project dynamics

3 Modelling the environmental impact

To provide insights into the way water quality in Bannister Creek has changed since the restoration project we consider phosphate and nitrogen data collected at a monitoring site located 1 km downstream from the study area. The measurements were taken fortnightly, and record nitrogen (mg/L) and phosphorus (mg/L) levels for the period January 1997 to December 2014. To identify trend changes in nitrogen and phosphate levels, each time series has been decomposed into a seasonal component, a trend component, and a remainder; with the specific decomposition based on the nonparametric loess method outlined in Cleveland et al. (1990). Plots of the raw data, along with the seasonal, trend, and remainder decomposition are shown in Figure 2.

If we first consider the nitrogen data, it can be seen that the raw data is very noisy. However, the decomposition reveals that, over the sample period, there has been a general downward trend in nitrogen levels. For the phosphate data, the trend series shows a decline immediately after the restoration project, followed by a broadly flat period, and more recently, a slight increase in phosphate levels. Overall, the main message of the decomposition plots is that the trend level of nitrogen and phosphate is lower today than it was prior to the restoration project.

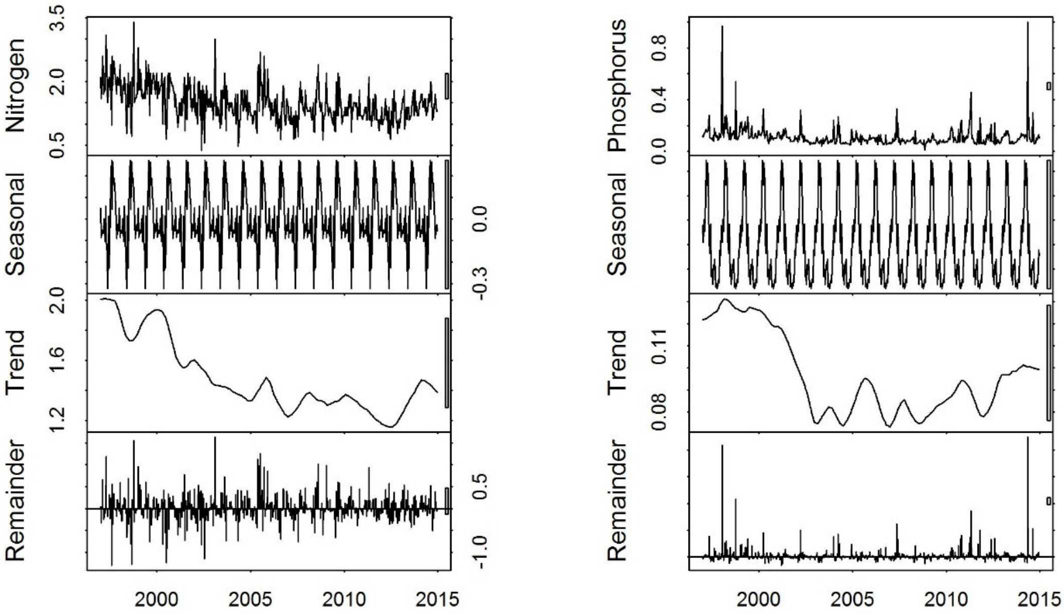

Figure 2 **Water quality time series decomposition**

Environmental conditions at the site have also been investigated by others. For example, Clark (2011) compared environmental conditions at the restoration site with sites both upstream and downstream from the restoration site; a reference undisturbed site; and three sites that have been degraded through use as drainage channels. All comparison sites are in metropolitan Perth. The first set of comparisons across the sites conducted by Clark relies on an environmental rating system that allocates points for: floodway and bank vegetation (15 points), verge vegetation (8 points), stream cover (8 points), bank stability and erosion (8 points), and habitat diversity (6 points). The maximum score obtainable is 45 points, and Clark gave a score of 36 to both the reference undisturbed site and the Bannister creek restoration site. The site upstream from the restoration site received a score of 15, and the site downstream received a score of 20. The scores for the comparison degraded sites were between 20 and 12. Overall, the environmental rating system comparison indicates a positive impact on environmental conditions due to the restoration work.

Analyses of differences in macroinvertebrate diversity, using a variety of measures, are also presented in Clark (2011). The results vary across diversity measures, but generally the differences that are detected across sites suggest that diversity at the restored site is better than at the degraded sites, but not as good as at the undisturbed site.

As the restoration project was just one of many local initiatives aimed at improving water quality in the Bannister creek catchment it is not possible to claim a causal relationship between the restoration project and trend changes in water quality and overall environmental condition. It is, however, reasonable to claim that the restoration project made some contribution to the improvement in overall environmental conditions.

4 Modelling the amenity impact

To model the amenity impact of the Bannister creek restoration project we estimate the impact the project had on local property values using the hedonic price approach due to (Rosen 1974). The hedonic price approach assumes the observed sale price of a property is a function of the underlying property attributes. The underlying attributes include property-specific attributes such as lot size, the number of bedrooms in the house, etc.; and location specific characteristics. The hedonic method is well suited to estimating amenity benefits and has been used to estimate the extent to which environmental and recreational assets such as open space, parks, wetlands, and street trees are capitalised into residential property prices (Acharya and Bennett 2001; Irwin 2002; Pandit, Polyakov and Sadler 2014; Tapsuwan et al. 2009).

Before estimating the impact of the restoration project on local property prices a number of empirical issues must be addressed. The first issue to consider is the spatial extent of the restoration effect. For our specific site, 200 m is approximately half-way between the restoration site and other local public open space. To minimise the potential confounding effect of other public open space with the effect of the restoration project, we therefore define the area of potential impact as limited to properties within 200 m of the restoration site. Although this decision rule is in part motivated by the specific distribution of open space in the local area, the decision rule is consistent with the approach and findings of others (Crompton 2001; Garrod and Willis 1994).

A related question is the extent of the overall study area. To keep the analysis tractable we define the relevant area as the cluster of six suburbs adjacent to the restoration site, where the main land-use classification is urban residential (see Figure 3).

The second empirical issue to consider is the temporal nature of the restoration project. The initial earthworks for the restoration project were substantial; and it took time for the vegetation planted along the banks to become established. This suggests that at the time of the main earth works there may have been dis-amenity effects. To model the project dynamics we use two approaches. In the first approach we model the effect of the restoration project using a linear time trend. Specifically, we add a binary variable to indicate whether a property is within 200 m of the restoration site and was sold after the year 2000; and then, in addition, we interact this variable with a continuous variable that measures the number of years since the construction phase. This specification allows for a pattern of effects that seems reasonable: an initial negative impact, and then a positive trend effect as the site becomes established. In the second approach we use binary variables that indicate whether a property is located within 200 m of the restoration site and was sold during different time periods. We consider the time periods: prior to 2001, 2001-2002, 2003-2005, 2006-2008, and 2009-2013, with prior to 2001 the base period.

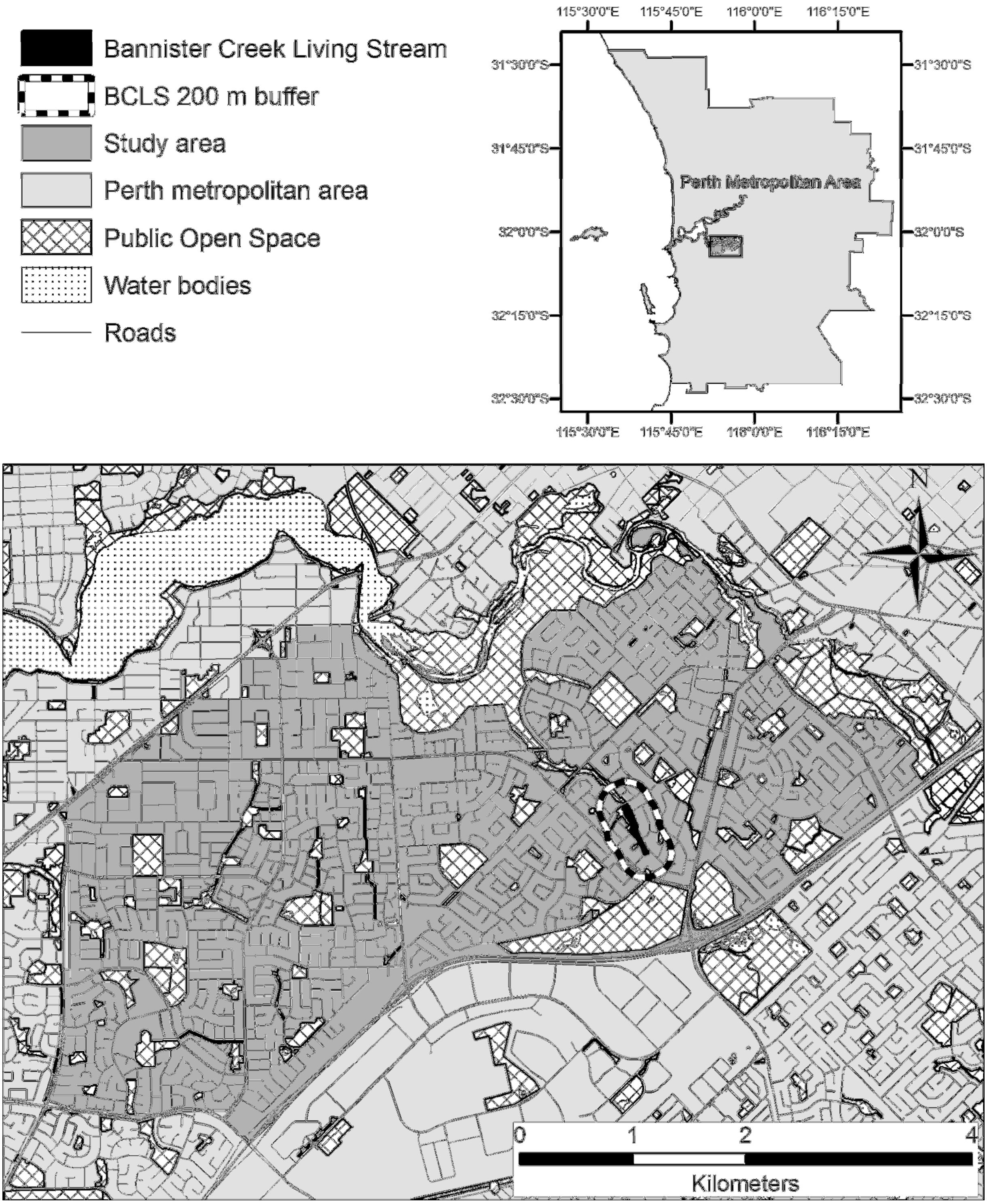

Figure 3 **Study area**

The third empirical issue is that property values, as well as the factors determining these values, are characterised by spatial dependencies (Anselin 1988). Failure to model spatial effects can result in biased and inconsistent estimates of model parameters. Spatial relationships can be modelled in several ways. Here we follow the approach of Kuminoff, Parmeter and Pope (2010) and control for unobserved variables and spatial dependency problems through use of spatial fixed effects, where the fixed effect is set at the Statistical Area 1 (SA1) level. SA1 is the smallest reporting unit of the Australian Census of Population and Housing, and on average, the population of a SA1 area is approximately 400 people. There are 96 SA1 units in our study area.

The fourth empirical issue is the existence of repeat sales in the database. As illustrated in Greene (2011), even when the proportion of repeat observations is modest, if the issue of repeat sale observations is ignored, OLS standard errors are biased towards zero, and the bias can be substantial. Here we address the issue of repeat sales by treating the data set as an unbalanced panel, and then use autocorrelation- and heteroskedasticty-robust standard errors for hypothesis testing.

The fifth empirical issue is the functional form of the hedonic model. Consistent with the modelling approach advocated in Triplett (2004), we treat this as an empirical issue and use the Box-Cox method to guide the transformation decision. Specifically, we consider values for lambda in the Box-Cox transformation of between minus three and three. Using this approach we find that the log likelihood is flat around zero with a minimum value slightly greater than zero. We therefore apply a log transformation to the dependent variable.

The final empirical issue is potential hedonic model misspecification through omitted variables. To establish the hedonic model is not miss-specified we exploit the existence of repeat sales in the database. Specifically, we estimate a repeat sales only model, which gives estimates that are consistent, but not efficient, and compare these estimates to the estimates from the hedonic model, which are efficient, but may not be consistent. Based on the logic of the Hausman specification test, if the two sets of estimates are similar we conclude that it is safe to use the hedonic model estimates.

Formally, the hedonic model can be written as:

$$\ln\left(p_{ijt}\right) = \mathbf{x}'_{ij}\boldsymbol{\beta} + \mathbf{z}'_{ijt}\boldsymbol{\gamma} + \mathbf{d}'_{t}\boldsymbol{\tau} + \mathbf{s}'_{j}\boldsymbol{\alpha} + \eta_{ij} + \varepsilon_{ijt}, \quad (1)$$

where p_{ijt} is the observed sale price of property *i*, in area *j*, at time *t*; $\mathbf{x}_{ij}$ is a vector of time-invariant property attributes; $\mathbf{z}_{ijt}$ is a vector of treatment variables representing property location and time since restoration; $\mathbf{d}_t$ is a vector of quarterly time dummy variables taking the value one if the house sold in time t, zero otherwise; $\mathbf{s}_j$ is a vector of spatial (SA1) dummy variables taking the value one if the house was sold in SA1 j, zero otherwise; ε_{ijt} is a zero mean observation-specific random error term; η_{ij} is a zero mean property-specific error term; and $\boldsymbol{\beta}$, $\boldsymbol{\gamma}$, $\boldsymbol{\tau}$, and $\boldsymbol{\alpha}$ are parameter vectors to be estimated.

If, in equation (1), we replace the area fixed effect $\mathbf{s}_j$ with a property fixed effect $\mathbf{s}_i$, the time-invariant attributes vanish, and we have an expression that is statistically equivalent to the classic repeat-sales model. This version of the repeat-sales model can then be written as:

$$\ln\left(p_{ijt}\right) = \mathbf{z}'_{ijt}\boldsymbol{\gamma} + \mathbf{d}'_t\boldsymbol{\tau} + \mathbf{s}'_i\boldsymbol{\alpha} + \varepsilon_{ijt}, \qquad (2)$$

where the notation is as above. Note that although our repeat-sales model notation is different to the notation introduced in Bailey, Muth and Nourse (1963), the models are statistically equivalent. Our notation is also similar to that set out in Heintzelman and Tuttle (2012).

5 Data and results

5.1 Data

Property sales data for the study area were obtained from the Real Estate Institute of Western Australia. The data set contains information on home sale prices and dates; the property construction date; and structural characteristics such as the number of bedrooms, bathrooms, etc.; whether or not a swimming pool is present on the lot; and the construction material used for the property walls and roof. Within the study area we select the sales records for single family homes sold between 1990 and 2013. These selection criteria provided 16,553 sales records for 8,088 unique properties. Of the properties in the sample, 5,020 were sold between two to seven times. Property sales records were then linked with the cadastral map retrieved from Landgate's Shared Land Information Platform to create a spatial reference for each property. The spatial reference was used to assign each property to the relevant SA1, and to calculate the distance of each property to the restoration site. In the sample there are 339 sale observations within 200 m of the restoration site; of which, 175 are after 2000.

Data cleaning identified one property where the 2013 sale price was less than half the 2008 sale price, and a property that sold in 2007 for less than $90,000. These observations were deleted from the data set before model estimation. Finally, to remove the effect of inflation, all price information was converted to 2012 values using the National Consumer Price Index. Summary information on key values in the data set is shown in Table 1.

Table 1. Summary data set information

Variable	Mean	SD	Min.	Median	Max.
Dependent variable					
House sale price (2012 AU$)	296,470	156,935	49,856	245,184	3,069,307
Explanatory variables					
Number of bedrooms	3.43	0.63	1	3	8
Number of bathrooms	1.37	0.50	1	1	4
Number of other rooms	4.08	1.14	2	4	9
Brick construction (yes =1, no =0)	0.97	0.18	0	1	1
Tile roof (yes =1, no =0)	0.97	0.18	0	1	1
Iron roof (yes=1,no=0)	0.01	0.07	0	0	1
Number of car spaces	1.23	0.72	0	1	7
Pool present (yes =1, no =0)	0.23	0.42	0	0	1
House age (years)	22.8	9.6	1	23	99
Land area (m^2)	733	106	235	703	2,186

5.2 Results

Estimation results for all models are presented in Table 2, and the first issue to consider is whether or not the hedonic model estimates are valid. We deem the hedonic model estimates to be valid if they are similar to the repeat-sales model estimates, and Figure 4 provides a visual comparison of hedonic and repeat-sale model estimates. The left panel of Figure 4 contains the comparisons for the restoration-effect variables and shows that, whether the restoration effect is modelled in terms of a slope-intercept relationship or as a series of dummy variables, there is always substantial overlap in the 95 percent confidence interval for the respective estimates. The right panel of Figure 4 plots the price-index information from the dummy-variable specification of both the repeat-sales model and the hedonic model. As can be seen, although the repeat-sales index values are generally lower than the hedonic price index values, there is always a substantial overlap in the 95 percent confidence interval for the matching point estimates from each model.[1] We interpret the similarity in the estimates as evidence that the hedonic model does not suffer from misspecification bias.

Further reassurance in the reliability of the hedonic model estimates can be found by noting that the estimates for the house attributes all have the expected sign; and that the pattern for house price evolution is consistent with other information (e.g., Jones 2010).

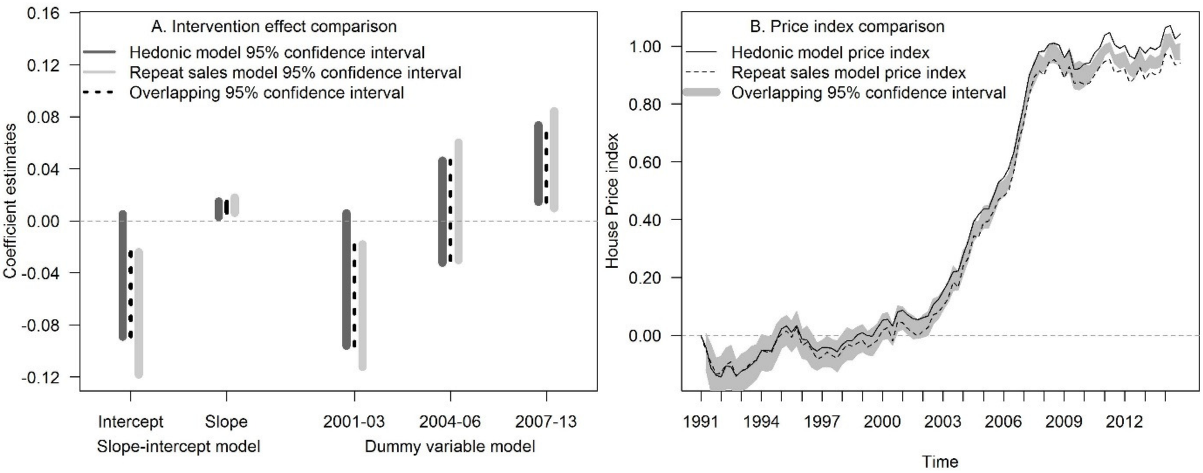

Figure 4 Model estimate comparison

Satisfied that the hedonic model estimates are reliable, we next consider the issue of whether the slope-intercept specification or the dummy variable specification is the better way to model the restoration effect. A simple comparison of the AIC values suggests that the dummy variable specification is the preferred specification, but using the Akaike weighting concept introduced in Akaike (1978), the normalised probability that the dummy variable specification is preferred to the intercept-slope model is 0.56. As this is not compelling evidence in favour of the dummy variable model we rely on some additional reasoning to support selecting this model as our preferred model. Specifically, in our base model we

[1] We also found the same result for the comparison of price-index estimates across the hedonic model and the repeat-sales model when using the intercept-slope specification for the restoration effect, but to save space this result is not shown.

found that the point estimates for the final two time period 2006-2008, and 2009-2013, were almost identical (difference 0.006), and following formal testing, we established that it was appropriate to model this overall time period with a single coefficient. That a common restoration effect coefficient is valid across a significant time period is evidence against the slope-intercept model. So, based on the weight of evidence, we select the hedonic dummy variable specification as our preferred model.

It is also worth noting that the restoration effect for the hedonic dummy variable model is actually the lowest estimate across all models, and so we have not selected a model that provides an overly favourable picture of the restoration amenity benefit.

The core conclusions we draw from the results in Table 2 and the left panel of Figure 4 are that at the start of the restoration project there was an initial negative effect on house prices that is both statistically significant and meaningful in magnitude; the negative impact is then fully reversed within about four or five years; and within about seven or eight years there is a substantial, statistically significant amenity benefit that appear to be permanent.

Table 2. Regression results summary information

Variables	Effect of Restoration modelled with an intercept and slope				Effect of living stream is modelled as year group effects			
	Hedonic model		Repeat sales		Hedonic model		Repeat sales	
	Estimate	Std Error	Estimate	Std Error	Estimate	Std Error	Estimate	Std Error
Restoration effect intercept	-0.042*	(0.024)	-0.071***	(0.024)				
Restoration effect slope	0.009***	(0.003)	0.012***	(0.003)				
Property within 200 m of BC sold 2001-2003					-0.045*	(0.026)	-0.065***	(0.024)
Property within 200 m of BC sold 2004-2006					0.007	(0.020)	0.015	(0.023)
Property within 200 m of BC sold 2007-2013[1]					0.044***	(0.015)	0.047**	(0.019)
Intercept	10.95***	(0.098)	13.12***	(0.036)	10.95***	(0.098)	13.12***	0.036
Log(Land area)	0.234***	(0.016)			0.234***	(0.016)		
House age × 10	-0.047***	(0.005)			-0.047***	(0.000)		
Number of bedrooms	0.039***	(0.003)			0.040***	(0.003)		
Number of bathrooms	0.080***	(0.004)			0.080***	(0.004)		
Number of other rooms	0.040***	(0.002)			0.040***	(0.002)		
Number of car spaces	0.027***	(0.002)			0.027***	(0.002)		
Brick walls	0.022	(0.015)			0.021**	(0.015)		
Tile roof	0.028***	(0.011)			0.029***	(0.011)		
Iron roof	0.112***	(0.024)			0.113***	(0.024)		
Pool present	0.046***	(0.004)			0.046***	(0.004)		
Year and quarter fixed effects (95) (F-value)	***		***		***		***	
SA1 fixed effects (96) (F-value)	***				***			
Property fixed effect (5060) (F-value)			***				***	
Variance of property random effect	0.007	(0.001)			0.007	(0.001)		
N	16,553		13,485		16,553		13,485	
AIC	-13150.2		-11,073.1		-13,150.7		-11073.9	
R^2			0.947				0.947	

Notes: [1] The point estimates for the 2006-2008 dummy variable and the 2009-2013 dummy variable were almost identical and formal testing indicated that these two groups could be pooled. Significance level: *** 1%; ** 5%; * 10%

6 Benefit–cost analysis

Our analysis has found that the restoration project created significant amenity benefits. We now consider whether these benefits are greater than project costs.

6.1 Benefits summary

Revealed preference methods, such as the hedonic price method, only capture information on use values. Use values are the benefits from direct or indirect utilization of natural resources, and in this case the use value is the amenity value capitalised into local property prices. The restoration project also generated non-use values. Non-use values are benefits that accrue from environmental resources without a person directly using them. Examples of non-use benefits include option value, existence value, and bequest value (Hackett 1998). In an increasingly dense urban environment, such as the study area, there are clear non-use values from the restoration project creating a wildlife habitat corridor. As these benefits are not captured in the hedonic model, the benefit estimate we use can be interpreted as a lower-bound estimate of total benefits.

At the time of the restoration project the area adjacent to the drain was an accessible grassed area and the drain was not fenced. Changes in community safety standards suggest that today, if the restoration project had not taken place, it would be necessary to install a fence along the drain line to restrict access. Fencing off access to the drainage channel would still have left some grassed space along the side of the drain, but the overall grassed area would have been reduced. Not all fence lines are unsightly, but a typical main drain steel mesh fence is unlikely to be seen as a visual amenity. Our baseline conditions therefore represent the best possible counterfactual scenario. Again this means our amenity value estimate is a conservative estimate.

Across the four models, the dummy-variable hedonic model gives the lowest estimate for the long-run amenity benefit and this is the estimate we use for the base-case comparison. Using the Kennedy (1981) approach to interpreting dummy variables in log-linear models, the estimated long-run amenity benefit for homes within 200 m of the restoration site from this model is a 4.4% increase in house prices. Consistent with the modelling results, we assume this benefit is not realised until 2007.

To obtain a total value for amenity benefits we multiply the average sale price of a house within 200 m of the restoration site at the time the final benefit is realised by the number of houses in the benefit area. To ensure we have a reasonably large sample for determining the average sale price we take the average across sales in the period 2009-11, and in 2012 dollars the average home sales value was $404,183. There are 258 single homes within 200 m of the restoration site, and 15 strata homes. The population statistical model is based on single family homes, and so for strata homes we attribute a benefit equal to two thirds the proportional benefit that accrues to single family homes. Using this approach, the amenity benefit estimate, in 2012 dollars, is $4.8M. This is our base-case estimate of the amenity benefit. As part of our sensitivity testing, we also consider the case of one standard deviation above (6.0%) and below (2.9%) the model point estimate for the average house price increase, and for these two scenarios the respective amenity benefit estimates are $6.4M and $3.2M.

6.2 Costs summary

When considering costs this specific project benefited greatly from volunteer contributions from the community and partner organisations. For all volunteer contributions we impute a full market price for the value of this labour. Additionally, we account for pre-establishment project costs incurred in the years prior to the actual start of the project. Finally, projects such as this require the existence of community organisations with a credible track record. We therefore attribute a proportion of overhead and general administration costs from the relevant community organisation to the project. Specifically, we add the following costs to the known project earthworks costs: labour and overhead cost of community organisation co-ordinating the project of $150,000 per year for five years; participating council staff labour contribution of $30,000 per year for five years; water utility labour contribution of $5,000 per year for three years; value of contract design services $50,000. For the cost of planting we assume a cost of $1.75 per plant, a planting rate of six plants per square metre for the first metre along each side of the bank, and a rate of three and one half plants per square metre for the second metre along each side of the bank. The maintenance cost for the living stream are higher than the cost of maintaining a grassed area. Based on analysis of council maintenance cost data, we estimate that the additional maintenance cost for the section of the living stream we evaluate is $9,000 per year.

6.3 Net benefit assessment

For the net benefit comparison we consider real discount rates of 5%, 7%, and 9%, and as can be seen from the detail in Table 3, for the central estimate of amenity benefit, the benefit–cost ratio ranges from 2.6 to 2.2. Importantly, it can also be seen that even if we consider a high discount rate (9%) and a low amenity benefit gain (2.9%) the benefit–cost ratio is still substantially above one. Based on this analysis we conclude that there is strong evidence that project benefits are greater than project costs.

Table 3. Summary benefit−cost ratio information

Benefit estimate	Discount rate		
	5%	7%	9%
Low (2.9%)	1.8	1.6	1.5
Central (4.4%)	2.6	2.5	2.2
High (6.0%)	3.5	3.3	3.0

7 Implications

We have shown that, for this specific WSUD project, benefits are greater than costs. However, because costs and benefits accrue to different parties, unless there are changes to drainage governance arrangements in Western Australia, it is unlikely many value-enhancing drain restoration projects will be completed. Projects that have been completed to date, such as the Banister Creek project, have been possible due to a combination of factors unlikely to be regularly reproduced: exceptional local community contributions; a local council that is especially committed to WSUD; and substantial Commonwealth government grant contributions. Here, we discuss current institutional arrangements in Western Australia and show why these arrangements are a barrier to the adoption of value-creating WSUD projects. We conclude by outlining the changes needed to allow the adoption of value-enhancing WSUD projects.

7.1 Local government

Local councils maintain local drains and the local council is often the owner of the land directly adjacent to main drains. Local councils are therefore potential co-ordinators of drain restoration projects. In Australia, the main revenue source for local councils is property tax, and in Western Australia councils set a rate in the dollar charge (property tax) based on the property Gross Rental Value (GRV). A working rule of thumb for the GRV of a property is to use 5% of the capital value of the property. So, holding other things constant, an increase in property values of $4.8M, which is what we found for our case study example, results in an increase in GRV of around $240,000. In the study area the current standard residential rate in the dollar charge is $0.037, so an increase in property GRV of $240,000 would result in additional annual rate income of around $9,000. If we assume a discount rate of 5%, the implied NPV of the additional revenue is then $9,000/0.05 = $180,000, which is substantially less than the cost of the restoration project. This result indicates that it will not be possible for local councils to finance drain restoration projects based only on the additional rate revenue they are likely to obtain from the properties that increase in value, even when those projects generate benefits greater than costs.

7.2 Water utility

In Western Australia, main drain services are provided by the State-owned water utility, and the terms of the water utility licence restrict the water utility to consideration of water conveyance issues only. The water utility cannot, therefore, initiate restoration projects. The water utility can, however, allow externally funded projects to proceed. The current main drain service fee is calculated as $0.00545 × the property GRV. So, holding other things constant, an increase in property GRV of $240,000 results in an increase in annual main drain rate income for the water utility of around $1,300; which, applying a 5% discount rate, gives a NPV of around $26,000.

Although this is a trivial amount, the issue of the revenue that would actually accrue to the water utility is complicated by the regulatory environment in Western Australia. Specifically, the main drain rate is set by an economic regulation agency to provide an allowable percentage rate of return on the main drain asset base. This means that the main drain rate in the dollar for metropolitan Perth is solved from a total revenue requirement. As such, any GRV increase should be accompanied by a reduction in the rate in the dollar. In the long run, increases in GRV cannot result in higher main drain revenue for the water utility, unless there is an increase in the main drain asset base. And, with an operating licence that only allows consideration of water conveyance issues, there can be no increase in the asset base to reflect restoration project costs as all projects would need to be externally funded.

7.3 A way forward

Given current governance arrangements for managing main drains in Western Australia, it is difficult to see how restoration projects will proceed, even when total project benefits are greater than project costs. One potential solution is to alter the terms of the water utility licence to make it explicit that, subject to demonstrating to the economic regulation authority (*ex ante*) that overall project benefits are higher than project costs, drain restoration projects can be considered as part of the standard main drain capital works program. Drain restoration projects could then be reviewed and approved (or rejected) by the economic regulator at the same time as other drainage capital works are approved (or rejected).

As well as being simple to implement, the approach is also more cost effective than current approaches. For example, at the moment community groups have to engage external consultants -- or rely on in-kind contributions -- to prepare the engineering works to support a restoration plan. The restoration plan must then be reviewed and approved by water utility staff to ensure that the water conveyance function is not compromised by the project. Having the water utility contribute directly to the development of the restoration plan would generate efficiency savings. Further, if the water utility was to undertake -- or at least co-ordinate -- all drain restoration works across metropolitan Perth, the knowledge base built up through this work would allow economies of scale and scope benefits to be realised. Finally, given main drain rates are based on GRV, allowing the water utility to undertake restoration projects would actually result in restoration costs being allocated roughly in proportion to benefits. The mechanics of why this is the case are explained below.

Following a restoration project that involves capital expenditure, and also results in an increase in the property value of at least one home, there will be two separate effects on the main drain rate calculation for any given property. The first effect is the pure restoration effect. The pure restoration effect is due to the increase in the main drain asset base and is always positive. The second effect is the house price effect. The house price effect is driven by changes in a property's relative share of total property GRV. For properties that increase in value due to the restoration project the house price effect is positive. For properties that are unaffected by the restoration project the house price effect is negative. This means that for properties that benefit directly from the restoration project, the main drain rate must increase following the restoration project; but for properties that do not directly benefit from the restoration project the impact on the drainage rate may be positive or negative.

Note, however, that there is an adding-up constraint on house price effects, and given that the number of properties that increase in value following a restoration project will be small, while the number of properties unaffected will be substantial, the adding up constraint means that for a given property not directly affected by the restoration project the house price effect will be small, and hence will be dominated by the pure restoration effect. Conversely, it also means that for properties that do directly benefit from the restoration project, although both the pure restoration effect and the house price effect both work to increase the drainage rate, it is the house price effect that is likely to dominate.

The above discussion can be made concrete by introducing some formal notation and then illustrating the results with a calibration example. Let the total main drain asset base at time *t* be denoted D_t, and let the regulator set the allowable rate of return on main drain assets at α, where $0<\alpha<1$. The total main drain revenue to be collected from all homes in the main drain catchment area is then $\alpha D_t = R_t$. If there are *n* houses in the main drain network catchment area, and we let the gross rental value of house *i* at time *t* be denoted g_{it}; total area GRV can be defined as $\sum_i g_{it} = G_t$, and the GRV budget share for house *i* at time *t* can be defined as $g_{it}/G_t = \theta_{it}$, with $\sum_i \theta_{it} = 1$. The main drain rate charge for house *i* at time *t* can then be written as $\delta_{it} = \theta_{it} R_t$, and $\sum_i \delta_{it} = R_t$.

Now, consider a main drain restoration project that involves capital expenditure approved by the regulator such that in the next period we have $D_{t+1} > D_t$, with $\alpha\left(D_{t+1} - D_t\right) = \Delta R_{t+1} > 0$ denoting the change in the current period total main drain revenue requirement due to the restoration project. If we hold constant all house prices such that $g_{it+1} = g_{it}$ for all *i*, following the restoration project we have $\delta'_{it+1} = \theta_{it} R_{t+1}$ as the new main drain rate for house *i*; and $\delta'_{it+1} - \delta_{it} = \rho_{it+1} > 0$ as the additional charge. Conceptually, we can think of ρ_{it+1} as a charge for non-market non-use benefits generated by the restoration project, where contributions are in proportion to one measure of capacity to pay: home values.

Assume the restoration project also results in a permanent increase in the value of house *j*, of Δg_j. For house *j* this implies that a positive fixed constant has been added to the numerator and denominator of the GRV budget share equation, so we have $\theta_{jt+1} = \left(g_{jt} + \Delta g_j\right) / \left(G_t + \Delta g_j\right) > \theta_{jt}$, and $\theta_{jt+1} - \theta_{jt} = \Delta \theta_{jt+1} > 0$. We can then identify the additional main drain charge for house *j* due to the increase in the value of the property as $\Delta \theta_{jt+1} R_{t+1} = \eta_{jt+1}$, with the actual new main drain charge for house *j* equal to $\delta_{jt+1} = \delta_{jt} + \rho_{jt+1} + \eta_{jt+1}$; where the first term is the old drainage charge, the second term is the pure restoration effect charge, and the third term is the house price effect charge. For $i \neq j$ we also have $\delta_{it+1} = \delta_{it} + \rho_{it} + \eta_{it+1}$, but note that due to the adding-up constraint, for $i \neq j$ we must have $\theta_{it+1} < \theta_{it}$ so that $\theta_{it+1} - \theta_{it} = \Delta \theta_{it+1} < 0$ and the house price effect is negative.

Finally, note that the adding-up constraint also requires $\eta_{jt+1} = \sum_{i \neq j} \eta_{it+1}$ so that for $i \neq j$ the average size of the house price effect is $\eta_{jt+1} / (n-1)$.

The relative magnitude of the effects can be understood if we consider a realistic scenario. Based on publicly available data, the value of the regulated main drain asset base of the Western Australian water utility is around $330M, and the allowable rate of return on the asset base has been 5.6% (ACIL Tasman 2009). Now, assume a restoration project costing $500,000 is completed by the water utility. Further, assume that the total number of homes connected to the main drain network is 300,300, and that the value of all homes before the restoration project is $400,000. Finally, assume that the restoration project impacts 300 properties, and all these properties increase in value by 4.4%.[2]

For these assumptions, Table 4 provides a summary of all relevant changes. Following the restoration project the allowable dollar return to the water utility increases by $500,000 × 0.056 = $28,000. Given the uniform house price assumption the pure restoration effect is found as $28,000/300,300 = 9¢. However, the house price effect then needs to be added to obtain the actual change in the drainage charge for each home. The ratio of properties that benefit to properties that do not benefit is 1,000 to one. So, on a per property basis, the house price effect on properties inside the benefit zone ($2.73) is 1,000 times the effect on properties outside the benefit zone (-0.27¢). Once the house price effect is added to the restoration effect we can see that for properties inside the benefit area drainage charges increases by 4.6% (from $61.54 to $64.36), and for properties outside the direct benefit area drainage charges increase by only 0.1% (from $61.54 to $61.63).

This example illustrates that, following a restoration project, if drainage charges are set with reference to property values, cost are allocated roughly in proportion to benefits. Also note that as local council taxes are based on GRV, the beneficiaries of the restoration project will also pay higher local council taxes. This additional tax revenue can, in turn, be used to pay for the higher ongoing maintenance costs that local councils will face to maintain the area. Although actual maintenance costs will vary from project to project, it is worth noting that in our specific case study example, our estimate of the additional annual maintenance cost was similar to our estimate of the additional property tax income the council is receiving due to higher property values.

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[2] There are several elements to the main drain charge. Here we focus only on the regulated main drain return on asset charge, which is the element impacted by the change to allow the water utility to undertake restoration works.

Table 4. Worked restoration project example

Item	Units	Pre restoration	Post restoration
Properties within the benefit area	No.	300	300
All other properties	No.	300,000	300,000
Average house value inside benefit area	$	400,000	417,718
Average house value all other properties	$	400,000	400,000
Total value of the housing stock	$M	120,120	120,125
Total GRV of the housing stock	$M	6,006.0	6,006.3
Drainage Regulatory Asset Base	$M	330.0	330.5
Allowable return on asset base at 5.6%	$M	18.48	18.51
Per property asset drainage charge inside the area	$	61.54	64.36
Pure restoration effect	$	-	0.09
House price effect	$	-	2.73
Per property drainage rate all other properties	$	61.54	61.63
Pure restoration effect	$	-	0.09
House price effect	¢	-	-0.27

8 Conclusion

In Western Australia, proponents of WSUD have had limited success in promoting their ideas. One reason for this is a lack of *ex post* evaluations that demonstrate WSUD project benefits are greater than project costs. Here we have evaluated a specific WSUD project using a conservative approach to calculate benefits, and a liberal approach to calculate costs; and have shown project benefits to be larger than project costs. Economic evaluations that demonstrate the value of WSUD are necessary, but such assessments are not sufficient to ensure greater adoption of value enhancing WSUD projects. In the case of main drain restoration projects our assessment indicates that in Western Australia changes to governance arrangements will be required if there is to be a significant increase in restoration projects. However, the required governance changes are small, and there is no need for additional institutional architecture. Specifically, we argue that a change to the operating licence conditions of the water utility that allowed it to undertake drain restoration projects, where such projects are approved by the independent economic regulation authority, would allow value-enhancing WSUD projects to proceed, and result in an increase in overall community welfare.

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