

KICA

WIP Report

**NPS Retaining Wall Inventory Program
Kings Canyon National Park**



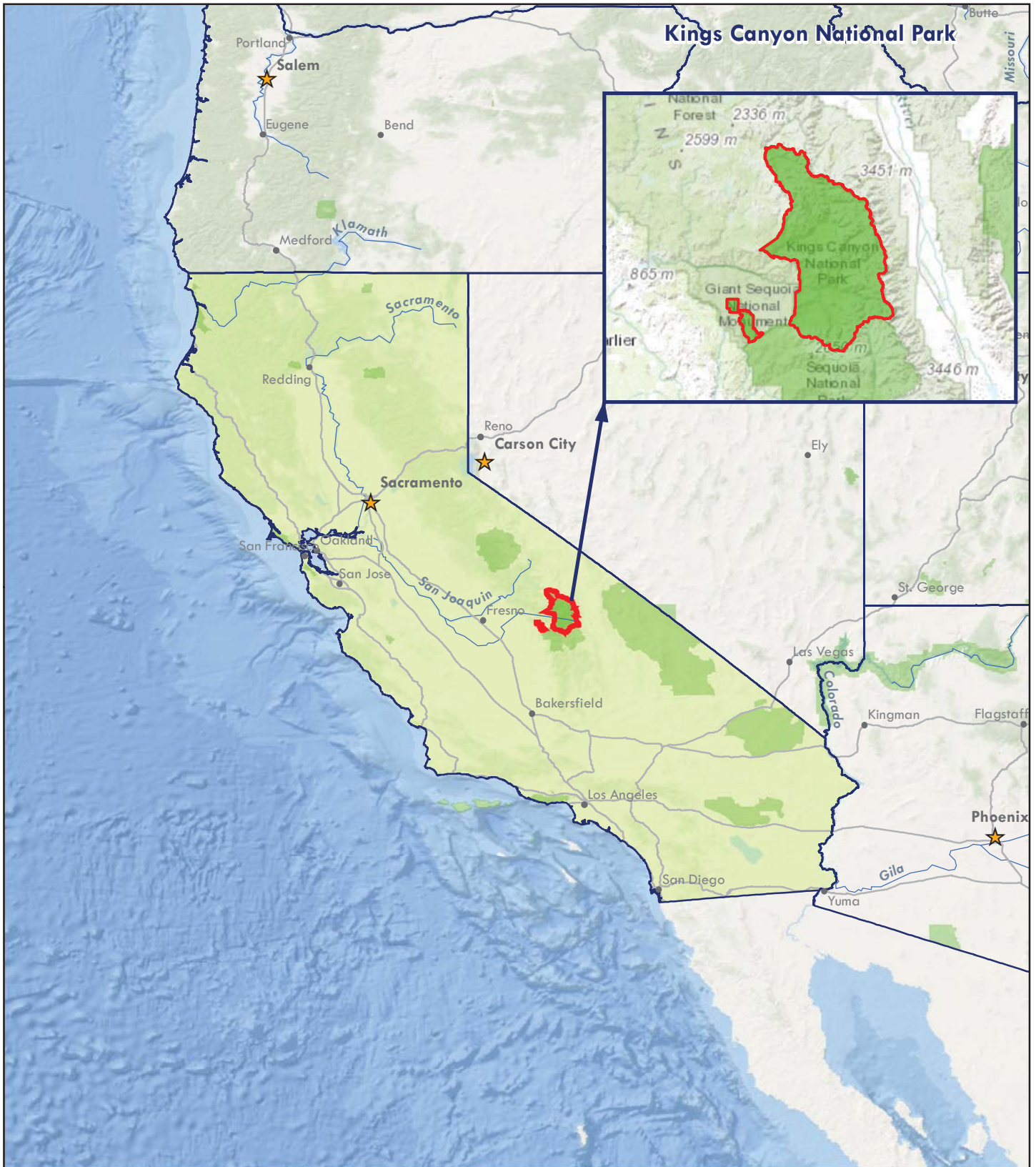
**Federal Lands Highway
Road Inventory Program**

Prepared By:

**Federal Highway Administration
Eastern Federal Lands Highway Division
Road Inventory Program (RIP)**

**Data Collection Date: August 2007
Report Date: November 2015**

Kings Canyon National Park in California



Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community
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Introduction



Kings Canyon National Park



**Federal Lands Highway
Road Inventory Program**

Introduction

The Federal Lands Highway Division (FLH) of the Federal Highway Administration (FHWA), in partnership with the National Park Service (NPS), has conducted a retaining wall inventory and condition assessment as part of the NPS Retaining Wall Inventory Program (WIP). This inventory provides information to the NPS Facility Management Software System (FMSS) regarding such things as type, size and location of retaining structures, as well as the condition of these facilities and consequences of failure. In addition, when wall and/or adjacent element deficiencies are identified, repair recommendations and estimated costs are also provided, suitable for use as FMSS work orders.

The main intent of this effort is to determine the backlog of needs associated with retaining wall assets – equipment features ascribed to the “parent” roadway asset. Inventory and condition assessments (pavement only) for the roads themselves are conducted under the NPS Road Inventory Program (RIP). Prior to development of the WIP, the vast majority of retaining walls were not accounted for in FMSS. Based on WIP inventory work to date, NPS wall assets are valued at well over \$400M. A second and equally important intent of this effort is to inform and improve project selection, prioritization, and development activities and processes at NPS regions/parks, FLH Division offices and the NPS Denver Service Center.

In support of WIP, a comprehensive procedures manual (available at the following link: <http://www.cflhd.gov/programs/techDevelopment/geotech/WIP/>) was developed to document the data collection and management process, wall attribute and element definitions, and team member responsibilities for conducting retaining wall inventories and condition assessments. This manual was used for nearly 3,500 wall assessments initially conducted between 2007 and 2008 within 34 national parks. WIP is supported by several key components described in the procedures manual, including a comprehensive training program for field inspectors, an Oracle-based database for long-term data management, unique data collection forms, a supporting field guide, and a wall repair/replace cost estimate guide.

Ultimately, condition assessments for retaining wall structures are expressed as deferred maintenance costs, which are then divided by current year replacement costs to arrive at a “Facility Condition Index” (FCI). Coupling this condition prioritization index with an “Asset Priority Index” (API), which measures the feature’s importance to the mission of the park, capital asset investments are made more efficiently. This approach appropriately focuses maintenance and construction priorities on value, rather than solely on cost. Wall inventory condition and cost data are transferred from the WIP database to FMSS, the primary asset documentation, management and planning platform maintained at each park. In addition, wall data are also provided to the Road Inventory Program to update equipment assets associated with the parent roadway asset.

Initial inventories were conducted based on RIP Cycle 3 data, but future planning has ensured updates to WIP will occur simultaneously with RIP. For long-term data management purposes, the WIP database will be linked to the larger, parent RIP database and be updated under the responsibility of the RIP Database Administrator.

This report is organized in a tiered approach from the broad park overview perspective (Tier 1) to a route overview perspective (Tier 2), then down to the details of each wall (Tier 3). Tier 1 presents park wall location maps and an overall park-specific summary narrative of the results of the wall inventory program. Tier 2 presents route overview maps with associated wall summary information. Tier 3 presents individual wall information in a three-page detailed format, including a photograph of each wall. Appendix A provides a condensed summary of wall inventory definitions and assessment categories to assist in reading this report.

Park Retaining Wall Location Maps



Kings Canyon National Park

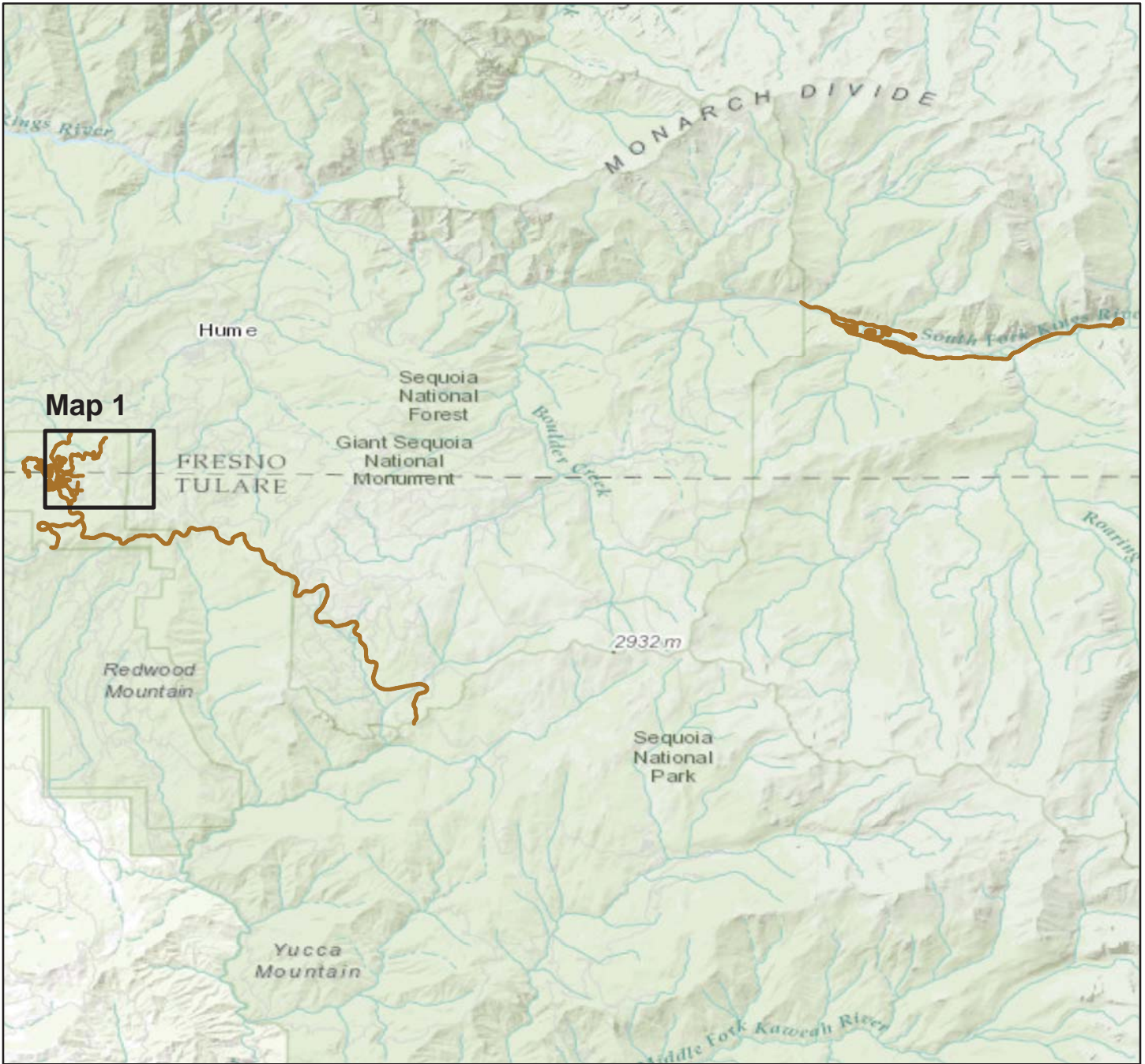


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Kings Canyon National Park

WALL LOCATION MAP

Key Map



Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

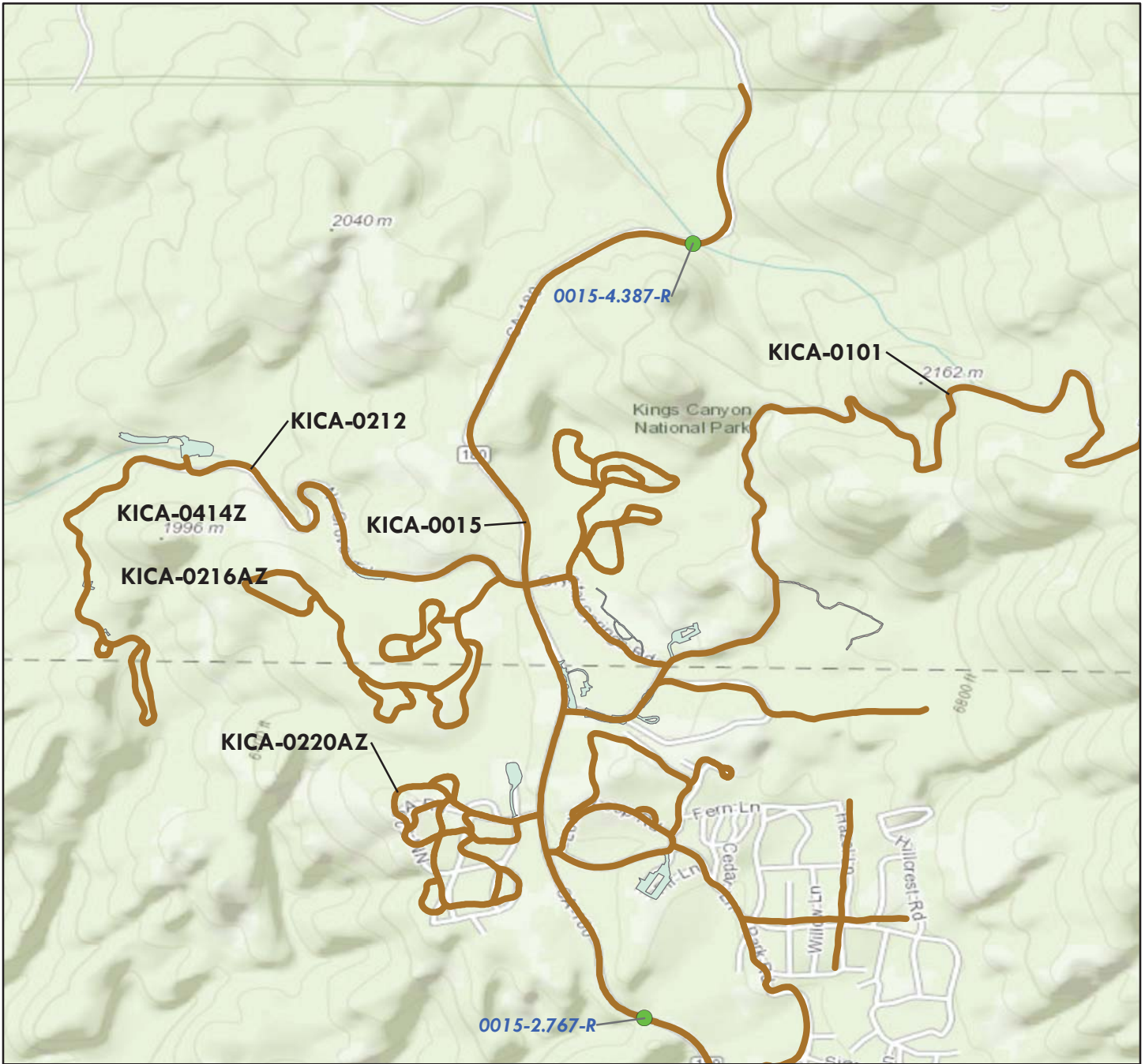
 RIP Collected Routes



Kings Canyon National Park

WALL LOCATION MAP

Map 1



Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

● Wall Locations

— RIP Collected Routes



Tier 1 Park Retaining Wall Overview



Kings Canyon National Park



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Parkwide Summary: Kings Canyon National Park

Initial retaining wall inspections were conducted at Kings Canyon National Park in 2007, and encompassed all known retaining wall structures associated with Park roadways - including structure's retaining cuts and fills, as well as qualifying headwalls at culverts. For the purposes of the assessment, walls must be a minimum of 4 feet in maximum height of retained earth and greater than 6 feet in maximum height for culvert headwalls. This does not include the height of parapet or guardwall above a retaining wall. In general, guardwall or parapets are not included in this assessment, but were inspected for Kings Canyon National Park in 2009 under a separate effort as part of the Guardwall/Rail Inventory Program (GIP). A report for GIP is available under separate cover.

All paved roadways and parking areas listed in the RIP Route Identification Report were inspected for walls. Occasionally, unpaved routes not in RIP were inventoried due to their future programmatic addition at the park, which was a decision made on site specific to each park.

The following tables provide an overview of the findings of this inspection and assessment effort. In all, 2 walls were inventoried on the routes listed below.

Table 1: Number of Walls by Route

Route Number	Route Name	No. of Walls
0015	GRANT GROVE ROAD	2

The following table shows the number of walls broken out by seven possible categories of basic wall function.

Table 2: Number of Walls by Wall Function

Wall Function	No. of Walls
FW - Fill Wall	1
HW - Head Wall	1

The following table shows the primary wall types that were inventoried and assessed. There are 24 possible primary wall types, which are summarized in Appendix A.

Table 3: Number of Walls by Primary Wall Type

Primary Wall Type	No. of Walls
CL, Cantilever - Concrete	1
GM, Gravity - Mortared Stone	1

The following table shows the number of walls by one of six categories of recommended action along with associated 2007 costs and the number of walls that are in each recommended action category. The majority of walls have a recommendation of *No Action* or *Monitor*; work orders were created for all other recommended actions.

Table 4: Number of Walls by Recommended Action and Associated 2007 Cost

Recommended Action	2007 Repair Costs*	No. of Walls
No Action	\$0	2
Monitor	\$0	0
Maintenance	\$0	0
Repair Elements	\$0	0
Replace Elements	\$0	0
Replace Wall	\$0	0
Totals	\$0	2

*2007 cost estimate (ASTM Class D), preliminary for comparison to other repair costs only.

The following table categorizes the number of walls that fall into one of ten cost ranges, based on the prepared work orders. The locations, work descriptions, and cost of the recommended repairs for these walls are listed by individual wall in Tier 3 of this report.

Table 5: Number of Walls Grouped by Associated 2007 Cost

Cost Range*	No. of Walls
\$0	2
\$1 - \$25,000	0
\$25,001 - \$50,000	0
\$50,001 - \$100,000	0
\$100,001 - \$250,000	0
\$250,001 - \$500,000	0
\$500,001 - \$1,000,000	0
\$1,000,001 - \$2,000,000	0
\$2,000,001 - \$3,000,000	0
\$3,000,001 - \$4,000,000	0
Total Number of Walls	2

*2007 cost estimate (ASTM Class D), preliminary for comparison to other repair costs only.

Routine inspection and performing the noted maintenance will greatly aid in the continued performance of all walls at Kings Canyon National Park. Work orders for walls needing maintenance generally included items such as replacing missing stones, replacing mortar, filling voids at the top or bottom of fill walls, and clearing vegetation.

Work orders for walls needing localized element repairs generally included items such as adding riprap protection to the wall foundation, replacing missing sections of dry stone walls, replacing culverts, grouting voids in walls, and patching/restoring roadway pavement. While decaying mortar generally does not threaten wall stability in the near term, grout repair will extend the life of these walls.

Work orders for walls needing major repairs (replace elements or replace wall) generally include items such as foundation repair or replacement, fill voids, repair roadway shoulder, replace or extend retaining wall in either height or length, rebuild failed segments of walls, repair elements across 50% or more of the wall, remove and recompact backfill material, add scour protection (typically with riprap, concrete, or rock fill), and remove/reset culvert headwalls. Due to the large unit items associated with major repairs, recommendations vary by specific wall and are presented in Tier 3 of this report.

WIP identified 55 critically deficient walls nationally based on wall ratings less than 49 (poor/critical overall condition). The following table presents the walls in Kings Canyon National Park that are on this list and have been elevated to the Park Regional Coordinators in a Regional Park Summary Memorandum. Generally, these are walls with major repair element recommendations that may be a priority for repair work in your park.

Table 6: Number of Walls by Route

Wall Identification	Failure Consequence⁽¹⁾	Wall Rating⁽²⁾	Recommended Action⁽³⁾	2007 Repair Costs⁽⁴⁾
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No critically deficient walls

Notes: 1) Low consequence of failure and/or no recommended action may indicate repairs are not needed.

2) Wall ratings listed range from 0-49 (Poor/Critical).

3) Information was prepared for project planning purposes only. Actual repair work order scopes and actual costs will need to be evaluated based on current pay item unit prices for specific locations.

4) 2007 cost estimate (ASTM Class D), preliminary for comparison to other repair costs only.

Tier 2 Route Retaining Wall Overview



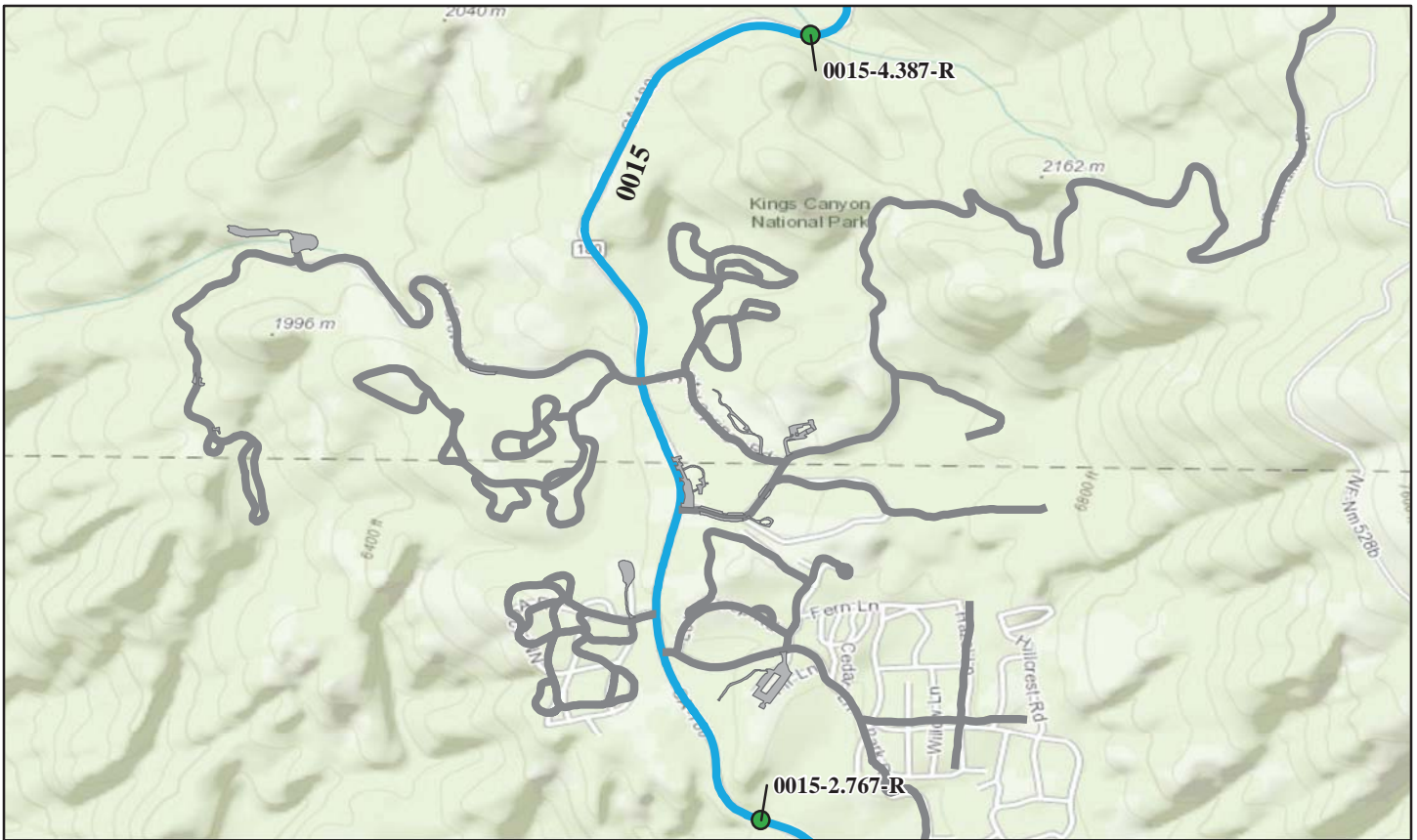
Kings Canyon National Park



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ROUTE 0015: GRANT GROVE ROAD



Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Retaining Wall Condition Legend – Wall Condition Rating

Critical / Poor (0 - 49)

Fair (50 - 69)

Good to Excellent (70 - 100)

No Data

Wall ID Inspection Date:	Wall Area (Sq. Ft.)	Wall Length (Ft.)	Wall Type	Wall Function	Overall Rating	Repair Cost
KICA-0015-2.767-R 8/14/2007	160	25	Gravity - Mortared Stone	Head Wall	88	\$0.00
KICA-0015-4.387-R 8/22/2007	550	186	Cantilever - Concrete	Fill Wall	86	\$0.00

*2007 cost estimate (ASTM Class D), preliminary for comparison to other repair costs only.

Tier 3 Retaining Wall Details



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Wall ID:	KICA-0015-2.767-R		
Route Name:	GRANT GROVE ROAD		
Inspection Date:	August 14, 2007	Approximate Year Built:	Unknown
*Wall Rating:	88	Maintenance Action:	No Action

Wall Description

Wall Function:	Head Wall	Primary Wall Type:	Gravity - Mortared Stone
Surface Treatment:		Secondary Wall Type:	
Secondary Surface Treatment:		Architectural Facing:	
General Description:	Mortared stone masonry headwall with 72 in CMP		

Wall Measurements

Wall Length (ft.):	25	Face Area (sq.):	160
Average Wall Height (ft.):	(1)	Face Angle (deg.):	90
Maximum Wall Height (ft.):	8	Vertical Offset (ft.):	-7

Assessed Elements

Element (Weighting Factor)	Narrative	Condition Rating (0 - 10)
PERFORMANCE 8.00	No significant wall distress - performing like new.	10
WALL FOUNDATION MATERIAL 8.00	Minor seepage evident along one side of wall, though no signs of settlement, wall staining, or eroded foundation materials.	7
MORTAR 8.00	Sound, durable, intact with no signs of cracking or significant weathering.	9
STONE MASONRY 8.00	Hard, fresh, durable, unweathered granite with no missing or cracked blocks.	10
DOWNSLOPE 0.50	Bottom of drainage. Shows no signs of instability or erosion.	8
LATERAL SLOPE 0.50	Very stable lateral slopes with no signs of settlement, slumping, or erosion.	8
UPSLOPE 0.50	Stable roadway fill with minor vegetation.	8
CULVERT 0.50	Nearly new culvert with no signs of significant corrosion or settlement-related deformation.	9
CURB/BERM/DITCH 0.50	No wall-related distress to concrete curb.	9

Repair Recommendations

Failure Consequence:	MODERATE
Recommendation Narrative:	None
Repair Cost:	\$0

2007 cost estimate (ASTM Class D), preliminary for comparison to other repair costs only.

Kings Canyon National Park

ROUTE 0015: GRANT GROVE ROAD

Retaining Wall Condition Photos



KICA_0015_2.767_R_1.jpg

Wall ID:	KICA-0015-4.387-R		
Route Name:	GRANT GROVE ROAD		
Inspection Date:	August 22, 2007	Approximate Year Built:	2002
*Wall Rating:	86	Maintenance Action:	No Action

Wall Description

Wall Function:	Fill Wall	Primary Wall Type:	Cantilever - Concrete
Surface Treatment:		Secondary Wall Type:	
Secondary Surface Treatment:		Architectural Facing:	Stone Veneer
General Description:	Cast in place concrete wall with a schist parapet (stone veneer on all faces).		

Wall Measurements

Wall Length (ft.):	186	Face Area (sq.):	550
Average Wall Height (ft.):	2	Face Angle (deg.):	90
Maximum Wall Height (ft.):	5	Vertical Offset (ft.):	0

Assessed Elements

Element (Weighting Factor)	Narrative	Condition Rating (0 - 10)
PERFORMANCE 8.00	Excellent performance. No overturning, settlement, or global instability.	9
WALL FOUNDATION MATERIAL 8.00	Compacted fill (decomposed granite) with 5 ft bench and no signs of erosion. Sufficient to support wall. Toe of wall is exposed near wall begin and near a weep hole at mid point.	8
CONCRETE 8.00	Concrete is faced with schist veneer. No visible and no signs of severe cracking.	9
VEGETATION 0.50	No vegetation on wall face.	8
ARCHITECTURAL FACING 0.50	Schist stone veneer are slight weathering and no cracks or shrinkage in mortar.	9
DOWNSLOPE 0.50	Compacted fill with ferns and trees. 2H:1V slopes. No signs of erosion are observed.	9
ROAD/SIDEWALK/SHOULDER 0.50	No cracks or distress are observed.	9
TRAFFIC BARRIER/FENCE 0.50	Parapet with schist veneer all sides. Parapet slightly weathered. Excellent condition.	9
WALL DRAINS 0.50	Weep holes are clean and functioning.	9

Repair Recommendations

Failure Consequence:	MODERATE
Recommendation Narrative:	None
Repair Cost:	\$0

2007 cost estimate (ASTM Class D), preliminary for comparison to other repair costs only.

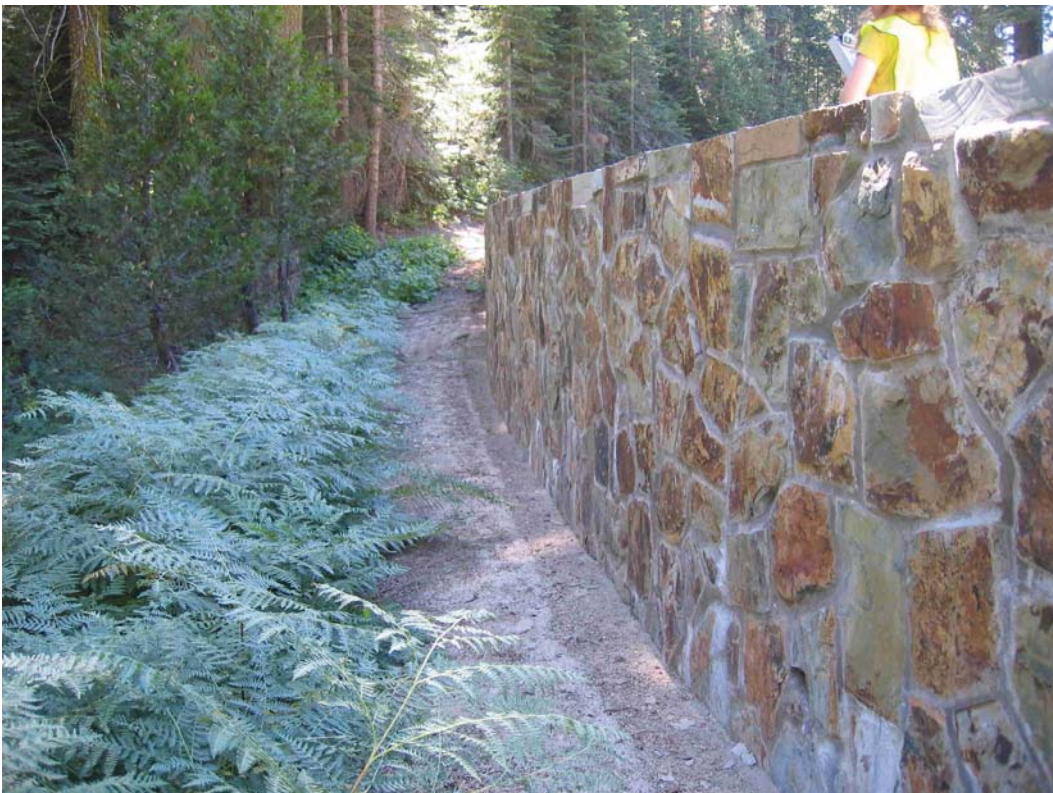
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ROUTE 0015: GRANT GROVE ROAD

Retaining Wall Condition Photos



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KICA_0015_4.387_R_2.jpg

Appendix A

Summary of WIP Definitions



Kings Canyon National Park



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Appendix A

Summary of WIP Definitions and Assessment Categories

Wall Naming Convention

Unique “Wall Identification” names were assigned to the retaining walls that were inventoried. The Wall Identification includes the Park Name, the RIP Route Number (e.g., **0013**), the beginning milepoint of a wall (e.g., **0.622**) and the side of the road the wall is located on (e.g., **L.**) relative to the primary direction of travel (direction of increasing mileposts). Thus, a typical wall identified would have the following format: **YOSE-0013-0.622-L.**

For roadways not in RIP, park-supplied route numbers were used or the convention RRR#. Similarly, for parking areas not in RIP, the park-supplied parking area number or the convention PPP# was used. Also for parking areas, walls are numbered in ascending order as they are encountered when traveling counterclockwise around the parking area (most common direction of traffic flow). Parking area walls are designated P1, P2, P3, etc. as new walls are encountered.

- NPS Retaining Wall Inventory Program Field Guide (WIFG)-

Retaining Wall Acceptance Criteria

- *All classes of paved roadways and parking areas included in the RIP Route Investigation Report and/or identified by park staff.
- *Walls must reside within the constructed roadway/parking area prism.
- *Maximum wall height, including only that portion actively retaining soil and/or rock, must be ≥ 4 ft. (>6ft for culvert headwalls).
- *Consider known/verifiable wall embedment in determining maximum retaining wall height. Include fully buried retaining structures.
- *Walls have an internal wall face angle $\geq 45^\circ$ ($\geq 1H:1V$ face slope ratio).
- *Include all walls where the intent is to support/protect the travelway, and where failure would require replacement with a retaining wall.

Definitions

Design Criteria	Measure of how well current design criteria are satisfied: None - Does not meet any known standards. Non-AASHTO - Does not meet AASHTO, but is consistent with other structures of its type/period with good performance. AASHTO - Apparently meets current AASHTO Geometric, Design, Materials, and Construction Standards.
Consequence of Failure	Low - No loss of roadway, no to low public risk, no impact to traffic during wall repair/replacement Moderate - Hourly to short-term closure of roadway, low-to-moderate public risk, multiple alternate routes available High - Seasonal to long-term loss of roadway, substantial loss-of-life risk, no alternate routes available
Action	Select from: No Action, Monitor, Maintenance, Repair Elements, Replace Elements, and Replace Wall
Weighting Factor	Weighting Factor to be applied to the Condition Rating (CR). When indicated on the Condition Assessment Input Form: WF=0.5 for CR=8-10; WF=1.0 for CR=4-7; and WF=5 for CR=1-3.
Data Reliability	Estimate of how well observed conditions represent wall performance, and if additional investigations may be warranted. 1-Poor Conditions cannot be sufficiently observed to rate element(s), warranting additional investigations to better define element performance and/or to determine the cause(s) or poor performance. 2-Good Observed conditions are sufficient to rate the conditions of wall element(s); however, additional investigations would be useful to better understand element performance. 3-Very Good Observed conditions clearly describe wall performance. Additional investigations are not needed.

Wall Function Codes

[FW] Fill Wall	[BW] Bridge Wall	[SW] Switchback Wall
[CW] Cut Wall	[HW] Head Wall	[SP] Slope Protection [FL] Flood Wall

Wall Type Codes

[AH] Anchor, Tieback H-Pile	[CC] Crib, Concrete	[MG] MSE, Geosynthetic Wrapped Face
[AM] Anchor, Micropile	[CM] Crib, Metal	[MP] MSE, Precast Panel
[AS] Anchor, Tieback Sheet Pile	[CT] Crib, Timber	[MS] MSE, Segmental Block
[BC] Bin, Concrete	[GB] Gravity, Concrete Block/ Brick	[MW] MSE, Welded Wire Face
[BM] Bin, Metal	[GC] Gravity, Mass Concrete	[SN] Soil Nail
[CL] Cantilever, Concrete	[GD] Gravity, Dry Stone	[TP] Tangent/ Secant Pile
[CP] Cantilever, Soldier Pile	[GG] Gravity, Gabion	[OT] Other, User Defined
[CS] Cantilever, Sheet Pile	[GM] Gravity, Mortared Stone	[NO] None

Architectural Facing Type Codes

[BV] Brick Veneer	[PF] Planted Face	[SS] Simulated Stone
[CO] Cementitious Overlay	[SC] Sculpted Shotcrete	[SV] Stone Veneer
[FF] Fractured Fin Concrete	[SH] Shotcrete (nozzle finish)	[TI] Timber
[FL] Formlined Concrete	[SM] Steel/Metal	[OT] Other, User Defined
[PC] Plain Concrete (float finish or light texture)	[SO] Stone	[NO] None

Surface Treatment Codes

[BG] Bush Gun (tool-textured concrete)	[PS] Preservative	[WS] Weathering Steel
[CA] Color Additive	[SE] Silane Sealer	[OT] Other, User Defined
[GL] Galvanized	[ST] Stain	[NO] None
[PA] Painted	[TR] Tar Coated	

Condition Ratings

Condition Ratings apply to all Primary and Secondary Wall Elements, and are intended to assist in consistently defining element **severity**, **extent**, and **repair/replace urgency** of wall element distresses.

9-10 (Excellent)	-Any defects are minor and are within normal range for <i>newly constructed or fabricated</i> elements. -Defects may include those typically caused from fabrication or construction.
7-8 (Good)	-Low-to-moderate extent of low severity distress. -Distress present does not significantly compromise the element function, nor is there significantly severe distress to major structural components of an element.
5-6 (Fair)	-High extent of low severity distress and/or low-to-medium extent of medium to high severity distress. -Distress present does not compromise element function, but lack of treatment may lead to impaired function/elevated risk of element failure in the near term.
3-4 (Poor)	-Medium-to-high extent of medium-to-high severity distress. -Distress present threatens element function, and strength is obviously compromised and/or structural analysis is warranted. -The element condition does not pose an immediate threat to wall stability and road closure is not necessary.
1-2 (Critical)	-Medium-to-high extent of high severity distress. -Element is no longer serving intended function. Element performance threatening overall stability of the wall at the time of inspection.

Wall Performance Condition Ratings

Performance	Evaluation of overall wall performance as indicated by observations not necessarily captured by observed distresses for specific elements, including global wall distresses (rotation, settlement, translation, displacement, etc.) and/or evidence of prior repairs that may further indicate component problems.	<p>Good to Excellent - No observation of distresses not already captured by individual element condition assessment. No combination of element distresses indicating unseen problems or creating significant performance problems. No history of remediation or repair to wall or adjacent elements.</p> <p>Fair - Some observed global distress is not associated with specific elements. Some observation of element distress combinations that indicate wall component problems. Minor work on primary elements or major work on secondary elements has occurred improving overall wall function.</p> <p>Poor to Critical - Global wall rotation, settlement, and/or overturning is readily apparent. Combined element distresses clearly indicate serious stability problems with components or global wall stability. Major repairs have occurred to wall structural elements, though functionality has not improved significantly.</p>
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