The impact of life-cycle cost management on portfolio strategies

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Abstract
The US National Park Service (NPS) is responsible for the management of some of the most recognisable and notable natural and cultural resources in the USA. To make the case for additional maintenance funding, NPS is instituting life-cycle cost management practices. Over the 50-year life cycle of the Redwood Information Center at Redwood National and State Parks in Crescent City, California, custodial costs alone will sum to more than the total replacement construction cost for the entire facility. This point illustrates an important aspect regarding the true cost of operating and sustaining physical infrastructure over its life cycle. It also suggests that understanding life-cycle costs is a critical element of effective, long-term portfolio and asset management. Often, institutional

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owners of physical assets inadequately assess the true cost of building and owning facilities, typically overemphasising initial construction costs. Life-cycle operations and maintenance (O&M) and capital renewal costs, however, almost always comprise a far greater percentage of total life-cycle building costs. Using actual life-cycle costs for an asset that is owned and managed by NPS, this paper explores the development of full life-cycle costing, highlighting key life-cycle cost drivers, of an information centre at the Redwood National and State Parks.

Keywords:
life cycle, costing, operations, maintenance, recapitalisation, portfolio, facilities, investment

INTRODUCTION

The US Department of Interior's (DOI), National Park Service (NPS) is responsible for the management of 388 park units, which include many of the most recognisable and notable built facilities and natural and cultural resources in the US. Among many others, these include the likes of Independence Hall, the Statue of Liberty and the Washington Monument. Understanding the total life-cycle costs for these facilities and assets has always been a difficult undertaking. But implementing new asset management technologies and accompanying business practices has helped NPS begin to understand these concepts in ways unimaginable until recently.

Asset management programmes do not happen overnight

Making a concerted effort to implement an asset management programme to manage NPS's unique and substantial portfolio better has been in progress for a number of years. Along the way, a number of efforts have come and gone, all in the interest of establishing a programme to manage and sustain the life cycle of the entire NPS asset inventory better. The NPS portfolio includes more than 16,000 buildings, many historic, an estimated 8,500 monuments, over 16,000 miles of trails, some 1,200 water systems, about 1,400 wastewater treatment plants, and more than 4,000 employee housing units. The road network consists of nearly 5,500 paved miles of road, an estimated 6,000 miles of unpaved roads and some 1,700 bridges. Today, NPS has positioned itself to become a public sector leader in managing its vast infrastructure. Recently, significant progress has been made in this area, largely in response to public pressure to arrest and correct a substantial maintenance backlog, currently estimated at more than $5bn.

The lessons in all of this are numerous. But several noteworthy ones stand out: (1) establishing an effective asset management programme is easier said than done — a substantial commitment of resources and dedication is required; (2) progress in developing accurate inventories, baseline condition assessments and long-term budgetary requirements occurs not overnight but incrementally over time; and (3) nothing can better state the business case for such an investment of time and resources than the outputs that NPS is beginning to see through implementation of an integrated asset management programme. Just one of these key outputs is the subject of this paper: managing the life cycle of a visitor information centre at the Redwoods National and State Parks in Crescent City, California. Accordingly, this paper will proceed with a brief history of the efforts NPS has taken to establish an asset management programme. Then, the paper will proceed into a live case study recently undertaken, which highlights the requirements to manage just one relatively small facility at a park on the west coast of the USA.

THE NPS ASSET MANAGEMENT PROGRAM — AN INCREMENTAL EVOLUTION

In 1985, US Public Law 98-540 directed NPS to develop, implement and maintain a computerised maintenance management system (MMS) to support its maintenance and operations programmes. Park managers, however, found that this work activity-based programme did not provide them with an effective planning tool, the ability to conduct condition assessments or the information needed to manage their deferred maintenance workload. A front-end module, the Inventory and Condition Assessment Program (ICAP), was developed later to include planning, inventory and condition assessment tools.

The NPS asset management programme has had several iterations

The most significant issue facing the NPS Facilities Management Program (FMP) was the lack of a defined business process was based on recognised professional standards and practices. The Service was practising reactive, corrective maintenance and not managing facilities on a proactive, preventive maintenance or life-cycle basis.

Years later in 1997, the NPS Service Maintenance Advisory Committee (SMAC), Task Group Four, completed a FMP Information Study which more clearly defined an asset management process for NPS. The asset management process consists of a series of business practices which identify the steps and procedures that the Service and individual park units will follow in order to plan for, acquire, sustain and dispose of built facilities, when appropriate. National Park Service asset management is represented by a set of asset management processes in which each subsequent process adds a greater level of maturity in effective facility stewardship. More mature processes are intended to result in a more efficiently managed, sustainable asset management organisation which is able to maximise the productivity of its physical infrastructure.

The results of this study were in full compliance with new federal accounting standards requiring that federal agencies develop a systematic method for documenting deferred maintenance needs and track progress in reducing the amount of deferred maintenance. In 1998, the auditing and evaluation arm of the US Congress — the General Accounting Office (GAO) — reported a backlog of $4.9bn in needed maintenance within the parks.

In 1998, DOI produced a document titled *Facilities Maintenance Assessment and Recommendations*, recommending adaptation of standardised definitions and activities in the areas of facilities budgeting, condition assessments, maintenance management and facilities conditions indexing. Later in that same year, NPS received notification from the US Office of Management and Budget that a request for Year 2000 appropriations to replace the Service's computerised MMS and ICAP had been funded. In meetings with DOI officials and other DOI bureaus, the Park Service decided to proceed with the development of a set of technical specifications for a facility management software system (FMSS) that would better meet the needs of NPS, but might also provide for the needs of other DOI bureaus.

After evaluating over 1,600 off the shelf maintenance management software programs, the Service selected Maximo in 1999 as its FMSS. While developing and implementing the FMSS, NPS established a process and an automated system for collecting detailed information about park assets. This inventory condition assessment was intended to provide accurate, verifiable cost estimates of deferred maintenance and establish a baseline for measuring the progress in remedying the problems. Also, this information is intended to indicate performance for future management planning and decision making and will fulfil reporting requirements set by the DOI and the US Congress.

NPS is now able to clearly articulate its inventory, replacement valves, and deferred maintenance needs

EARLY RESULTS FROM NPS ASSET MANAGEMENT IMPLEMENTATION EFFORTS

After several years of implementation efforts, NPS has quite a lot to show for its efforts, including a complete inventory of more than 58,000 unique assets with complete current replacement values, quantities and an evolving programme of condition assessment information which clearly identifies deficiencies and cost estimates to correct them. The implementation of the FMSS program has given NPS preliminary information about highly sought after maintenance backlog information and is providing the basis for future work management.

NPS had always hoped that implementing FMSS would provide it with more than maintenance backlog information. The hope was, that, for the first time ever, NPS could provide a baseline of current inventory condition, costs required to return the inventory to an acceptable level of condition over time, and enough information about the asset inventory to manage a programme of preventive maintenance and recapitalisation effectively. All these things taken together would establish a foundation for sustaining the portfolio over time to ensure that the unacceptable levels of maintenance backlog that exist today never happen again.

Perhaps without knowing it, NPS FMP managers began a programme focused on managing the life cycle of its enormous inventory. And given the historic nature of many NPS structures, this is no small feat. The evolution of this thought process developed incrementally. Triggered by a staggering maintenance backlog, NPS originally recognised that capturing existing deficiency information about its inventory simply was not enough. While the condition assessment process has been useful to this end, NPS recognised immediately that the rehabilitation process was going to take a number of years. Further, even if NPS could marshal all the funds necessary to clear the large backlog of existing deficiencies quickly, the enormous inventory would continue to live its natural design life during the lengthy rehabilitation process, leaving NPS with a new backlog, unimagined and undocumented during the time of the initial condition assessments. For example, an asphalt shingle roof may have been inspected with no deficiency determinations. If it was not documented that the roof was 18 years into a 20-year design life, however, the opportunity to capture a likely project two years down the road went unrealised.

This realisation amounted to the discovery that this evolving NPS asset management programme had become about much more than the need to fund badly needed maintenance backlog projects. It had become about life-cycle management and understanding that, as long as each asset in the NPS inventory is kept in service (maintenance backlog notwithstanding), an understanding is essential about preventive maintenance and recapitalisation needs, as well as operational requirements.

Capturing information about existing deficiencies is not enough ...

The NPS is now implementing new business practices to support these life-cycle management concepts. The organisation is rolling out procedures to capture complete recapitalisation and preventive maintenance requirements for its assets. Armed with this information, NPS is confident about its ability to demonstrate that, even when the maintenance backlog is brought under control, preventive maintenance and recapitalisation needs will still require substantial resources to ensure that the portfolio never again slips into unacceptable levels of condition.

Efforts are just getting under way to implement these highly mature asset management business practices of capturing preventive maintenance, recapitalisation and operational requirements over a 50-year period. But several examples throughout the NPS portfolio exist which illustrate the power of what this type of management information will ultimately yield. This is the subject for the remainder of this paper.

LIFE-CYCLE CASE STUDY OF THE REDWOOD INFORMATION CENTER

Surrounded by some of the most magnificent trees in the entire world, the Redwood Information Center (RIC) at Redwood National and State Parks is a critical asset and structure in enabling the Redwood experience for those who visit one of northern

Over a fifty-year life cycle, RIC cleaning costs alone will come to more than the total replacement cost of the facility

California's greatest treasures. Over the 50-year life cycle of the RIC, custodial costs alone will sum to more than the total replacement construction cost for the entire facility. This point illustrates an important aspect regarding the true cost of operating and sustaining physical infrastructure over its life cycle. It lends credibility to the previous statement that understanding life-cycle costs is a critical element of effective, long-term portfolio and asset management. Table 1 highlights RIC life-cycle costs accounting for operational maintenance functions including cleaning, purchased utilities and other miscellaneous items. Table 2 covers preventive and recurring maintenance for the RIC wall coverings, roof and plumbing, and Table 3 highlights component renewal (ie recapitalisation or the planned replacement of building subsystems[1]) including flooring, roofing, windows, doors, plumbing and HVAC. All this is calculated over a 50-year operating period in current year dollars.

The top row of Table 1 provides some basic information about the RIC: that it is 3,825 square feet; it has a facility condition index (FCI) rating of 0.08: and a current replacement value (CRV) of $971,104. The 0.08 FCI rating, according to the FCI formula, indicates that there is $77,688 in deferred maintenance associated with the facility ($77,688/$971,104 = 0.08). The columns of Table 1 gives us information leading to the calculation of 50-year life-cycle

Table 1: RIC life-cycle operational costs*

REDWOOD INFORMATION CENTER				3825 SF	FCI 0.08	CRV $971,104		
Function / System / Component	Work Type	Feature / Location	RS Means Section	Quantity	Cost / UM	Frequency	Total Cost/Cycle	Total Cost /50 Years
	Operational Maintenance							
Custodial	OM	Vacuum Carpet	1837-900-0070	1948 SF	9.25/MSF	$18 Daily	$6,570.00	$328,500.00
	OM	Dust Walls	1937-925-0020	5400 SF	2.43/MSF	$14 Daily	$5,110.00	$255,500.00
	OM	Wash Windows	1835-900-0400	693 SF	84.5/MSF	$59 Monthly	$708.00	$35,400.00
	OM	Clean Restrooms	1837-200-0110+	3 EA	$48.66	$49 Daily	$17,885.00	$894,250.00
						SUBTOTAL	$30,273.00	$1,513,650.00
Utilities	OM	Electrical		36040KWH	$5,074.00	1 year	$5,074.00	$253,700.00
	OM	Propane (heating)		862 GAL	$912.00	1 year	$912.00	$45,600.00
	OM	Water		40600 GAL	$739.00	1 year	$739.00	$36,950.00
						SUBTOTAL	$6,725.00	$336,250.00
Other	OM	Service Sprinkler System	PM8.2-170-1950	1 EA	$745.00	1 year	$745.00	$37,250.00
	OM	Service Fire/Intrusion Alarms	PM8.2-270-1950	1 EA	$720.00	1 year	$720.00	$36,000.00
	OM	Service HVAC/AirHandlers	PM8.3-410-1950	2 EA	$430.00	1year	$860.00	$43,000.00
	OM	Service Water Heater	PM8.3-910-1950	2 EA	$144.00	1 year	$288.00	$14,400.00
	OM	Service Lift Station	PM8.4-050-1950	2 EA	$91.00	1 year	$182.00	$9,100.00
	OM	Service Urinals	PM8.5-050-1950	2 EA	$13.00	1 year	$26.00	$1,300.00
	OM	Service Flush Toilets	PM8.5-050-3950	7 EA	$21.00	1 year	$147.00	$7,350.00
	OM	Service Lavatories	PM8.5-050-4950	7 EA	$24.00	1 year	$168.00	$8,400.00
	OM	ServiceShower	PM8.5-050-5950	1 EA	$18.00	1 year	$18.00	$900.00
	OM	Service BackFlow Preventer	PM8.5-110-2950	1 EA	$26.50	1 year	$26.50	$1,325.00
	OM	Service Refrigerator	PM11.2-160-1950	1 EA	$26.00	1 year	$26.00	$1,300.00
	OM	Service Gate Valves	PM12.2-200-3950	1 EA	$64.00	1 year	$64.00	$3,200.00
						SUBTOTAL	$3,270.50	$163,525.00
				OPERATIONAL TOTALS			$40,268.50	$2,013,425.00

*All systems data is from the Redwood Information Center, Redwood National and State Parks. The columns *RS Means Section*, *Quantity* and *Cost/UM* are taken from the RS Means Cost Estimating Reference for Facilities Maintenance and Repair, 2003.

Life cycle costs are key to understanding the total costs of owning and operating the RIC

costs associated with only the operational maintenance of the RIC. The first column lists the key functions of custodial, utilities and other operational maintenance functions. The Feature/Location column provides more detail associated with activities within each function. The column labelled 'RS Means Section' references a link to RS Means, the standard cost reference used by NPS for cost estimating. The next four columns provide detail about quantity, cost per unit of measure, frequency and total cost per cycle. In some cases, the 50-year life-cycle totals are actual costs (utilities), the total cost per cycle times 50 years or the total cost per cycle times 50 years divided by the frequency. The last column provides the 50-year life-cycle totals for each of these functions. Cleaning costs alone, as stated previously, represent more than $1.5m over the period of time covered in this analysis. The RIC cleaning costs are high by most standards but not high when considering that this is a public use facility which requires substantial effort when it comes to cleaning. Utilities are another $336,000, and other operational requirements amount to more than $163,000. Total operational maintenance requirements sum to more than $2.0m over the 50-year period. In Table 2, preventive and recurring maintenance is covered, summing to an additional $355,852 over the 50-year period. This analysis is notable because it is not based on any rule of thumb planning value for maintenance activities (eg 2–4 per cent of CRV[2]). Rather, it reflects highly accurate preventive

Table 2: RIC life-cycle preventative and recurring maintenance*

Function / System / Component	Work Type	Feature / Location	RS Means Section	Quantity	Cost / UM	Frequency	Total Cost/Cycle	Total Cost /50 Years
	Preventive / Recurring Maintenance							
	Painting	Interior						
Wall Covering	PM/RM	Int Doors	6.4-420-1020	9 EA	$46.00	4 years	$414.00	$5,175.00
	PM/RM	Int Trim	6.2-110-0030	500 LF	$1.40	7 years	$700.00	$4,999.00
	PM/RM	Int Drywall (Walls)	6.5-230-0050	5150 SF	$1.00	5 years	$5,150.00	$51,500.00
	PM/RM	Int Paneling	6.5-590-0020	210 LF	$1.00	5 years	$210.00	$2,100.00
	PM/RM	Int Drywall (Ceiling)	6.7-120-0020	3600 SF	$1.37	6 years	$4,932.00	$41,099.00
	PM/RM	Int Paneling	6.7-510-0030	490 SF	$1.05	6 years	$515.00	$4,291.00
							SUBTOTAL	$109,164.00
	Painting	Exterior						
	PM/RM	Deck	4.1-558-1030	3736 SF	$1.25	3 years	$4,670.00	$77,833.00
	PM/RM	Handrail	4.1-558-1030	441 LF	$2.04	3 years	$900.00	$14,999.00
	PM/RM	Siding/trim	4.1-534-1030	5124 SF	$2.67	7 years	$13,681.00	$97,721.00
	PM/RM	Ext Doors	4.6-320-1050	9 EA	$180.00	4 years	$1,620.00	$20,250.00
	PM/RM	Fascia	4.1-558-1030	598 LF	$1.57	7 years	$938.00	$6,699.00
	PM/RM	Soffit	4.1-558-1030	492 SF	$1.67	7 years	$822.00	$5,871.00
	PM/RM	Fencing/Screen	4.1-558-1030	100 LF	$1.57	7 years	$1,570.00	$11,214.00
							SUBTOTAL	$234,587.00
Roofing	PM/RM	Inspection/cleaning	5.1-345-0100	6600 SF	$20.00	1 year	$132.00	$6,600.00
							SUBTOTAL	$6,600.00
Plumbing	PM/RM	Rebuild Backflow Prev	8.1-299-3020	1 EA	$486.00	10 years	$486.00	$2,430.00
	PM/RM	Drain/Flush Hotwater Heater	8.8-187-0010	2 EA	$215.00	7 years	$430.00	$3,071.00
							SUBTOTAL	$5,501.00
				PM / SM TOTALS			$7,117.00	$355,852.00

All systems data is from the Redwood Information Center, Redwood National and State Parks. The columns *RS Means Section*, *Quantity* and *Cost/UM* are taken from the RS Means Cost Estimating Reference for Facilities Maintenance and Repair, 2003.

Table 3: RIC life-cycle component renewal (recapitalisation) costs*

Function / System / Component	Work Type	Feature / Location	RS Means Section	Quantity	Cost / UM	Frequency	Total Cost/Cycle	Total Cost /50 Years
	Component Renewal							
Flooring	CR	Vinyl	6.6-240-0020	74 SY	$78.00	18 years	$5,772.00	$16,033.00
	CR	Carpet	6.6-910-0020	217 SY	$35.00	8 years	$7,595.00	$47,468.00
	CR	Base	6.2-160-0010	300 LF	$2.75	8 years	$825.00	$5,156.00
Roofing	CR	Composition	5.1-345-0700	6600 SF	$258.00	20 years	$17,028.00	$42,570.00
Windows	CR	Vinyl Clad	4.7-240-3030	41 EA	$548.00	40 years	$22,468.00	$28,085.00
Doors	CR	Ext. Door Hardware	4.9-110/310/410	9 EA	$769.00	15 years	$6,921.00	$23,069.00
	CR	Ext Door	4.6-320	9 EA	$1,114.00	30 years	$10,026.00	$16,709.00
	CR	Int Door Hardware	6.4-710/720/740	9 EA	$711.00	20 years	$6,399.00	$15,997.00
Plumbing	CR	Urinal	8.1-213-0300	2 EA	$783.00	35 years	$1,566.00	$2,237.00
	CR	Lavatory	8.1-214-0060	7 EA	$569.00	40 years	$3,983.00	$4,978.00
	CR	Electric Water Heater	8.1-287-0030	2 EA	$1,257.00	15 years	$2,514.00	$8,379.00
HVAC	CR	LPG Furnace	8.3-424-3030	2 EA	$2,418.00	15 years	$4,836.00	$16,120.00
						REPLACEMENT TOTAL		$226,801.00

*All systems data is from the Redwood Information Center, Redwood National and State Parks. The columns *RS Means Section*, *Quantity* and *Cost/UM* are taken from the RS Means Cost Estimating Reference for Facilities Maintenance and Repair, 2003.

maintenance specifications which represent the RIC's actual subsystems and equipment.

Life cycle recapitalisation costs are often overlooked

Table 3 highlights the recapitalisation or component renewal needs of the RIC. This often forgotten aspect of facilities life-cycle management represents another $226,801 over the 50-year period.

The recapitalisation of RIC subsystems is reflective of the need to replace building systems once they have exceeded their expected design lives. That is, even with good maintenance execution over the life of the RIC, certain systems will need to be replaced.

All the costs represented in Tables 1–3 are summarised in Table 4.

In total, Redwood park managers can expect to fund more than $2.5m over the life of the RIC, in addition to having to fund more than $77,000 to clear the current maintenance backlog associated with the structure. All this for a building that has a CRV of less than $1.0m. Looking at it another way, if the total life-cycle cost of the RIC is considered as its initial acquisition and construction cost

Table 4: RIC summary life-cycle costs*

Function / System / Component	Work Type	Feature / Location	RS Means Section	Quantity	Cost / UM	Frequency	Total Cost/Cycle	Total Cost /50 Years
	Operational Maintenance							
				OPERATIONAL TOTALS				$2,013,425.00
	Preventive / Recurring Maintenance							
				PM TOTALS				$355,852.00
	Component Renewal							
				REPLACE TOTALS				$226,801.00
						TOTAL		$2,596,078.00

*All systems data is from the Redwood Information Center, Redwood National and State Parks. The columns *RS Means Section*, *Quantity* and *Cost/UM* are taken from the RS Means Cost Estimating Reference for Facilities Maintenance and Repair, 2003.

(assume the CRV for this example, since the actual value is unknown), and a conservative value is assumed for ultimate disposition of the facility of $25,000, plus all the costs highlighted in Tables 1–3, the RIC life-cycle cost total can be summed as follows:

Initial construction (CRV for this example)
+ 50-year operational maintenance requirements
+ 50-year preventive and recurring maintenance
+ 50-year recapitalisation costs
± final disposal/salvage
+ deferred maintenance
= RIC total life-cycle costs

Or

$971,104 + $2,013,425 + $355,852 + $226,801 + $25,000 + $77,688 = $3,669,870 (RIC life-cycle costs)

RIC life cycle costs for O&M and renewal exceed initial construction costs

It should be noted that the addition of deferred maintenance is not typically included in estimating the life-cycle costs of an asset. Of course, there would be no need to add this cost element for a planned asset. But for an existing asset such as the RIC, deferred maintenance is a cost liability for the facility, and leaving it out would make any life-cycle estimate incomplete. Also, life-cycle cost analysis typically requires conversion to present value, since the costs are spread over many years, 50 in this example, and because money is worth more today than it is tomorrow. That conversion, however, serves as a means of normalising and comparing construction or project alternatives when costs occur at different times under different circumstances. In this case, no such comparisons are being made and, therefore, no discount rate for the purpose of conducting present value analysis has been selected. All costs are in current year 2003 dollars. The important message for the purpose of this paper is not about making life-cycle comparisons between project alternatives. Rather, it is a demonstration of the importance of accurately developing the actual life-cycle costs themselves, as depicted in Tables 1–3.

Further, this analysis should serve to highlight that life-cycle costs are deserving of more substantial analysis to ensure that initial construction costs for new facilities are not overemphasised when considered alongside total life-cycle costs. In the case of the RIC, life-cycle O&M and capital renewal costs comprise a far greater percentage of total life-cycle building costs.

For comparative purposes, an analysis of 50 different building types was conducted to explore this concept further. To perform this analysis, the 2003 Whitestone Cost Reference was used to evaluate 50-year life-cycle costs for 50 different building types as a means for comparing those costs with the replacement value for

Table 5: Analysis of Whitestone 50-year maintenance and repair costs*

	$/SF CRV	50 YR M&R $/SF	M&R 50 YR Costs as % of TLCC
RIC	$253.88	$678.71	73%
Whitestone Buildings			
Median for All Bdgs. (n=50)	$99.54	$185.55	65%
Median for Bdgs. < 10k SF (n=11)	$112.63	$271.57	71%
Median for Bdgs. < 30k SF, > 10k SF (n=20)	$96.27	$189.44	66%
Median for Bdgs. < 80k SF, > 30k SF (n=9)	$90.51	$146.98	62%
Median for Bdgs. > 80k SF (n=10)	$95.48	$116.65	55%

*2003 Whitestone Reference for Maintenance and Repair

each building. The results of this analysis are shown in Table 5. The RIC's 50-year operations, maintenance and repair and recapitalisation costs represent 73 per cent of the total life-cycle cost for that facility.

The Whitestone buildings do not include costs for operations but do include costs for standard maintenance activities and recapitalisation. For these buildings, the median maintenance and repair costs represent 65 per cent of life-cycle costs. For this analysis, the assumption is again made that building replacement value is a fair approximation for initial construction costs, an important element in developing total life-cycle costs.

Productivity of the asset inventory cannot be maximised when deferred maintenance costs are high

For NPS, there are potentially other lessons to be learned from this analysis: that the smaller buildings of less than 10,000 square feet in Table 5 appear to have greater life-cycle costs associated with maintenance and repair (71 per cent), contrasted to building groupings in larger square footage categories that show lower life-cycle costs associated with maintenance and repair. While the sample sizes in the analysis are small, the trend is noteworthy, since most of the building structures in the NPS inventory average less than 2,000 square feet.

For an organisation, such as NPS, which is just now beginning to understand better issues associated with maintenance backlog, the RIC provides a useful case study about the nature of the infrastructure life cycle. It highlights high costs that are often overlooked when decisions are being made to design and construct or acquire new assets into the inventory. Also, it demonstrates the difficulties created by a burdensome maintenance backlog. Large portfolios are costly to manage and sustain over time. Carrying a large maintenance backlog simply ensures that the portfolio will not receive adequate life-cycle O&M funding. Therefore, the productivity of the asset inventory cannot be maximised for the most effective possible uses.

Perhaps the greatest question raised in this analysis comes in the form of inventory affordability. When considering the size and historic nature of the NPS asset inventory, a large maintenance backlog and potentially higher than normal life-cycle maintenance costs, the issue of disposal seems to stand out as a highly viable alternative for helping to arrest maintenance backlog and help the NPS right size its portfolio to a more affordable and manageable size.

NEXT STEPS

Inspired by the RIC analysis, and other preliminary outputs from the new FMSS system, NPS is now expanding these life-cycle concepts by piloting the same type of analysis at the park level. In the coming months, NPS will be creating what it is calling an Asset Management Plan (AMP) at Grand Canyon National Park. The AMP will describe the total cost of owning, operating and maintaining the Grand Canyon physical asset inventory over time, including all built structures and utilities, roads, trails and other assets. It is hoped that the AMP will support and facilitate management discussion and decision making in requesting and managing resources for the park's infrastructure managers.

CONCLUSION

Using NPS as an example, this paper highlights the amount of time and resources required to establish an effective asset management programme. NPS has been working to implement an asset management programme for years, and is only now beginning to see early results. The paper also demonstrates what can be accomplished through the implementation of an integrated asset management system: accurate inventories, baseline condition assessments, long-term budgetary requirements and a life-cycle understanding about what is truly required to operate and sustain an asset inventory. The RIC life-cycle case study reveals several important findings for NPS. It shows that life-cycle operations, maintenance and recapitalisation costs are surprisingly high in comparison with initial construction costs. Yet, the initial construction cost is typically where management focus is almost always directed when making decisions about building or acquiring new assets. The RIC should serve as a useful example of the need to capture more detailed life-cycle information about its assets, especially for an organisation such as NPS, whose large maintenance backlog should give pause to any manager interested in constructing or acquiring new park assets without understanding the life-cycle costs of the existing inventory.

References

1. Neve, T. and Selman, J. (2002) 'How Much Should We Really Spend on Recapitalisation?' *Proceedings of the IFMA World Workplace Conference*, Toronto, Ontario, October.
2. Federal Facilities Council (1998) *Stewardship of Fed Facilities*, Federal Facilities Council.