LAX MASTER PLAN

MITIGATION MONITORING AND REPORTING PROGRAM (MMRP)

2016 ANNUAL PROGRESS REPORT

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Los Angeles World Airports

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Prepared by

Los Angeles World Airports

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Acknowledgements

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Disclaimer: LAWA obtained data from a variety of sources to generate this report. The reporting team did not have access to each individual primary document and thus was not able to verify all data sets fully against the source documents. Due to these limitations, it is possible that certain numbers may not be accurate.

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Appendices:

A. LAX Master Plan MMRP as adopted December 2004
Reference LAWA Website
http://www.lawa.org/ourLAX/AnnualReports.aspx?id=8067 for a copy of the document

B. MMRP (BWP, WAMA, and MSC-specific measures)
Reference LAWA Website for a copy of these documents:
BWP MMRP dated September 2009
http://www.lawa.org/ourLAX/Pastprojects.aspx?id=10040
WAMA MMRP dated February 2014
http://www.lawa.org/uploadedFiles/OurLAX/pdf/WAMA/EDR%20Attachment%203%20-%20MMRP.pdf
MSC MMRP dated June 2014
http://www.lawa.org/MSCNorth/projectdocuments.aspx

C. LAX El Segundo Blue Butterfly 2016 Flight Season Monitoring Report dated January 29, 2017

1.0 Introduction/Background

On December 7, 2004, the Los Angeles City Council certified the LAX Master Plan Final Environmental Impact Report (FEIR) and related entitlements for the future development of LAX, and adopted the LAX Master Plan Mitigation Monitoring and Reporting Program (MMRP).

Pursuant to Section 15097 of the California State CEQA Guidelines, the lead agency, Los Angeles World Airports (LAWA), is responsible for reporting, monitoring, and ensuring implementation of all applicable mitigation measures in accordance with the adopted MMRP. This document is the eleventh annual progress report for the LAX Master Plan MMRP. This report provides a status update on applicable mitigation activities, policies, and programs that have been and are being implemented by LAWA to ensure compliance with mitigation measures identified in the LAX Master Plan FEIR.

The MMRP (reference ***Appendix A***) documents all mitigation measures set forth in the LAX Master Plan FEIR as well as mitigation measures required in conjunction with environmental (i.e., CEQA) review of individual projects proposed under the Master Plan.

The Los Angeles City Council approved the South Airfield Improvement Project (SAIP) and certified its FEIR on January 11, 2006, the Crossfield Taxiway Project (CFTP) and its FEIR on February 9, 2009, the Bradley West Project (BWP) and its FEIR on October 14, 2009, the West Aircraft Maintenance Area (WAMA) project and its FEIR on April 1, 2014, and the Midfield Satellite Concourse project and its FEIR on July 21, 2014. The Board of Airport Commissioners and the Los Angeles City Council adopted MMRPs for the SAIP, CFTP, BWP, WAMA, and MSC to mitigate or avoid potentially significant effects on the environment during construction of these projects. As a result, current project-specific mitigation measures are included in this report for the BWP, WAMA project, and the MSC project. LAWA previously completed the mitigations for the SAIP and CFTP.

The primary purpose of this report is to document and report on the status of the current and recently completed mitigation measures set forth in the LAX Master Plan MMRP. This report covers the period January 1, 2016 through December 31, 2016.

2.0 Noise

2.0.A N-1 Maintenance of Applicable Elements of Existing Aircraft Noise Abatement Program (ANAP)

The LAX Master Plan MMRP states:

*"**Maintenance of Applicable Elements of Existing Aircraft Noise Abatement Program**. All components of the current airport noise abatement program that pertain to aircraft noise will be maintained."*

The existing Aircraft Noise Abatement Program (ANAP) at LAX currently is maintained by LAWA's Noise Management Section (NMS). The existing ANAP at LAX sets forth LAWA's noise abatement procedures for aircraft traffic, flight, and runway use. All aircraft operations at LAX must comply with FAA regulations and procedures for noise abatement and noise emission standards and with all rules, policies, procedures, resolutions, and ordinances established by the State of California, City of Los Angeles, LAWA, and LAWA's Board of Airport Commissioners relative to noise abatement. LAWA's NMS will continue to maintain the ANAP throughout implementation of the LAX Master Plan projects. Actions indicating compliance include submission of the Quarterly Report per the 2011 Noise Variance (Variance), currently in effect, to the County of Los Angeles. Included in each quarterly report is a short summary of actions indicating compliance with each condition of the variance, including "continue, in full force and effect, the implementation and enforcement of the…. noise abatement policies to the extent of its authority."

Status → Existing Policy:
LAWA complied with this commitment in 2016 by maintaining the existing Aircraft Noise Abatement Program (ANAP) at LAX, as well as submitting the summary report with each Quarterly Report to the County of Los Angeles, per the Variance requirement.

2.0.B MM-N-4 Update the Aircraft Noise Abatement Program Elements as applicable to adapt to the future Airfield configuration

The LAX Master Plan MMRP states:

*"**Update the Aircraft Noise Abatement Program Elements as applicable to adapt to the future Airfield configuration.** When existing runways are relocated or reconstructed as part of the Master Plan, the aircraft noise abatement actions associated with those runways shall be modified and re-established as appropriate to assure continuation of the intent of the existing program."*

Status → No action required at this time:
No existing runways were relocated or reconstructed as part of the Master Plan, therefore no changes to the ANAP were required by this mitigation measure during the 2016 reporting period.

2.0.C MM-N-5 Conduct Part 161 Study to Make Over-Ocean Procedures Mandatory

The LAX Master Plan MMRP states:

*"**Conduct Part 161 Study to Make Over-Ocean Procedures Mandatory.** A 14 CFR Part 161 Study shall be initiated to seek federal approval of a locally-imposed Noise and Access Restriction on departures to the east during Over-Ocean Operations, or when Westerly Operations remain in effect during the Over-Ocean Operations time period."*

The Part 161 Study is a technical and legal study regarding implementation of a Noise and Access Restriction. The proposed restriction included departures between the hours of midnight and 6:30 a.m. over the communities to the east of LAX, when LAX is operating in either over-ocean operations or remains in westerly operations, and excluding times when LAX operates in easterly operations (49 U.S.C. Section 47521 et seq.). The Part 161 Study must meet the relevant requirements of the Airport Noise and Capacity Act of 1990 (ANCA) and the Part 161 regulations (14 C.F.R. Part 161).

Status → Completed:
The Part 161 Study Process was completed in 2014 when FAA issued a formal rejection of the application. All materials related to this application and study, and all formal communications with LAWA and FAA may be found at *http://www.lawa.org/LAXPart161.aspx?id=7203*

2.0.D. MM-N-7 Construction Noise Control Plan

The LAX Master Plan MMRP states:

*"**Construction Noise Control Plan.** A Construction Noise Control Plan will be prepared to provide feasible measures to reduce significant noise impacts throughout the construction period for all projects near noise sensitive uses. For example, noise control devices shall be used and maintained, such as equipment mufflers, enclosures, and barriers. Natural and artificial barriers such as ground elevation changes and existing buildings may be used to shield construction noise."*

BWP Status → Completed

WAMA Status → Ongoing:
No construction occurred within 600 feet of any noise-sensitive uses during the 2016 reporting period. Therefore, a construction noise control plan was not required in the 2016 reporting period.

MSC Status → Ongoing:
Construction activities in 2016 included work on "Enabling Projects" such as demolition of the former Qantas aircraft hangar on the project site, demolition of the U.S. Coast Guard aircraft hangar, and other such work, as well as start of site preparation for the MSC North Concourse. All of these activities are near the middle of the airport, well removed from any noise-sensitive uses. As such, a construction noise control plan was not required in the 2016 reporting period.

2.0.E. MM-N-8 Construction Staging

The LAX Master Plan MMRP states:

*"**Construction Staging.** Construction operations shall be staged as far from noise-sensitive uses as feasible."*

BWP Status → Completed

WAMA Status → Ongoing:
Staging for the WAMA project (including both the WAMA and Qantas hangar components) is located in an existing LAX construction-staging area near the southwest corner of the airport, south of World Way West and east of Pershing Drive. This area is located away from noise-sensitive uses and has been used for construction staging for many years.

MSC Status → Ongoing:
Staging for the MSC Enabling Project and the North Concourse occured on-site, which is near the middle of the airport, well-away from any noise-sensitive uses.

2.0.F. MM-N-9 Equipment Replacement

The LAX Master Plan MMRP states:

*"**Equipment Replacement.** Noisy equipment shall be replaced with quieter equipment (for example, rubber tired equipment rather than track equipment) when technically and economically feasible."*

BWP Status → Completed

WAMA Status → Ongoing:
Noisy equipment has been replaced with quieter equipment (for example, rubber tired equipment rather than track equipment) when technically and economically feasible. Some construction equipment, such as dump trucks and front loaders, is rubber-tired. Other equipment, such as dozers and excavators, is required to be tracked equipment due to site requirements and to ensure safety. Construction equipment is well-maintained, which reduces noise.

MSC Status → Ongoing:
The vast majority of equipment used for the MSC Project in 2016 was rubber-tired. The most notable exception was the use of large long/high-reach excavators required for the demolition of the former Qantas hangar and the USCG hangar. That particular type of large equipment is only available as tracked units because a large/long equipment base is required for stability and must also be able to quickly move and turn the equipment during demolition. The subject equipment was/is well-maintained, which reduced potential noise levels during operation.

2.0.G. MM-N-10 Construction Scheduling

The LAX Master Plan MMRP states:

*"**Construction Scheduling.** The timing and/or sequence of the noisiest on-site construction activities shall avoid sensitive times of the day, as feasible (9 p.m. to 7 a.m. Monday-Friday; 8 p.m. to 6 a.m. Saturday; anytime on Sunday or Holidays)."*

BWP Status → Completed

WAMA Status → Ongoing:
The timing and/or sequence of the noisiest on-site construction activities avoided sensitive times of the day when feasible. Most construction activities occurred outside of sensitive times of day. Construction activity related to the final stages of the taxiway improvements was conducted at night to minimize disruption to aircraft activity. The construction occurred far from residents and was not disruptive to communities. No noise complaints were received. There were no noisy activities, such as pile driving or jack hammering, during weekend or nighttime hours.

MSC Status → Ongoing:
The timing and/or sequence of the noisiest on-site construction activities in 2016, which primarily involved building/structure demolition, avoided sensitive times of the day when feasible. The most notable exception was the planned collapsing of the superstructure frame of the former Qantas Hangar, which occurred around 5:00 AM before the start of aircraft activity in the nearby area. (The purpose of avoiding aircraft activity was to ensure that aircraft would not be exposed to dust generated by the collapse, notwithstanding that the site and building were heavily watered to reduce dust during demolition.) The construction occurred far from residents and was not disruptive to communities. No noise complaints were received. There were no noisy activities, such as pile driving or jack hammering, during weekend or nighttime hours.

2.0.H. MM-N-11 Automated People Mover (APM) Noise Assessment and Control

The LAX Master Plan MMRP states in part:

*"**Automated People Mover (APM) Noise Assessment and Control Plan.** In conjunction with detailed design and engineering of the proposed APM systems, a noise control plan shall be prepared specifying noise attenuation measures to reduce APM noise levels at the two significantly impacted hotels to acceptable level (i.e. less than 67 dBA [A-weighted decibels] Community Noise Equivalency Level [CNEL] for the Courtyard by Marriott and the Four Points Sheraton)."*

Status → No longer applicable:
Subsequent to the adoption of the LAX Master Plan MMRP, LAWA refined the alignment of the Automated People Mover (APM). Noise impacts associated with the refined alignment were evaluated in the LAX Landside Access Modernization Program EIR. As stated in that EIR, with implementation of the proposed APM, transit noise impacts would be less than significant at all locations, including at the Courtyard by Marriott and the Four Points Sheraton hotels. Therefore, this mitigation measure no longer applies.

3.0 Land Use

3.0.A LU-1 Incorporation of City of Los Angeles Ordinance No. 159,526 (Q) Zoning Conditions for LAX Northside into the LAX Northside/Westchester Southside Project

The LAX Master Plan MMRP states in part:

*"**Incorporation of City of Los Angeles Ordinance No. 159,526 (Q) Zoning Conditions for LAX Northside into the LAX Northside/Westchester Southside Project.** To the maximum extent feasible, all [Q] Conditions (Qualifications of Approval) from City of Los Angeles Ordinance No. 159,526 that address the Northside project area will be incorporated by LAWA into a new LAX Zone/LAX Specific Plan for the LAX Northside/Westchester Southside project."*

Status → In Progress:
The LAX Plan establishes a land use policy framework, the LAX Specific Plan establishes zoning and development regulations and standards consistent with the LAX Plan areas. The LAX Specific Plan established the LAX Northside as a district land use designation. The (Q) Zoning Conditions have been incorporated into the updated LAX Specific Plan that was adopted in 2016. The 2016 LAX Specific Plan update for the Northside includes development standards and design guidelines to capture the (Q) Zoning Conditions. No projects were constructed in the Northside in 2016.

3.0.B LU-2 Establishment of a Landscape Maintenance Program for Parcels Acquired Due to Airport Expansion

The LAX Master Plan MMRP states:

*"**Establishment of a Landscape Maintenance Program for Parcels Acquired due to Airport Expansion.** Land acquired and cleared for airport development will be fenced, landscaped, and maintained regularly until the properties are actually developed for airport purposes."*

Status → Plan Established, Implementation Ongoing:
LAWA completed the LAX Street Frontage and Landscape Development Plan (LDP) was completed in March 2005. It addresses landscaping requirements for parcels acquired under the LAX Master Plan. This measure was not applicable during the 2016 reporting period as LAWA did not acquire any Alternative D parcels in 2016.

3.0.C LU-4 Neighborhood Compatibility Program

The LAX Master Plan MMRP states in part:

*"**Neighborhood Compatibility Program.** Ongoing coordination and planning will be undertaken by LAWA to ensure that the airport is as compatible as possible with surrounding properties and neighborhoods."*

Status → Ongoing:
LAWA continues to consult with neighboring communities on all projects (including LAX Master Plan projects) subject to the LAX Plan Compliance Review (LAX Specific Plan Section 7). The LAX Plan Compliance Review process includes community input before approval. Conditions of development along the northern and southern boundaries of the airport property include, but are not limited to, setbacks, buffer zones and landscaping.

3.0.D LU-5 Comply with City of Los Angeles Transportation Element Bicycle Plan

The LAX Master Plan MMRP states in part:

*"**Comply with City of Los Angeles Transportation Element Bicycle Plan.** LAWA will comply with bicycle policies and plans in the vicinity of LAX, most notably those outlined in the City of Los Angeles Transportation Element Bicycle Plan and the General Plan Framework, including Pershing Drive, Sepulveda Boulevard, and Aviation Boulevard."*

Status → Ongoing:
The City of Los Angeles approved the 2010 Bicycle Master Plan (independent of LAWA) in March 2011. The Plan includes streets that are expected to have bike routes and bike lanes in the future. LAWA used the information in the Los Angeles Bicycle Master Plan when considering off-airport mitigations for the Specific Plan Amendment Study. LAWA is in compliance with the Plan. The Bicycle Plan was incorporated into the Mobility Plan 2035 and is no longer a stand-alone plan.

3.0.E MM-LU-1 Implement Revised Aircraft Noise Mitigation Program

The LAX Master Plan MMRP states:

*"**Implement Revised Aircraft Noise Mitigation Program.** LAWA shall expand and revise the existing Aircraft Noise Mitigation Program (ANMP) in coordination with affected neighboring jurisdictions, the State, and the FAA. The expanded Program shall mitigate land uses that would be rendered incompatible by noise impacts associated with implementation of the LAX Master Plan, unless such uses are subject to an existing avigation easement and have been provided with noise mitigation funds. LAWA shall accelerate the ANMP's timetable for achieving full compatibility of all land uses within the existing noise impact area pursuant to the requirements of the California Airport Noise Standards (California Code of Regulations, Title 21, Subchapter 6) and current Noise Variance. With the exception of a possible new interior noise level standard for schools to be established through the study required by Mitigation Measure MM-LU-3, Conduct Study of the Relationship Between Aircraft Noise Levels and the Ability of Children to Learn, the relevant performance standard to achieve compatibility for land uses that are incompatible due to aircraft noise (i.e., residences, schools, hospitals and churches) is adequate acoustic performance (sound insulation) to ensure an interior noise level of 45 CNEL or less. As an alternative to sound insulation, incompatible property may also achieve compatibility if the incompatible use is converted to a noise-compatible use.*

LAWA shall revise the ANMP to incorporate new, or expand existing measures, including, but not necessarily limited to, the following:

- *Continued implementation of successful programs to convert existing incompatible land uses to compatible land uses through sound insulation of structures and the acquisition and conversion of incompatible land use to compatible land use.*

- *Ongoing monitoring and provision of annual updates in support of the requirements of the current Variance pursuant to the California Airport Noise Standards, with the updates made available (upon request) to affected local jurisdictions, the Airport Land Use Commission of Los Angeles County, and other interested parties.*

- *Continue the current pre- and post-insulation noise monitoring to ensure achievement of interior noise levels at or below 45 CNEL.*

- *Accelerated rate of land use mitigation to eliminate noise impact areas in the most timely and efficient manner possible through:*

  - *Increased annual funding by LAWA for land use mitigation;*

  - *Reevaluating avigation easements requirements with sound insulation mitigation;*
  - *Provision by LAWA of additional technical assistance, where needed, to local jurisdictions to support more rapid and efficient implementation of their land use mitigation programs;*

  - *Reduction or elimination, to the extent feasible, of structural and building code compliance constraints to mitigation of sub-standard housing.*

- *Revised criteria and procedures for selection and prioritization of properties to be sound insulated or acquired in consideration of the following:*

  - *Insulation or acquisition of properties within the highest CNEL measurement zone;*
  - *Acceleration of the fulfillment of existing commitments to owners wishing to participate within the current ANMP boundaries prior to proceeding with newly eligible properties;*
  - *Insulation or acquisition of incompatible properties with high concentrations of residents or other noise-sensitive occupants such as those housed in schools or hospitals.*

- *Amend the ANMP to include libraries as noise-sensitive uses eligible for aircraft noise mitigation.*

- *Upon completion of the acquisition and/or soundproofing commitment under the current Program, expand the boundaries of the ANMP as necessary over time. LAWA will continue preparing quarterly reports that monitor any expansion of the 65 CNEL noise contours beyond the current ANMP boundaries. Based upon these quarterly reports, LAWA will evaluate and adjust the ANMP boundaries, periodically as appropriate, so that as the 65 CNEL noise contours expand, residential and noise sensitive uses newly impacted by 65 CNEL noise levels*

would be included within the Program."

The Aircraft Noise Mitigation Program (ANMP) describes the ongoing efforts by LAWA to convert existing incompatible land uses surrounding LAX to compatible land uses through the implementation of two noise mitigation strategies: (1) sound insulation of structures; and (2) acquisition of property followed by the conversion of its incompatible land use to compatible land use (land recycling).

LAWA implements the ANMP in an effort to reduce adverse impacts of airport noise and achieve airport standards as set forth in Chapter 6 of Title 21 of the California Code of Regulations. ANMP reports are also specifically required by the State of California as a formal condition of approval of the three-year variances granted by the State to LAWA airports that have not achieved land use compatibility. Based on current data and funding commitments, the ANMP documents the progress made toward achieving land use compatibility and projects the ultimate date when full compatibility will be reached.

Status → In Progress:
As described above, LAWA has an existing program in place with periodic updates to the State of California and the County of Los Angeles. In addition, specific updates are as follows:

- LAWA continues to implement two programs to convert existing incompatible land uses to compatible land uses through sound insulation of structures (LAWA's LAX Soundproofing program) and the acquisition and conversion of incompatible land use to compatible land use (LAWA's Residential Acquisition program). LAWA completed the final phase of the LAX Soundproofing program in 2014.

- Annual updates in support of the requirements of the current Variance pursuant to the California Airport Noise Standards are submitted with the Quarterly Report for the second quarter each year, with the updates provided to all affected jurisdictions, and made available upon request to other interested parties.

- Pre- and post-insulation noise monitoring audits are regularly conducted to ensure achievement of interior noise levels at or below 45 CNEL.

- Land use mitigation programs are being implemented as quickly as possible given that participation in the programs is voluntary.

- LAWA makes available land use mitigation funds as soon as the jurisdiction has met all program requirements and upon approval of the Board of Airport Commissioners (BOAC).

- Avigation easements are no longer required for sound insulation, except for limited circumstances. Avigation easements are still required for land acquisition using LAWA funds.

- Under very limited circumstances, as required by California Airport Noise Standards where acoustical treatments alone are insufficient to convert

residential land uses to compatible uses with airport operations, noise easements are required for residential sound insulation mitigation.

- Where needed, LAWA makes available the resources for timely technical assistance to local jurisdictions to support more rapid and efficient implementation of their land use mitigation programs.

- The following criteria are used to select and prioritize properties to be sound insulated or acquired:

    a. Insulation or acquisition of properties within the highest CNEL measurement zone.

    b. Acceleration of the fulfillment of existing commitments to owners wishing to participate within the current ANMP boundaries prior to proceeding with newly eligible properties.

3.0.F MM-LU-2 Incorporate Residential Dwelling Units Exposed to Single Event Awakenings Threshold into Aircraft Noise Mitigation Program

The LAX Master Plan MMRP states:

*"**Incorporate Residential Dwelling Units Exposed to Single Event Awakenings Threshold into Aircraft Noise Mitigation Program.** In addition to any restrictive measures that may be implemented resulting from completion of Mitigation Measure MM-N-5, Conduct Part 161 Study to Make Over-Ocean Departure Procedures Mandatory, the boundaries of the ANMP will be expanded to include residential uses newly exposed to single event exterior nighttime noise levels of 94 dBA SEL, based on the Master Plan alternative that is ultimately approved and periodic reevaluation and adjustments by LAWA. Uses that are newly exposed would be identified based on annual average conditions as derived from the most current monitored data."*

Status → In Progress:
In 2006, LAWA developed the methodology for producing single event noise contours, based on the N94 noise metric developed as part of the LAX Master Plan. Any newly impacted areas were prioritized in accordance with the existing ANMP priority requirements. By definition, these newly impacted areas would be outside of the 65 CNEL areas as defined by the ANMP, and were to be mitigated after any areas within the program boundary, which has not yet been completed.

For the build out year under the LAX Master Plan (2015), LAWA produced the 2015 N94 contour to identify any newly impacted incompatible residential properties to be included in the ANMP program. Within the 2015 N94 contour, there are no newly impacted areas within the Cities of Los Angeles or El Segundo, based on the current ANMP Program Boundary (2020 Noise Exposure Map 65 CNEL Contour). There are certain parcels within the County of Los Angeles that are within the N94 Contour, and outside of the current Program Boundary. However, these parcels have been included as part of the FAA-approved Block Rounding areas for the program. These parcels were also eligible under the prior program which recently ended in 2015, based on the prior Program Boundary (4Q92 65 CNEL Contour).

Within the City of Inglewood, there are several parcels located within the 2015 N94 contour that are outside of the current Program Boundary. All of these parcels are in close proximity to the 2020 NEM contour, but were not requested by the City to be included in the City of Inglewood's Block Rounding areas. These properties are part of an area of the City planned for Industrial or Commercial uses, and included in the City's Residential Acquisition Program. All of these parcels were eligible for mitigation under the prior program that ended in 2015, based on the prior program boundary (4Q92 65 CNEL Contour). The City's Residential Acquisition Program has been on hold for many years. If the City wishes to include residential properties in an acquisition program, eligibility for such a program will be evaluated at that time, based on current FAA-eligible areas at that time.

As part of the standard Variance requirements, annual ANMP progress reports and periodic ANMP report updates will continue to be submitted to the County of Los Angeles.

3.0.G MM-LU-3 Conduct Study of the Relationship Between Aircraft Noise Levels and the Ability of Children to Learn

The LAX Master Plan MMRP states:

*"**Conduct Study of the Relationship Between Aircraft Noise Levels and the Ability of Children to Learn.** Current studies of aircraft noise and the ability of children to learn have not resulted in the development of a statistically reliable predictive model of the relative effect of changes in aircraft noise levels on learning. Therefore a comprehensive study shall be initiated by LAWA to determine what, if any, measurable relationship may be present between learning and the disruptions caused by aircraft noise at various levels. An element of the evaluation shall be the setting of an acceptable replacement threshold of significance for classroom disruption by both specific and sustained aircraft noise events."*

Status → In Progress:
The Transportation Research Board's (TRB's) Airport Cooperative Research Program (ACRP) completed the study entitled "Evaluating the Impact of Aviation Noise on Learning." A panel created by the TRB, including one LAWA staff member, defined the scope and objectives of the study, selected the contractor to perform the work, evaluated the work, and reviewed and commented on the draft and final reports.

The objectives of the ACRP study were to determine when aircraft noise impacts student learning and what noise metric(s) best defines impact on learning. In 2010, ACRP hired a contractor to perform the study, which ACRP and TRB staff finalized. The study included a recommendation for follow-on research, including specific case studies.

ACRP funded a follow-on research project in the amount of $600,000, entitled Assessing Aircraft Noise Conditions Affecting Student Achievement – Case Studies (Case Studies research). The objectives of the Case Studies research are to (1) develop and implement a rigorous case study methodology to identify and measure those factors at the individual classroom, student, and teacher level that influence the impact of aircraft noise on student achievement, especially as it relates to reading comprehension; (2) identify appropriate metrics that define the level and characteristics of aircraft noise that

impact student achievement; and (3) develop practical guidance for use by decision makers on how to reduce the impact of aircraft noise on student achievement. Similar to the first study, the panel for the Case Studies research includes one LAWA staff member.

In 2014, the panel selected the contractor to perform the study, and the project commenced in May of 2014. The panel reviewed and approved the proposed research plan, including the selection of schools to be included in the research.

In 2016, the data collection, data analysis, and draft report were completed. The final report is now scheduled for completion in 2017.

Upon completion of these studies, LAWA will assess the conclusions of the studies against the goal of setting an acceptable replacement threshold of significance for classroom disruption by both specific and sustained aircraft noise events. If the goals are met, then further study will not be necessary. If the goals are not met, or only partially met, then LAWA will assess the need for additional study, as needed.

3.0.H MM-LU-4 Provide Additional Sound Insulation for Schools Shown by MM-LU-3 to be Significantly Impacted by Aircraft Noise

The LAX Master Plan MMRP states:

*"**Provide Additional Sound Insulation for Schools Shown by MM-LU-3 to be Significantly Impacted by Aircraft Noise.** Prior to completion of the study required by Mitigation Measure MM-LU-3, Conduct Study of the Relationship Between Aircraft Noise Levels and the Ability of Children to Learn, and within six months of the commissioning of any relocated runways associated with implementation of the LAX Master Plan, LAWA shall conduct interior noise measurements at schools that could be newly exposed to noise levels that exceed the interim LAX interior noise thresholds for classroom disruption of 55 dB Lmax, 65 dB Lmax, or 35 Leq(h), as presented in Section 4.1 Noise, of the Final EIS/EIR. All school classroom buildings (except those within schools subject to an avigation easement) that are found through the noise measurements to exceed the interim interior noise thresholds, as compared to the 1996 baseline conditions presented in the Final EIS/EIR, would become eligible for soundproofing under the ANMP.*

Upon completion of the study required by Mitigation Measure MM-LU-3 and acceptance of its results by peer review of industry experts, any schools found to exceed a newly established threshold of significance for classroom disruption based on comparison with 1996 baseline conditions due to implementation of the LAX Master Plan, shall be eligible for participation in the ANMP administered by LAWA, unless they are subject to an existing avigation easement. A determination of which schools become eligible will be made following application of the new threshold based on measured data."

Status → No action required at this time:
LAWA will implement this measure's requirements contingent on the results from the study required by MM-LU-3. There is ongoing work related to settlement agreements between LAWA and both the Inglewood Unified and Lennox School Districts. LAWA actively assists each school district in its efforts to mitigate the impacts to schools, per those agreements.

On October 2, 2008, Congress amended Section 40117(b) of Title 49 of the United States Code, which allowed eligibility for Passenger Facility Charge (PFC) funding for noise mitigation of certain schools located within the LAX noise impact area in both the Lennox School District (LSD) and the Inglewood Unified School District (IUSD), notwithstanding the grant of an easement to LAWA.

On July 9, 2009, LAWA submitted a letter to the FAA asking that a determination be made related to which schools are impacted. On August 24, 2009 the FAA responded to LAWA by letter with information that this determination will be made as part of the PFC application process. LAWA proceeded with the PFC application with information from each respective school district sufficient for the FAA to make such a determination.

Lennox School District

In January and February 2011, the BOAC authorized and LAWA submitted a PFC application to the FAA for authorization to collect and use PFC funds to sound insulate impacted schools in the Lennox School District (the District).

On May 2, 2011 the FAA issued the Final Agency Decision finding the schools in LSD to be "significantly impacted and adversely affected by aircraft noise," and authorized the expenditure of up to $34,089,058 in PFC funds to insulate the schools listed in the Settlement Agreement between LAWA and LSD.

On September 19, 2011, BOAC approved the Letter of Agreement between LAWA and LSD, and authorized the release of $10 million to LSD for the first year of the sound insulation program. The funds were delivered to LSD on December 12, 2011. The initial schools treated were Felton Elementary, Lennox Middle School, Animo Leadership High School, and Jefferson (new construction phase).

In September 2012, sound attenuation work was completed for the Animo Leadership High School, the District's charter school managed by Green Dot.

In September 2013, the District sent LAWA a written request to remove Lennox Fine and Performing Arts Academy from the list of approved new schools to be mitigated because the school will not be built by the District.

On June 2, 2014, LAWA authorized $10 million for the Second Work Plan and released $4,079,000 as the first installment. This Second Work Plan focuses on existing Jefferson Elementary and Buford Elementary Schools. Sound attenuation plans for both of these schools were submitted to the Division of State Architect (DSA).

In August 2015, work at both Lennox Middle School and Felton Elementary were deemed completed and closed out by the Lennox School Board.

In November 2016, LAWA released to the District $5,921,000 as the second installment of the $10,000,000 award provided in 2014 to pay for both Buford and Jefferson Elementary Schools.

Inglewood Unified School District (IUSD)

LAWA worked with the Inglewood Unified School District (IUSD) and the FAA to complete the PFC application process requesting authorization to use PFC funding for sound insulation of impacted schools for the IUSD. LAWA submitted the PFC application to the FAA on August 19, 2013 for $64 million dollars, which would attenuate seven schools plus the Child Development Center at Woodworth Elementary.

In October, 2014, the FAA issued the Final Agency Decision for the IUSD, finding the schools to be "significantly impacted". The FAA approved $44,378,659 to fund sound attenuation projects in the IUSD with PFC funds. The Los Angeles International Airport will collect PFC funds to pay for the sound attenuation of five campuses and the Child Development Center at Woodworth. Two schools, Inglewood High School and Hudnall Elementary, are located outside the 65 dB of the FAA-approved noise contour and were not approved for PFC funding by FAA. The schools/campuses approved for sound attenuation are as follows:

- Morningside High School
- Oak Street Elementary School
- Payne Elementary School
- Woodworth Elementary School
- Monroe Middle School
- Child Development Center at Woodworth Elementary

In the spring of 2015, LAWA worked with IUSD to develop their First Work Plan, which will outline the schools that are scheduled for design and construction phases first. The District identified Payne Elementary, Woodworth Elementary, and Woodworth Child Development Center for the schools in the First Work Plan.

The BOAC approved the Work Plan and the initial funding allocation for $10 million in August 2015.

In the fall of 2015, the District contracted with an architectural firm to begin designs for Payne Elementary School.

In 2016, IUSD amended their First Workplan to accommodate for logistical and planning issues. Monroe Middle School and Morningside High School were moved up on the schedule ahead of Woodworth Elementary. The First Workplan now includes Payne Elementary, Monroe Middle School and Morningside High School.

In 2016, the District requested LAWA review the exclusion of Inglewood High School from the FAA-approved portfolio. The school is bisected by the 2020 NEM approved by FAA in February 2016. LAWA sent the FAA a request to reconsider Inglewood High School in the sound insulation program.

3.0.I MM-LU-5 Upgrade and Expand Noise Monitoring Program

The LAX Master Plan MMRP states:

"***Upgrade and Expand Noise Monitoring Program.*** *LAWA shall upgrade and expand its existing noise monitoring program in surrounding communities through new system procurement, noise monitor location, and equipment installation. Permanent or portable monitors shall be located in surrounding communities to record noise data 24 hours per day, seven days per week for correlation with FAA radar data to cross-reference noise episodes with flight patterns. The upgraded system will support LAWA and other jurisdictional ANMP's when considering adjustments to airport noise mitigation boundaries."*

Status → Completed:
On February 4, 2010, CalTrans approved LAWA's Noise Monitoring Plan for LAX, Ontario, and Van Nuys airports that included the upgraded and expanded Aircraft and Noise Monitoring and Management System (ANMMS). The system is fully functional at this time.

4.0 Surface Transportation (On-Airport)

4.0.A ST-2 Non-Peak CTA Deliveries

The LAX Master Plan MMRP states:

*"**Non-Peak CTA Deliveries.** Deliveries to the CTA terminal reconstruction projects will be limited to non-peak traffic hours whenever possible."*

Status → Ongoing:
LAWA established the Coordination and Logistic Management (CALM) team. Working in cooperation with LAWA staff, including Terminal Operations, Airport Police, Capital Programming and Planning Group, and the Commercial Development Group, the CALM team monitors construction traffic, coordinates lane and roadway closures and analyzes traffic conditions to determine the need for additional traffic controls, lane restriping and traffic signal modifications. The CALM team established an approval process for proposed construction work in which contractors submit request forms describing the work, when the work is proposed to take place, duration, and coordination efforts with other projects, among other items. If pedestrian or vehicular traffic will be impacted, the submittal form will include proposed traffic control plans. The CALM team and other LAWA divisions review these requests and address any concerns prior to approval. The CALM team also develops an informational campaign for construction activities, including wayfinding signage for pedestrians to locate ground transportation facilities and parking during construction, information for commercial shuttle drivers regarding lane closures and detours, and traffic alerts on LAWA's website for the public and airport employees. The CALM team holds weekly meetings to discuss minimizing the construction impacts of current and future projects.

In 2016, the CALM team and LAWA staff reviewed deliveries that required lane closures in the Central Terminal Area (CTA). LAWA imposed restrictions whenever possible to limit deliveries during certain times of the day or certain days of the week depending on anticipated traffic impacts.

4.0.B ST-7 Adequate GTC, ITC, and APM Design

The LAX Master Plan MMRP states:

***Adequate GTC, ITC, and APM Design.** LAWA will ensure that the surface transportation system and curbfront for the GTC and ITC, commercial vehicle staging areas, and APM systems will be designed to adequately accommodate all forecast vehicular activity through 2015.*

Status → No action required at this time:
This measure was not applicable in 2016 because no design occurred.

4.0.C ST-8 Limited Short-Term Lane Closures

The LAX Master Plan MMRP states:

*"**Limited Short-Term Lane Closures.** When construction of any new ramps at the Century Boulevard/Sepulveda Boulevard interchange or construction for the GTC, ITC, or APM elevated structures require short-term lane closures, the lane closures will be for as brief a period as practical, with a goal that closures would principally be scheduled for non-peak periods."*

Status→ No action required at this time:
No new ramps at the Century Boulevard/Sepulveda Boulevard interchange were constructed in 2016, and the Ground Transportation Center (GTC), Intermodal Transportation Center (ITC), and the APM were not under construction in 2016.

4.0.D MM-ST-1 Require CTA Construction Vehicles to Use Designated Lanes

The LAX Master Plan MMRP states:

*"**Require CTA Construction Vehicles to Use Designated Lanes.** Whenever feasible, construction vehicles shall be restricted to designated roadways or lanes of traffic on CTA roadways adjacent to the existing close-in parking, thus limiting the mix of construction vehicles and airport traffic."*

Status → Ongoing:
LAWA established the Coordination and Logistic Management (CALM) team. Working in cooperation with LAWA staff, including Terminal Operations, Airport Police, Capital Programming and Planning Group, and the Commercial Development Group, the CALM team monitors construction traffic, coordinates lane and roadway closures and analyzes traffic conditions to determine the need for additional traffic controls, lane restriping and traffic signal modifications. CALM established an approval process for proposed construction work in which contractors submit request forms describing the work, when the work is proposed to take place, duration, and coordination efforts with other projects, among other items. If pedestrian or vehicular traffic will be impacted, the submittal form will include proposed traffic control plans. The CALM team and other LAWA divisions review these requests and address any concerns prior to approval. The CALM team also develops an informational campaign for construction activities, including wayfinding signage for pedestrians to locate ground transportation facilities and parking during construction, information for commercial shuttle drivers regarding lane closures and detours, and traffic alerts on LAWA's website for the public and airport employees. The CALM team holds weekly meetings to discuss minimizing construction impacts of current and future projects.

In 2016, the CALM team and LAWA staff reviewed deliveries that required lane closures in the Central Terminal Area (CTA). LAWA imposed restrictions whenever possible to limit the number and/or types of lanes used by construction vehicles.

4.0.E MM-ST-2 Modify CTA Signage

The LAX Master Plan MMRP states:

*"**Modify CTA Signage.** During construction, additional signage will be installed, as required, to separate construction traffic from non-construction traffic to the extent feasible."*

Status → Ongoing:
LAWA established the Coordination and Logistic Management (CALM) team. Working in cooperation with LAWA staff, including Terminal Operations, Airport Police, Capital Programming and Planning Group, and the Commercial Development Group, the CALM team monitors construction traffic, coordinates lane and roadway closures and analyzes traffic conditions to determine the need for additional traffic controls, lane restriping and traffic signal modifications. CALM established an approval process for proposed construction work in which contractors submit request forms describing the work, when the work is proposed to take place, duration, and coordination efforts with other projects, among other items. If pedestrian or vehicular traffic will be impacted, the submittal form will include proposed traffic control plans. The CALM team and other LAWA divisions review these requests and address any concerns prior to approval. The CALM team also develops an informational campaign for construction activities, including wayfinding signage for pedestrians to locate ground transportation facilities and parking during construction, information for commercial shuttle drivers regarding lane closures and detours, and traffic alerts on LAWA's website for the public and airport employees. The CALM team holds weekly meetings to discuss minimizing construction impacts of current and future projects.

In 2016, LAWA staff and the CALM team reviewed and approved worksite traffic control plans for construction projects within the CTA. These worksite traffic control plans include the need for additional and modified signage.

4.0.F MM-ST-3 Develop Designated Shuttle Stops for Labor Buses and ITC-CTA Buses

The LAX Master Plan MMRP states:

*"**Develop Designated Shuttle Stops for Labor Buses and ITC-CTA Buses.** Develop shuttle stops for labor buses (i.e. buses carrying construction workers) and the ITC-CTA shuttle buses at the CTA arrivals level. All ITC-CTA shuttle buses will be routed to these lower level (arrivals) curb areas. These buses will not circulate through the upper level (departures) curbfront."*

Status → No action required at this time:
There were no LAX Master Plan projects that required labor or shuttle buses for construction workers in the CTA in 2016.

4.0.G MM-ST (BWP)-2 Improve the Intersection of Center Way and World Way South

The Bradley West Project MMRP states in part:

*"**Improve the Intersection of Center Way and World Way South.** Widen World Way South approach on the east side of the roadway to provide an additional right turn lane. The resulting configuration would be a single left turn lane, one through-left turn lane, two through lanes, and two right turn lanes."*

Status → Completed:
This project was completed in the third quarter of 2015.

4.0.H MM-ST (BWP)-3 Widen World Way Across from TBIT

The Bradley West Project MMRP states:

*"**Widen World Way Across from TBIT.** Widen the arrivals-level outer roadway across from TBIT by changing the left-most lane that currently terminates at Center Way to a through/left lane and extending this lane to World Way South."*

Status → Completed:
This improvement was completed in June 2013 as part of the Central Utility Plant upgrade.

4.0.I MM-ST (BWP)-12 Distribution of Contractor Employee Parking between the Northwest Construction Staging/Parking Area and the East Contractor Employee Parking Area or Southeast Construction Staging/Parking Area

The Bradley West Project MMRP states in part:

*"**Distribution of Contractor Employee Parking between the Northwest Construction Staging/Parking Area and the East Contractor Employee Parking Area or Southeast Construction Staging/Parking Area.** General parking for Bradley West Project contractor employees within the Northwest Construction Staging/Parking Area and within the East Contractor Employee Parking Area or Southeast Construction Staging/Parking Area shall be distributed such that neither the northwest area (i.e., Northwest Construction Staging/Parking Area) or the east/southeast area (i.e., East Contractor Employee Parking Area or Southeast Construction Staging/Parking Area) is assigned parking for more than 601 vehicles."*

Status → Completed

5.0 Surface Transportation (Off-Airport)

5.0.A ST-9 Construction Deliveries

The LAX Master Plan MMRP states:

*"**Construction Deliveries.** Construction deliveries requiring lane closures shall receive prior approval from the Construction Coordination Office. Notification of deliveries shall be made with sufficient time to allow for any modifications to approved traffic detour plans."*

BWP Status → Completed

WAMA Status → Ongoing:
No lane closures were required for construction deliveries in 2016.

MSC Status → Ongoing:
No lane closures were required for construction deliveries in 2016.

5.0.B ST-12 Designated Truck Delivery Hours

The LAX Master Plan MMRP states:

*"**Designated Truck Delivery Hours.** Truck deliveries shall be encouraged to use night-time hours and shall avoid the peak periods of 7:00 a.m. to 9:00 a.m. and 4:30 p.m. to 6:30 p.m."*

BWP Status → Completed

WAMA Status → Ongoing:
Truck deliveries are strictly enforced by LAWA inspectors and mitigation monitors. One truck waiver was requested for the WAMA Project during 2016, for a large-scale concrete pour in February 2016.

MSC Status → Ongoing:
During the course of demolition and removal of the former Qantas Hangar in 2016, a total of four (4) truck waivers were requested when large amounts of demolition debris needed to be removed by end of day. .

5.0.C ST-14 Construction Employee Shift Hours

The LAX Master Plan MMRP states:

*"**Construction Employee Shift Hours.** Shift hours that do not coincide with the heaviest commuter traffic periods (7:00 a.m. to 9:00 a.m., 4:30 p.m. to 6:30 p.m.) will be established. Work periods will be extended to include weekends and multiple work shifts, to the extent possible and necessary."*

BWP Status → Completed

WAMA Status → Ongoing:
Prior to the initiation of construction, the contractor developed a Construction Traffic Management Plan and a Logistics Plan, both of which LAWA reviewed. The plans specify a number of traffic-related provisions, including provisions related to construction employee shift hours. The standard shift for the WAMA project (including both the LAWA WAMA construction component and the Qantas hangar component) conforms to the restrictions contained in this measure. To meet engineering and scheduling requirements, some shifts extended past 4 pm; however, this was not typical and consisted of a very limited crew (e.g., 2 to 4 workers).

MSC Status → Ongoing:
The standard shift for the MSC project conforms to the restrictions contained in this measure. Worker shifts typically started around 5:00 a.m. and concluded around 3:00 p.m.

5.0.D ST-16 Designated Haul Routes

The LAX Master Plan MMRP states:

*"**Designated Haul Routes.** Every effort will be made to ensure that haul routes are located away from sensitive noise receptors."*

BWP Status → Completed

WAMA Status → Ongoing:
No haul routes in noise-sensitive areas were used during 2016.

MSC Status → Ongoing:
No haul routes in noise-sensitive areas were used during 2016.

5.0.E ST-17 Maintenance of Haul Routes

The LAX Master Plan MMRP states:

*"**Maintenance of Haul Routes.** Haul routes on off-airport roadways will be maintained periodically and will comply with City of Los Angeles or other appropriate jurisdictional requirements for maintenance. Minor striping, lane configurations, and signal phasing modifications will be provided as needed."*

BWP Status → Completed

WAMA Status → Ongoing:
Off-airport roadways required no maintenance by construction contractors during 2016.

MSC Status → Ongoing:
Off-airport roadways required no maintenance by construction contractors during 2016.

5.0.F ST-18 Construction Traffic Management Plan

The LAX Master Plan MMRP states:

*"**Construction Traffic Management Plan.** A complete construction traffic plan will be developed to designate detour and/or haul routes, variable message and other sign locations, communication methods with airport passengers, construction deliveries, construction employee shift hours, construction employee parking locations and other relevant factors."*

BWP Status → Completed

WAMA Status → Ongoing:
Prior to the initiation of construction, the contractor developed a Construction Traffic Management Plan, which LAWA reviewed. LAWA inspectors and construction monitors monitored construction traffic, including haul routes, delivery hours, construction employee shift hours, construction employee parking locations, and other considerations. Construction employees on the LAWA construction component parked in a designated area within the construction site, accessed via Pershing Drive. Construction employee hours were reported weekly. Construction employees working on the Qantas hangar component parked onsite.

MSC Status → Ongoing:
Prior to the initiation of demolition of the former Qantas Hangar, the contractor developed a Construction Traffic Management Plan, which LAWA reviewed. LAWA inspectors and construction monitors monitored construction traffic, including haul routes, delivery hours, construction employee shift hours, construction employee parking locations, and other considerations. Demolition employees parked in the project office (trailers) area, located within the western portion of the project site. .

5.0.G ST-19 Closure Restrictions of Existing Roadways

The LAX Master Plan MMRP states:

*"**Closure Restrictions of Existing Roadways.** Other than short time periods during nighttime construction, existing roadways will remain open until they are no longer needed for regular traffic or construction traffic, unless a temporary detour route is available to serve the same function. This will recognize that there are three functions taking place concurrently: (1) airport traffic, (2) construction haul routes, and (3) construction of new facilities."*

BWP Status → Completed

WAMA Status → Ongoing:
No closure restrictions of existing roadways were required for the WAMA Project in 2016.

MSC Status → Ongoing:
No closure restrictions of existing roadways were required for the MSC Project in 2016.

5.0.H ST-20 Stockpile Locations

The LAX Master Plan MMRP states:

*"**Stockpile Locations.** Stockpile locations will be confined to the eastern area of the airport vicinity, to the extent practical and feasible. After the eastern facilities are under construction in Alternative D, stockpile locations will be selected that are as close to I-405 and I-105 as possible, and can be accessed by construction vehicles with minimal disruption to adjacent streets. Multiple stockpile locations may be provided, as required."*

Status→ No action required at this time:
This measure was not applicable during the 2016 reporting period because eastern area airport facilities were not under construction.

5.0.I ST-21 Construction Employee Parking Locations

The LAX Master Plan MMRP states:

*"**Construction Employee Parking Locations.** During construction of the eastern airport facilities, employee parking locations will be selected that are as close to I-405 and I-105 as possible and can be accessed by employee vehicles with minimal disruption to adjacent streets. Shuttle buses will transport employees to construction sites. In addition, remote parking locations (of not less than 1 mile away from project construction activities) will be established for construction employees with shuttle service to the airport. An emergency return system will be established for employees that must leave unexpectedly."*

Status → No action required at this time:
This measure was not applicable during the 2016 reporting period because eastern area airport facilities were not under construction.

5.0.J ST-22 Designated Truck Routes

The LAX Master Plan MMRP states in part:

*"**Designated Truck Routes.** For dirt and aggregate and all other materials and equipment, truck deliveries will be on designated routes only (freeways and non-residential streets). Every effort will be made for routes to avoid residential frontages…."*

BWP Status → Completed

WAMA Status → Ongoing:
The designated truck routes used in 2016 avoided residential frontages. LAWA inspectors and monitors checked to see that trucks used the designated routes.

MSC Status → Ongoing:
The designated truck routes used in 2016 avoided residential frontages. LAWA inspectors and monitors checked to see that trucks used the designated routes.

5.0.K ST-23 Expanded LAX Gateway Improvements/Greening of Impacted Communities

The LAX Master Plan MMRP states in part:

*"**Expanded LAX Gateway Improvements/Greening of Impacted Communities.** Gateway LAX improvements will be enabled through transportation improvements along Century Boulevard to the east as they are proposed to extend into low-income and minority communities in the City of Inglewood. LAWA anticipates making financial contribution, on a fair-share basis up to a maximum of ten million dollars, to various off-airport surface transportation related components."*

Status → Completed:
The funding and implementation of the Master Plan commitments, as well as the MMRP mitigation measures, are subject to LAWA's ability to use airport revenue to the extent permissible under federal law and policies, or to develop other state or federal funding sources. In 2006, LAWA requested a determination on the use of funds for this measure. As LAWA had not received a final determination on whether airport revenues may be used, LAWA submitted a new request on December 3, 2013 that FAA make a determination to provide funding for MMRP Commitment ST-23, Expanded Gateway Improvements/Greening of Impacted Communities. On November 23, 2015, LAWA received a letter from the FAA stating that airport revenues may not be used to provide funding for LAX Master Plan Commitment ST-23.

5.0.L ST-24 Fair Share Contribution to Congestion Management Plan (CMP) Improvements

The LAX Master Plan MMRP states in part:

*"**Fair Share Contribution to Congestion Management Plan (CMP) Improvements.** At the time of substantial completion of the LAX Master Plan, LAWA will contribute funding on a fair-share basis to future transportation improvements identified through the Congestion Management Plan (CMP) analysis completed for Alternative D."*

Status → No action required at this time:
As the LAX Master Plan was not substantially complete in 2016, no action was required.

5.0.M MM-ST-6 Add New Traffic Lanes

The LAX Master Plan MMRP states in part:

*"**Add New Traffic Lanes.** Traffic lanes shall be added to select intersections to the satisfaction of LADOT or other appropriate jurisdiction, sufficient to increase the capacity of the intersection without unnecessarily reducing sidewalk widths, removing on-street parking, or encroaching onto other land uses."*

Status → No action required at this time:
Per the LAX Master Plan traffic mitigation program, no action was required in 2016.

5.0.N MM-ST-7 Restripe Existing Facilities

The LAX Master Plan MMRP states in part:

*"**Restripe Existing Facilities.** Existing traffic lanes shall be restriped to the satisfaction of LADOT or other appropriate jurisdiction, so that additional lane capacity will be provided without adding any new pavement to the intersection or road segment."*

Status → No action required at this time:
Per the LAX Master Plan traffic mitigation program, no action was required in 2016.

5.0.O MM-ST-8 Add ATSAC, ATCS or Equivalent

The LAX Master Plan MMRP states in part:

*"**Add ATSAC, ATCS or Equivalent.** Automated Traffic Surveillance and Control (ATSAC) or Adaptive Traffic Control System (ATCS) capability or equivalent shall be added to select intersections to the satisfaction of LADOT or other appropriate jurisdiction. The improved capability will result in a more effective traffic signal network."*

Status → No action required at this time:
Per the LAX Master Plan traffic mitigation program, no action was required in 2016.

5.0.P MM-ST-10 Modify Signal Phasing

The LAX Master Plan MMRP states in part:

*"**Modify Signal Phasing.** The traffic signal phasing of select intersections shall be modified to the satisfaction of LADOT or other appropriate jurisdiction, to allow more efficient use of the intersections, particularly those that will experience a notable change in traffic characteristics as a result of the project."*

Status → No action required at this time:
Per the LAX Master Plan traffic mitigation program, no action was required in 2016.

5.0.Q MM-ST-12 Provide New Ramps Connecting I-105 to LAX Between Aviation Boulevard and La Cienega Boulevard

The LAX Master Plan MMRP states:

*"**Provide New Ramps Connecting I-105 to LAX Between Aviation Boulevard and La Cienega Boulevard.** These ramps shall be provided to allow for direct access and egress to/from the ITC and GTC via I-105, between Aviation Boulevard and La Cienega Boulevard. A feasibility study is underway to determine the best design for these ramps."*

Status → No action required at this time:
LAWA amended the LAX Specific Plan in 2013. The amended Specific Plan removed the Intermodal Transportation Center (ITC) and the Ground Transportation Center

(GTC). Therefore, this measure no longer applies to the LAX Master Plan or individual Master Plan projects.

5.0.R MM-ST-13 Create a New Interchange at I-405 and Lennox Boulevard

The LAX Master Plan MMRP states:

*"**Create a New Interchange at I-405 and Lennox Boulevard.** This interchange shall provide grade-separated ramps from I-405 directly into airport property, and vice-versa. It shall be located approximately mid-way between Century Boulevard and Imperial Highway. A feasibility study is underway to determine the best design for the interchange. Should this proposed interchange not be constructed, suitable and alternate traffic mitigation measures shall be designed and implemented to the satisfaction of LADOT and the Bureau of Engineering."*

Status → No action required at this time:
Per the LAX Master Plan traffic mitigation program, no action was required in 2016.

5.0.S MM-ST-14 Ground Transportation/Construction Coordination Office Outreach Program

The LAX Master Plan MMRP states:

*"**Ground Transportation/Construction Coordination Office Outreach Program.** The construction coordination office proposed in Master Plan Commitment C-1, Establishment of a Ground Transportation/Construction Coordination Office, shall establish appropriate mechanisms to involve and coordinate with other major airport-area development projects to the extent feasible, to ensure that the cumulative impacts of construction in the airport area are coordinated and minimized."*

Status → Ongoing:
In 2016, LAWA's CALM team worked in cooperation with LAWA staff including Terminal Operations, Airport Police, Environmental Programs Group, and Commercial Development Group, to monitor construction traffic, coordinate lane and roadway closures and analyze the need for additional traffic controls.

5.0.T MM-ST-15 Provide Fair-Share Contributions to Transit Improvements

The LAX Master Plan MMRP states in part:

*"**Provide Fair-Share Contributions to Transit Improvements.** Provide fair-share contributions to benefit transit to and from LAX to the satisfaction of LADOT and/or other appropriate jurisdiction or agency."*

Status → Ongoing:
Per the LAX Master Plan traffic mitigation program, no action was required in 2016.

5.0.U MM-ST-16 Provide Fair-Share Contribution to LA County's project to extend the Marina Expressway

The LAX Master Plan MMRP states in part:

*"**Provide Fair-Share Contribution to LA County's project to extend the Marina Expressway.** Provide fair-share contribution to Los Angeles County's project to extend the Marina Expressway (Route 90) to Admiralty Way or complete alternative off-site improvements at the following intersections: By 2015: Lincoln Boulevard & Washington Boulevard, Bali Way & Lincoln Boulevard, Fiji Way & Lincoln Boulevard, Lincoln Boulevard & Marina Expressway, Lincoln Boulevard & Maxella Avenue, Lincoln Boulevard & Mindanao Way…"*

Status → No action required at this time:
Per Los Angeles County, the Marina Expressway extension project is not currently programmed or funded. Per the LAX Master Plan traffic mitigation program, no action was required in 2016 for the alternative off-site improvements.

5.0.V MM-ST (BWP)-1 Trip Reduction Measures

The Bradley West Project MMRP states:

*"**Trip Reduction Measures.** LAWA will implement the following trip reduction measures:*

(a) Continue to promote and expand the FlyAway services in accordance with LAX Master Plan Mitigation Measure MM-AQ-3. It is anticipated that the continued expansion of the FlyAway service will promote a shift in mode-share away from the private vehicle mode which would reduce traffic volume using the CTA roadway system.

(b) Continue to promote the consolidation of shuttle services (e.g., hotel/motel, off-airport parking, rental cars) or programs to reduce trips associated with these modes."

Status → Ongoing:
In 2016, LAWA operated FlyAway service between LAX and the following locations:

- Van Nuys
- Union Station
- Westwood
- Hollywood
- Long Beach
- Orange Line Busway station at Woodley Avenue in the San Fernando Valley.

Marketing included the manufacturing, printing and distribution of FlyAway brochures, and information published on LAWA's website and on the Twitter and Facebook apps. The FlyAway network has also been included in Google Transit since 2012. Google Transit provides route, location, fare, and schedule information for the FlyAway network as well as connecting transit service information from Santa Monica Big Blue Bus, Metro,

and other participating agencies. Google Transit is accessible via Google maps on computers and Google's app.

5.0.W MM-ST (BWP)-4 Modify the Intersection of Airport Boulevard and Manchester Avenue (Intersection #9)

The Bradley West Project MMRP states in part:

*"**Modify the Intersection of Airport Boulevard and Manchester Avenue (Intersection #9).** The eastbound approach to the Airport Boulevard and Manchester Avenue intersection shall be restriped to provide one left-turn lane, two through lanes, and a through/right lane… Implementation of this measure shall occur if/when international passenger activity levels at TBIT increase to 19.7 million annual passengers."*

Status → Completed:
In 2014, this intersection improvement was completed as part of another project unrelated to the airport.

5.0.X MM-ST (BWP)-5 Modify the Intersection of Arbor Vitae Street and Aviation Boulevard (Intersection #10)

The Bradley West Project MMRP states in part:

*"**Modify the Intersection of Arbor Vitae Street and Aviation Boulevard (Intersection #10).** The eastbound approach to the Arbor Vitae Street and Aviation Boulevard intersection shall be widened to provide one left-turn lane, two through lanes, and a right-turn lane.…Los Angeles and City of Inglewood. Implementation of this measure shall occur if/when international passenger activity levels at TBIT increase to 20.7 million annual passengers."*

Status → In Progress:
In 2016, LADOT and the City of Inglewood approved preliminary engineering plans for this improvement project.

5.0.Y MM-ST (BWP)-6 Modify the Intersection of Imperial Highway and Sepulveda Boulevard (Intersection #71)

The Bradley West Project MMRP states in part:

***"Modify the Intersection of Imperial Highway and Sepulveda Boulevard (Intersection #71).** The northbound approach to the Imperial Highway and Sepulveda Boulevard intersection shall be restriped to provide one left-turn lane, three through lanes, and two right-turn lanes. …… Implementation of this measure shall occur if/when international passenger activity levels at TBIT increase to 19.7 million annual passengers."*

Status → In Progress:
As the intersection is within Caltrans' jurisdiction, Caltrans must approve the design plans prior to construction. In 2016, Caltrans was reviewing the engineering plans prepared by LAWA's consultant, T.Y. Lin International.

5.0.Z MM-ST (BWP)-7 Modify the Intersection of La Cienega Boulevard and I-405 Ramps N/O Century Boulevard (Intersection #96)

The Bradley West Project MMRP states in part:

*"**Modify the Intersection of La Cienega Boulevard and I-405 Ramps N/O Century Boulevard (Intersection #96).** The southbound approach to the La Cienega Boulevard and I-405 Ramps N/O Century Boulevard intersection shall be widened to provide two left-turn lanes and two through lanes….*

Implementation of this measure shall occur if/when international passenger activity levels at TBIT increase to 20.7 million annual passengers."

Status → In Progress:
LAWA proposed to LADOT and Caltrans to substitute the widening of southbound La Cienega Boulevard for the widening of the southbound off-ramp from the I-405 Freeway at La Cienega Boulevard. This refined improvement will mitigate the impact at this intersection. In 2016, LAWA's consultant began preparing a Project Study Report for this project, which Caltrans requires prior to the preparation of engineering plans.

5.0.AA MM-ST (BWP)-8 Modify the Intersection of La Tijera Boulevard and Sepulveda Boulevard (Intersection #101)

The Bradley West Project MMRP states in part:

*"**Modify the Intersection of La Tijera Boulevard and Sepulveda Boulevard (Intersection #101).** The westbound approach to the La Tijera Boulevard and Sepulveda Boulevard intersection shall be restriped and the traffic signal modified to provide two left-turn lanes, one through lane, and a through/right lane. … Implementation of this measure shall occur if/when international passenger activity levels at TBIT increase to 18.7 million annual passengers."*

Status → Monitoring:
In 2016, there were 13.15 million annual international passengers at TBIT. When discussing the implementation of this mitigation with the Los Angeles Department of Transportation, LADOT informed LAWA that they are pursuing a separate project to install bike lanes on LaTijera Boulevard east of Sepulveda Boulevard. If both the bike lane project and MM-ST (BWP)-8 were installed, it would result in the loss of approximately 18 parking spaces on LaTijera Boulevard between Sepulveda Boulevard and Sepulveda Eastway. The mitigation, and the resulting parking loss if both the mitigation and LADOT's bike lane project were installed, was discussed at a Westchester Neighborhood Council meeting on August 5, 2014 and at a meeting with the Westchester Business Improvement Association on August 21, 2014. LAWA has received requests to postpone implementation of this traffic mitigation, to monitor the

level of service at this intersection and report back to LADOT for a determination as to when the traffic mitigation should be implemented.
A traffic analysis conducted using 2016 traffic volumes revealed that this intersection is operating at Level of Service B during the AM and PM peak hours and Level of Service C during the midday peak, which is better than the Level of Service D which was projected to occur during these peak hours when TBIT reached 18.7 million annual international passengers. This information was sent via e-mail to LADOT on December 27, 2016.

5.0.BB MM-ST (BWP)-9 Modify the Intersection of Sepulveda Boulevard and 76th/77th Street (Intersection #136)

The Bradley West Project MMRP states in part:

"Modify the Intersection of Sepulveda Boulevard and 76th/77th Street (Intersection #136). *The eastbound approach to the Sepulveda Boulevard and 76th/77th Street intersection shall be restriped to provide two left-turn lanes, a through/left-turn lane, and one right-turn lane…. Implementation of this measure shall occur if/when international passenger activity levels at TBIT increase to 19.7 million annual passengers."*

Status → In Progress:
In 2014, LADOT changed the signal phasing and installed a crosswalk on the north leg of the intersection. The existing traffic signal now conflicts with the mitigation measure.

In 2016, there were 13.15 million annual international passengers at TBIT. A traffic analysis conducted using 2016 traffic volumes revealed that this intersection is operating with a volume/capacity of 0.802 and a Level of Service D during the AM peak hour. This is better than the 0.803 volume/capacity and Level of Service D that was projected to occur at this intersection post mitigation during the AM peak hour when TBIT reached 18.7 million annual international passengers.

5.0.CC MM-ST (BWP)-10 Modify the Intersection of Imperial Highway and Main Street (Intersection #68)

The Bradley West Project MMRP states:

"Modify the Intersection of Imperial Highway and Main Street (Intersection #68). *Modify the median island on the east leg of the intersection to provide a second left turn lane. The resulting westbound configuration would be comprised of a dual left-turn lane and two through lanes."*

Status → Completed:
LAWA completed this project on February 14, 2012.

5.0.DD MM-ST (BWP)-11 Modify the Intersection of Imperial Highway and Pershing Drive (Intersection #69)

The Bradley West Project MMRP states:

*"**Modify the Intersection of Imperial Highway and Pershing Drive (Inter-section #69).** Widen the north side of the westbound approach of Imperial Highway to provide a second right-turn lane. The resulting westbound lane configuration would be comprised of one left turn lane, two through lanes, and two right turn lanes."*

Status → Completed:
LAWA completed this project on February 14, 2012.

5.0.EE MM-ST (MSC)-1 Restripe Manchester Avenue at Sepulveda Boulevard

The MSC MMRP states:

*"**Restripe Manchester Avenue at Sepulveda Boulevard**. Restripe Manchester Avenue westbound approach to provide a right-turn lane and one additional left-turn lane. The resulting westbound lane configuration would be comprised of two left-turn lanes, two through lanes, and one right-turn lane."*

Status → In Progress:
In 2016, LAWA staff prepared a preliminary design of this mitigation which was approved by LADOT.

6.0 Relocation of Residences and Businesses

6.0.A RBR-1 Residential and Business Relocation Program

The LAX Master Plan MMRP states in part:

*"**Residential and Business Relocation Program.** To address the acquisition of properties and relocation of businesses and residents associated with the proposed Master Plan, LAWA will prepare a Residential and Business Relocation Plan (Relocation Plan) in compliance with the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, as amended, state and local regulations, and FAA Advisory Circular 150/5100-17, prior to the commencement of acquisition."*

Status→ Completed:
LAWA completed an LAX Master Plan Program, Alternative D Draft Relocation Plan in April 2004 in accordance to the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, as amended, and Title 49 of the Code of Federal Regulations Part 24 to address proposed acquisition and relocation of properties under Alternative D of the LAX Master Plan. However, no LAX Master Plan improvements requiring acquisition and relocation in the Alternative D Proposed Property Acquisition Areas occurred in 2016.

6.0.B MM-RBR-1 Phasing for Business Relocations

The LAX Master Plan MMRP states in part:

*"**Phasing for Business Relocations.** To maximize opportunities for airport/airport-dependent businesses and other businesses being acquired to relocate in proximity to their current sites, LAWA shall, to the maximum degree feasible, schedule acquisition phasing and/or development phasing to accommodate interested parties on airport property in a manner that would avoid delays to the overall construction and development schedule."*

Status→ No action required at this time:
This measure was not applicable during the 2016 reporting period, as no LAX Master Plan improvements requiring acquisition and relocation in the Alternative D Proposed Property Acquisition Areas occurred in 2016.

6.0.C MM-RBR-2 Relocation Opportunities through Aircraft Noise Mitigation Program

The LAX Master Plan MMRP states in part:

*"**Relocation Opportunities through Aircraft Noise Mitigation Program.** As a special project under the Aircraft Noise Mitigation Program (ANMP) for LAX, LAWA shall coordinate with the City of Inglewood and the County of Los Angeles to identify residential land uses that are subject to high levels of aircraft noise where land*

acquisition and conversion to compatible land uses is contemplated under applicable plans or is otherwise deemed appropriate."

Status→ Ongoing:
LAWA supports the efforts of Inglewood and Los Angeles County in using land acquisition to achieve land use compatibility. However, because LAWA does not run their mitigation programs, it is up to those jurisdictions to identify properties for acquisition and make requests for funding to LAWA via the Grant Implementation Plan (GIP) process. During 2016, neither Inglewood nor the County submitted an acquisition GIP. Los Angeles County has never identified any properties for acquisition, and has no plans to submit an acquisition GIP.

7.0 Environmental Justice

7.0.A EJ-1 Aviation Curriculum

The LAX Master Plan MMRP states:

*"**Aviation Curriculum.** LAWA will work with local school districts to offer aviation-related curriculum at elementary schools, middle schools, high schools and colleges in affected communities near the Los Angeles International Airport. Potential pilot schools could include: Beulah Payne Elementary School, Lennox Middle School, Hillcrest Continuation School, Inglewood High School, Morningside High School, and Los Angeles Southwest College."*

Status → Ongoing:
LAWA continually is coordinating with the local school districts in developing aviation-related curriculum. LAWA is working on a pilot program with Orville Wright Middle School in Westchester to offer an on-site Flight Simulation training program for their students. LAWA has begun coordinating aviation-related activities with Playa Vista Elementary School in the Playa Vista community, Visitation Elementary School in Westchester and Graham Elementary School in Los Angeles.

7.0.B EJ-2 Aviation Academy

The LAX Master Plan MMRP states:

*"**Aviation Academy.** LAWA will work with local school districts to provide comprehensive educational and trade training for aviation-related careers, targeting students in the affected communities to provide them with increased career opportunities."*

Status → Ongoing:
The Aviation Career Education (ACE) Academy is a free, week-long motivational program to provide students with a basic understanding of career opportunities within the aviation industry, as well as a general knowledge about LAX. This program is open to all Los Angeles area seventh-and eighth-grade students (between the ages of 12 and 14) and high school students (between the ages of 15 and 18) in communities surrounding LAX, including El Segundo, Hawthorne, Inglewood, Lennox, South Los Angeles, and Westchester/Playa del Rey. Approximately 35 local students participated in the program during the summer of 2016.

In 2016 LAX hosted its first Aviation Career Day bringing more than 500 LAX area and Los Angeles area high school students to the LAX airfield for a career fair focusing on aviation and aviation-related services.

Job Shadow Day is an opportunity for students to learn about the aviation industry and its career possibilities while experiencing the workplace. LAWA hosts a group of students to introduce them to the airport and the career possibilities in aviation. In 2016, LAWA coordinated with the Saint Bernard High School to host Job Shadow Day for

approximately 20 students. LAWA also coordinated with the Orville Wright Middle School in Westchester and (Judge) Albert Monroe Middle School in Inglewood to host aviation career talks for approximately 40 students.

LAX Community Relations hosted schools at LAX for Aviation Career Days. These events featured talks about careers and jobs at LAX and other airports. For 2016 to 2017, LAWA hosted students from the Los Angeles Cowan Elementary School in Westchester, and the Zeta Rho Foundation that mentors 'at risk' youth from South Central Los Angeles. There was also a Career Day with Amino Westside Charter Middle School in the Playa Vista community near LAX.

LAWA is continually coordinating with local school districts to provide education and trade training programs for aviation-related careers. Positive feedback was received from participants surveyed in these LAX education outreach programs.

7.0.C EJ-3 Job Outreach Center

The LAX Master Plan MMRP states in part:

*"**Construction and Other LAX-Related Job Outreach -** LAWA will create or utilize an existing resource center to assist historically underrepresented and at-risk local residents to find construction and other substantive jobs with LAWA and surrounding airport-related businesses through training and comprehensive outreach."*

Status → Ongoing:

Gateways Internship Program

The Gateways Internship Program provides college and high school students with exposure to career opportunities in the aviation industry and other airport-related jobs. The Internship Program gives students on-the-job practical experience in various airport jobs through education, training, and mentoring activities to better prepare them to enter the workforce.

The Gateways Internship Program has partnered with various colleges such as UCLA, USC, Cal State University of Long Beach, Cal State University of Los Angeles, Loyola Marymount, West Los Angeles College, Cal State Fullerton, Cal State University, Northridge, Cal State University Dominquez Hills, Cerritos College, Santa Monica College, Los Angeles Trade Technical College, and Southwest College. The high school students that participated in the internship program lived in the following Cities: El Segundo, Gardena, Inglewood, Los Angeles and Westchester.

LAWA's Gateways Program is comprised of four internship programs

- Gateways College Student Professional Worker Program
- Gateways College Volunteer Internship Program
- Gateways International Student Professional Worker Program
- Gateways High School Volunteer Internship Program

In 2016 the BJRC placed over 44 students through its four programs within various internships in LAWA divisions. Placement of students into the internship program was accomplished primarily through Business & Job Resources partnerships with local universities, community colleges, and community and faith-based organizations.

The BJRC conducted extensive outreach to students by attending Career Days and job fairs facilitated by various colleges, community organizations and Worksource Centers. Internship job descriptions were posted to college career and social media websites such as Facebook to create awareness. BJRC staff worked with various colleges' career advisors to continue strengthening its partnership and in 2016, LAWA's BJRC staff disseminated internship information at 30 community job fairs. Additionally, BJRC continues to work with the Economic Workforce Development Department to be a worksite for the Mayor's Hire LA's Youth Program. Other organizations that remain partners are the International Trade Education Program (ITEP) and the Gardena Global Leadership Academy.

In addition to students from local and out-of-state schools, the BJRC also attracts international students who wish to intern at LAX. In 2016, BJRC placed international students from China, France, Japan, and Korea.

Job Training Program

Although the FAA has not approved a job training program (JTP) for LAWA, and therefore no LAWA funds were used for job training, LAWA leveraged its relationships with various agencies funded to provide job training.

By leveraging relationships with over 15 JTP partners, LAWA, through its Business and Job Resources Division (BJRD), initiated its JTP in January 2007. LAWA was successfully able to work with agencies funded through other means to provide job training opportunities to residents in the Project Impact Area (PIA). During the reporting period, LAWA worked with agencies that provide an array of training, including computer skills, customer service, time management, bilingual skills, leadership skills, and other classes.

Many local residents have completed training in customer service, retail sales, auto mechanics and other disciplines through the LAWA partnerships. The Mayor's Office has initiated discussions with area Work Source Centers, the Los Angeles Community College District and surrounding LAWA businesses to conduct Hospitality Training for local residents. Plans are underway to create training modules that will result in career paths for residents within the hospitality industry. Upon the completion of training, these candidates will be well-positioned to compete for job opportunities at the hotels or with various Airport employers.

JTP Referrals in 2016:	24	Program-to-Date:	907
Completed Training in 2016 :	8	Program-to-Date:	518

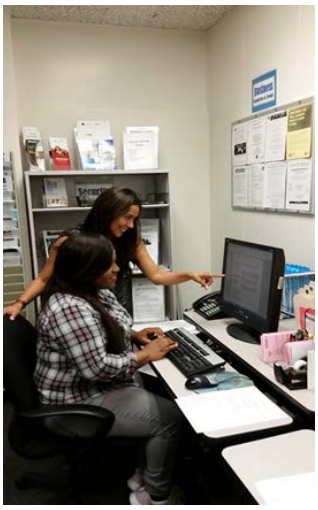
First Source Hiring Program

The First Source Hiring Program (FSHP), housed in the Business and Job Resources Center (BJRC), is designed to provide residents from the communities immediately surrounding the airport and those most impacted by airport operations access to airport jobs. Those communities are a part of the Project Impact Area (PIA) and are comprised

of South Los Angeles, El Segundo, Hawthorne, Inglewood, and Lennox. FSHP focuses much of its outreach in these areas.

FSHP works closely with local Community Organizations such as Work Source Centers, One-Stop Centers, and faith-based organizations to promote airport jobs for LAX employers. FSHP provides training to these organizations on how to apply for jobs at LAX and what is needed to obtain a job at LAX. FSHP also promotes jobs through social media and currently has over 2,600 followers on Facebook. In 2016, the BJRC attended 30 job/community events.

LAWA is currently proposing a Landside Access Modernization Program (LAMP). In 2016, FSHP participated in three LAMP events to promote the potential program and inform future potential LAX contractors of the opportunities to promote their employment opportunities.



LAWA representative informing job seeker at El Camino College Job Fair of employment opportunities available at LAWA

LAWA representatives announcing new website, Jobs at LAX, at a job fair

	2016
Job Openings	5,562
Registered Job Seekers	33,335
Website Visits	357,815
Job Referrals to LAX Employers	67,674
LAX Employers	166
Community Partners	112

For more information on the First Source Hiring Program, please visit the program website at http://www.lawa.org/bjrc/Employment.aspx?id=2058 and the Jobs@LAX website at www.jobsatlax.org.

7.0.D EJ-4 Community Mitigation Monitoring

The LAX Master Plan MMRP states:

*"**Community Mitigation Monitoring.** LAWA will include community participation in monitoring the implementation of the final Mitigation Measures and Master Plan Commitments in order to ensure agency compliance and accountability. The community participation will include a diverse group of residents, stakeholders, environmental specialists and community leaders that will convene on a regular basis."*

Status → Ongoing:
The LAX Master Plan LAX Stakeholder Liaison Office (SLO) provides stakeholders with direct access to applicable projects. During 2016, the LAX SLO did not receive or process any projects associated with the LAX Master Plan Projects.

8.0 Air Quality

8.0.A AQ-1 Air Quality Source Apportionment Study

The LAX Master Plan MMRP states in part:

*"**Air Quality Source Apportionment Study.** LAWA will conduct an air quality source apportionment study to evaluate the contribution of on-airport aircraft emissions to off-airport air pollutant concentrations."*

Status → Completed:
LAWA completed the LAX Air Quality and Source Apportionment Study (AQSAS) in 2013, and presented it to LAWA's Board of Airport Commissioners on June 18, 2013.

The study and informational materials can be found, at http://www.lawa.org/AirQualityStudy.aspx?id=7716, entitled Final Report and Materials..

8.0.B AQ-2 School Air Filters

The LAX Master Plan MMRP states:

*"**School Air Filters.** LAWA will provide funding for air filtration system at qualifying public schools with air conditioning systems in place. The qualifying schools will be determined based upon review of the conclusions and recommendations of the Air Quality Source Apportionment Study to be conducted in Master Plan Commitment AQ-1."*

Status → In Progress:
The funding and implementation of the Master Plan commitments, as well as the MMRP mitigation measures, are subject to LAWA's ability to use airport revenue to the extent permissible under federal law and policies, or to develop other state or federal funding sources. On December 3, 2013, LAWA requested that the FAA make a determination on whether airport revenues may be used to provide funding for MMRP Commitment AQ-2, School Air Filters. LAWA did not receive FAA's formal response in 2016.

8.0.C AQ-3 Mobile Health Research Lab

The LAX Master Plan MMRP states:

"***Mobile Health Research Lab**. LAWA will explore the ability to fund/co-fund, to the extent feasible and permissible by federal and local regulations, or seek funding sources to support the goal of a Mobile Health Research Lab. The goal of the Mobile Health Research Lab will be to research and study, not diagnose or treat, upper respiratory and hearing impacts that may be directly related to the operation of LAX."*

Status → Completed:
The funding and implementation of the Master Plan commitments, as well as the MMRP mitigation measures, are subject to LAWA's ability to use airport revenue to the extent

permissible under federal law and policies, or to develop other state or federal funding sources. On November 23, 2015, LAWA received a letter from the FAA stating that airport revenues may not be used to provide funding for MMRP Commitment AQ-3, Mobile Health Research Lab. A mobile lab was not included in the 2005 LAX Master Plan's Record of Decision as mitigation to Alternative "D" at LAX, significant portions of which LAWA has yet to implement. Also, the FAA stated that a mobile health research lab is not a design refinement of, nor a mitigation of, an airport development project.

8.0.D MM-AQ-1 LAX Master Plan – Mitigation Plan for Air Quality (Framework)

The LAX Master Plan MMRP states in part:

*"**LAX Master Plan - Mitigation Plan for Air Quality** - LAWA shall expand and revise the existing air quality mitigation programs at LAX through the development of an LAX Master Plan – Mitigation Plan for Air Quality (LAX MP-MPAQ)."*

Status → Plan Established, Implementation Ongoing:
In 2005, LAWA completed a Mitigation Plan for Air Quality that established the overall framework for the implementation of specific measures for mitigating air quality impacts associated with the LAX Master Plan. The BOAC adopted the MM-AQ-1 Plan in December 2005, in conjunction with approval of the SAIP - prior to implementation of the first project under the LAX Master Plan.

8.0.E MM-AQ-2 Construction-Related Mitigation Measures

The LAX Master Plan MMRP states in part:

*"**Construction-Related Mitigation Measures** - The required components of the construction-related air quality mitigation measures are itemized below [starting on page 4-725 of the FEIR]. These components include numerous specific actions to reduce emissions from on-road and non-road mobile sources and stationary engines. All of these measures must be in place prior to commencement of the first Master Plan construction project and must remain in place through build out of the Master Plan. An implementation plan will be developed which provides available details as to how each of the elements of this construction-related mitigation measures will be implemented and monitored."*

Status → Plan Established, Implementation Ongoing:
LAWA completed a Construction-Related Mitigation Plan that set forth specific implementation requirements for the measures referenced in the LAX Master Plan Final EIR. The BOAC adopted the MM-AQ-2 Plan in December 2005, in conjunction with approval of the SAIP - prior to implementation of the first project under the LAX Master Plan - and LAWA has integrated required measures into the individual project construction specifications as appropriate, including those projects described herein. The execution of this implementation plan (the MM-AQ-2 Plan) occurs in conjunction with construction of each Master Plan project.

BWP Status → Completed

WAMA Status → Ongoing:
WAMA's compliance with this measure is accomplished through implementation of LAX-AQ-1 and LAX-AQ-2. See measure 8.0.H LAX-AQ-1 – General Air Quality Control Measures (WAMA) and measure 8.0.I LAX-AQ-2 – Construction-Related Measures (WAMA), below.

MSC Status → Ongoing:
MSC's compliance with this measure is accomplished through implementation of LAX-AQ-1 and LAX-AQ-2. See measure 8.0.L LAX-AQ-1 – General Air Quality Control Measures (MSC) and measure 8.0.M LAX-AQ-2 – Construction-Related Measures (MSC), below.

8.0.F MM-AQ-3 Transportation-Related Mitigation Measures

The LAX Master Plan MMRP states in part:

*"**Transportation-Related Mitigation Measure** - The primary feature of the transportation-related air quality mitigation measure is the development and construction of at least eight (8) additional sites with Flyaway service similar to the service provided by the Van Nuys Flyaway currently operated by LAWA. The intent of these FlyAway sites is to reduce the quantity of traffic going to and from LAX by providing regional locations where LAX employees and passengers can pick up an LAX-dedicated, clean-fueled bus that will transport them from a FlyAway closer to their home or office into LAX and back."*

Van Nuys FlyAway Bus at LAX Airport

Status → In Progress:
In 2016, LAWA operated seven FlyAway routes between LAX and remote boarding locations at Van Nuys, the Van Nuys Orange Line, Union Station, Westwood/UCLA, Santa Monica, Hollywood, and Long Beach.

The Santa Monica FlyAway service was discontinued on September 5, 2016 due to low ridership. There was an average of 1,500 riders per day for the first eight months of 2016.

The full 2016 FlyAway network service realized an average daily ridership of 4,441 passengers, reduced vehicle emissions by 19.16 tons each day, and removed 3,424 vehicles trips per day, travelling a combined total of 70,644 miles per day on roads accessing and egressing LAX Airport.

LAWA continues to promote the FlyAway at various travel, aviation and community events. Complete information about the FlyAway is available at www.LAXFlyAway.org.

Table 1: Summary of CY 2016 FlyAway Network Service Locations & Level of Service

Route Name	Weeks Operating	Bus Trips Runs	Total Annual	Avg. No. of	Operating Dates
Van Nuys	52	42,779	1,029,385	24.1	Since 1975; facility upgraded: 12/2005
Union Station	52	33,154	432,358	13	Since 3/15/2006
Westwood	52	12,817	41,578	3.2	Since 6/14/2007
Santa Monica	26	9,467	12,293	1.3	7/15/2014 to 9/5/2016
Hollywood	52	12,490	86,123	6.9	Since 9/3/2014
Long Beach	52	12690	17,923	1.4	Since 12/2015
Orange Line	52	15,823	1,331	0.1	Since 12/7/2015
La Brea/ Expo	0	0	0	0	7/1/2016 to 9/2/2014
Irvine	0	0	0	0	11/16/2009 to 08/31/2012
TOTAL/AVERAGE:		**139,220**	**1,620,991**	**7.1**	

Table 2: LAX FlyAway Network Emissions Reduction Summary: CY 2010 thru 2016

(Emissions reported include NOX, CO, ROG, PM10 and CO2)

ROUTE DATA		2010	2011	2012	2013	2014	2015	2016
Van Nuys	Ridership	807,485	835,346	887,260	890,740	957,602	989,513	1,029,385
	Vehicle Trips Saved	686,315	709,995	754,119	741,013	796,636	823,183	856,353
	Reduction in Miles Traveled	14.4 million	14.9 million	15.8 million	15.6 million	16,729,354 miles	17,286,840 miles	17,983,406 miles
	Emissions reduced	5,595.2 tons	6,033.5 tons	6,296.8 tons	4,808.3 tons	5,264.0 tons	5,495.3 tons	5,807.8 tons
	Auto operating cost savings	$6.8 million	$8.4 million	$9.4 million	$9.5 million	$9,853,589	$10,043,654	$10,322,475
Union Station	Ridership	413,975	434,096	455,919	508,019	531,702	512,902	432,358
	Vehicle Trips Saved	351,854	368,956	387,504	352,277	368,699	355,663	299,811
	Reduction in Miles Traveled	6.9 million	7.3 million	7.7 million	6.9 million	7,300,241 miles	7,042,118 miles	5,936,253 miles
	Emissions reduced	2,328.9 tons	2,496.3 tons	2,674.3 tons	1,751.8 tons	1,804.4 tons	1,707.8 tons	1,243.6 tons
	Auto operating cost savings	$3.3 million	$4.1 million	$4.6 million	$4.2 million	$4,299,842	$4,091,471	$3,407,409
Westwood	Ridership	107,136	97,337	84,179	78,030	62,704	47,592	41,578
	Vehicle Trips Saved	91,059	82,731	71,547	60,460	48,585	36,876	9,467
	Reduction in Miles Traveled	1.1 million	1.0 million	0.9 million	0.7 million	583,020 miles	442,509 miles	386,591 miles
	Emissions reduced	204 tons	187.4 tons	158.2 tons	174.6 tons	118.3 tons	60.9 tons	36.1 tons
	Auto operating cost savings	$618,000	$562,000	$511,000	$441,000	$343,399	$257,098	$221,903
Santa Monica	Ridership					7,407	16,180	12,293
	Vehicle Trips Saved					5,762	12,588	9,525
	Reduction in Miles Traveled					46,101 miles	100,704 miles	84,722 miles
	Emissions reduced					-19.4 tons	- 40.4 tons	-33.2 tons
	Auto operating cost savings					$27,154	$722,397	$65,608
Hollywood	Ridership					16,682	71,164	86,123
	Vehicle Trips Saved					12,144	51,807	59,720
	Reduction in Miles Traveled					291,466 miles	1,243,369 miles	1,074,968 miles
	Emissions reduced					- 67.5 tons	- 48.2 tons	26.5 tons
	Auto operating cost savings					$171,674	$58,509	$678,735
Long Beach	Ridership						70	17,923
	Vehicle Trips Saved							13,887
	Reduction in Miles Traveled							295,799 miles
	Emissions reduced							-96.4 tons
	Auto operating cost savings							$95,656

Table 2: LAX FlyAway Network Emissions Reduction Summary: CY 2010 thru 2016

(Emissions reported include NOX, CO, ROG, PM10 and CO2)

ROUTE DATA		2010	2011	2012	2013	2014	2015	2016
Orange Line (Van Nuys)	Ridership							1,331
	Vehicle Trips Saved							1,107
	Reduction in Miles Traveled							23,253 miles
	Emissions reduced							12.9 tons*
	Auto operating cost savings							$17,770
La Brea Expo	Ridership				1,210	848		
	Vehicleps Saved				932	654		
	Reduction in Miles Traveled				7,000 miles	5,227 miles		
	Emissions reduced				- 19.4 tons	- 26.5 tons		
	Auto operating cost savings				$4,534	$3,079		
Irvine	Ridership	13,604	16,504	11,897				
	Vehicle Trips Saved	11,563	14,027	10,112				
	Reduction in Miles Traveled	580 Th. miles	701 Th. miles	505 Th.miles				
	Emissions reduced	- 81 tons	- 20.3 tons	5.5 tons				
	Auto operating cost savings	$327,000	$397,000	$301,000				
Network Summary	Ridership	1,342,200	1,383,283	1,439,255	1,477,999	1,576,945	1,637,421	1,620,991
	Vehicle Trips Saved	1,140,791	1,175,709	1,223,282	1,154,682	1,232,480	1,280,117	1,249,870
	Reduction in Miles Traveled	23.0 M.miles	23.9 M. miles	24.9 M. miles	23.2 M. miles	24.9 miles	26,115,540 miles	25,784,992 miles
	Emissions reduced	7,966 tons	8,697 tons	9,134.8 tons	6,715.3 tons	7,073.3 tons	7,175.4 tons	6,997 tons
	Auto operating cost savings	$13.0 million	$13.5 million	$14.8 million	$14.1 million	$14.7 million	$15,173,129	$14,809,556

**The Orange Line is serviced by the same buses that serve Van Nuys, therefore, the bus emissions for the Orange Line are zero, as they are counted as part of the Van Nuys Route. The emission reduction only includes the savings created by the bus passenger using the FlyAway instead of an alternative ground transportation mode.*

*** Santa Monica closed September 5, 2016.*

*"**Transportation-Related Mitigation Measure** – Other feasible mitigation elements may be developed to ensure that the emission reductions for this transportation-related measure are achieved. These may include, for example"… Clean Vehicle Fleets measures such as:*

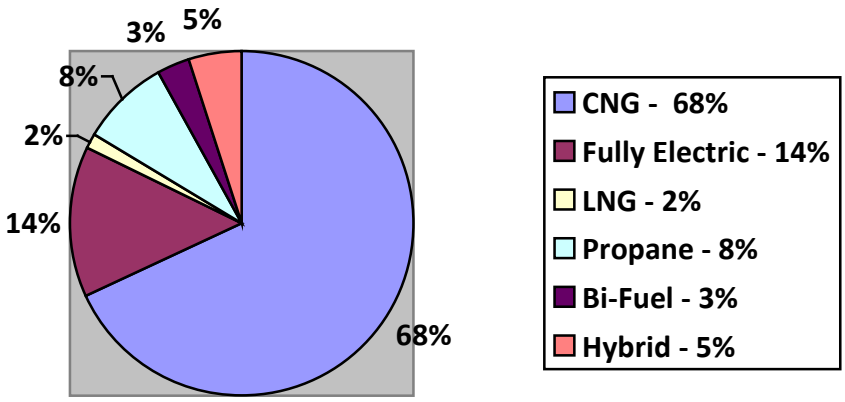
- *Promoting commercial vehicles/trucks/vans using terminal areas (LAX and regional intermodal) to install SULEZ/ZEV engines to reduce vehicle air emissions.*

100% of LAWA's LAX Shuttles are fueled by
Compressed Natural Gas (CNG)

Status → In Progress:
LAWA's fleet is the largest Alternative Fuel Vehicle (AFV) airport fleet in the nation. In 2016, 60 percent of the LAX fleet (a total of 982 vehicles) used alternative fuels, consisting primarily of compressed natural gas (CNG), liquefied natural gas (LNG), propane, full electric, and hybrid-electric vehicles. Additionally, 100 percent of the LAX courtesy shuttle fleet was powered by natural gas. LAWA has a state-of-the-art, high-technology LNG/LCNG fueling station at LAX.

According to Airports Council International's Environmental Benchmark Survey, LAWA has the largest AFV fleet of any airport in the nation

LAWA's 2016 LAX Alternative Fuel Vehicle Fleet by Fuel Type

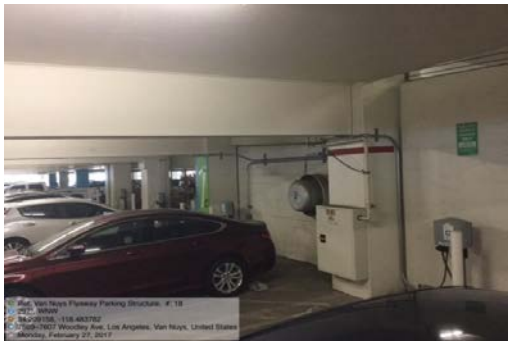


In 2016, LAWA replaced all obsolete level 2 electric vehicle (EV) chargers in parking structures PS 1, PS 6, Van Nuys (VNY) FlyAway Terminal and added six new chargers in Lot C, bringing the total number of level 2 chargers at LAX to 78, including 71 for public use.

EV Charger Locations at LAX

Location	Level 2 EV Charger	Direct Current Fast Charger
Parking Garage 1 (P-1)	19	1
Parking Garage 6 (P-6)	20	
Park N Fly (Park One) - *installed Oct 2013*	4	
Long Term Parking Lot C	20	
Van Nuys FlyAway Terminal Parking at LAX	8	
Admin West Building LAWA Fleet (not for public use)	4	
Maintenance Services LAWA Fleet (not for public use)	3	
TOTAL ( )* with public access	**78 (*71*)***	**1**

EV Chargers in Lot C at LAX



EV Chargers at VNY FlyAway Terminal.

8.0.G MM-AQ-4 Operations-Related Mitigation Measures

The LAX Master Plan MMRP states in part:

*"**Operations-Related Mitigation Measure:** The primary component of the operations-related air quality mitigation measure consists of one airside item, the conversion of ground support equipment (GSE) to extremely low emission technology (such as electric power, fuel cells, or other future technological developments)."*

Status → In Progress:
LAWA updated the 2007 LAX GSE inventory by completing a comprehensive e-GSE feasibility study in 2013. Based on the updated feasibility study, LAWA reviewed and analyzed strategies and options to achieve GSE emission reductions in consultation with airlines. LAWA's GSE strategies are aligned with the California Air Resources Board's current approach to achieving GSE emission reductions. In April 2015 LAWA's Board of Airport Commissioners adopted a Ground Support Equipment Emissions Policy to reduce emissions. This requirement is in effect at LAX. The Policy calls for GSE operators to:

1. Reduce their fleet-wide GSE emissions to 2.65 g/bhp-hr by December 31, 2021;
2. Provide LAWA with an interim assessment of the fleet-wide emission as of March 1, 2019;
3. Provide LAWA with an annual accounting of the composite HC plus NOx emission factors of their LAX GSE fleet; and
4. Provide LAWA with fleet inventory data for their LAX GSE Fleet that is consistent with data provided to the California Air Resources Board (CARB) and in a form or forms as requested by LAWA on an annual basis.

Current LAX GSE inventory includes emission-saving electric forklift

Current LAX GSE inventory includes emission-saving SmarteCarte electric baggage cart retriever

WAMA Status → Ongoing:
WAMA's compliance with this measure is accomplished through implementation of LAX-AQ-4. See measure 8.0.J LAX-AQ-4 – Operations-Related Control Measures (WAMA), below

MSC Status → Ongoing:
MSC's compliance with this measure is accomplished through implementation of LAX-AQ-4. See measure 8.0.N LAX-AQ-4 – Operations-Related Control Measures (MSC), below.

8.0.H LAX-AQ-1 General Air Quality Control Measures (WAMA)

The WAMA MMRP states in part:

"This measure describes a variety of specific actions to reduce air quality impacts associated with projects at LAX, and applies to all projects. Specific measures are identified below:"

1a "Watering (per SCAQMD Rule 403 and CalEEMod default) – twice daily"
1b "Ultra-low sulfur diesel (ULSD) fuel will be used in construction equipment.
1c Post a publicly visible sign with the telephone number and person to contact regarding dust complaints; this person shall respond and take corrective action within 24 hours. "
1d "Prior to final occupancy, the applicant demonstrates that all ground surfaces are covered or treated sufficiently to minimize fugitive dust emissions."
1e "All roadways, driveways, sidewalks, etc., being installed as part of the project should be completed as soon as possible; in addition, building pads should be laid as soon as possible after grading."
1f "Prohibit idling or queuing of diesel-fueled vehicles and equipment in excess of five minutes. This requirement will be included in specifications for any LAX projects requiring on-site construction."
1g "Require that all construction equipment working on-site is properly maintained (including engine tuning) at all times in accordance with manufacturers' specifications and schedules."

WAMA Status → Ongoing:

The status of these measures during the reporting period is as follows:

1a The vast majority of grading and other notable dust generating activities at the WAMA site were completed in 2015 and the site was paved/stabilized prior to the 2016 reporting period. As such, the need for dust control measures in 2016 was minimal; nevertheless, the dust control program requirements were met in 2016.
1b ULSD is the only fuel commercially available and is used in all construction equipment. No shortage of ULSD was experienced within Southern California during the 2016 reporting period, and no substitution of ULSD occurred on the WAMA project.
1c Not Applicable. Grading activities and other notable dust-related activities at the WAMA site did not occur in 2016; therefore, the dust complaint sign that was posted on Pershing Drive during the previous MMRP reporting years was removed.
1d On the LAWA component, LAWA completed all major concrete work associated with the WAMA apron in 2015 and Phase I of the project was operational in December 2015. For the Qantas hangar component, the contractor finished the remaining concrete work in early 2016 and employee parking lot paving was completed a few months later.
1e See 1 d above.
1f This requirement is a condition of the Qantas lease**.** LAWA monitors and inspectors monitored compliance with this requirement. There were no written violations in 2016.

1g This requirement is a condition of the Qantas lease**.** LAWA inspectors and monitors monitor compliance with this requirement. When new diesel equipment was proposed to be used, construction firm was required to submit, in writing, the scheduled maintenance procedures for the equipment. All such maintenance plans were reviewed by LAWA monitors.

8.0.I LAX-AQ-2 LAX Master Plan - Mitigation Plan for Air Quality; Construction-Related Measures (WAMA)

The WAMA MMRP states:

"This measure describes numerous specific actions to reduce fugitive dust emissions and exhaust emissions from on-road and off-road mobile and stationary sources used in construction. Some components of LAX-AQ-2 are not readily quantifiable, but would be implemented as part of LAX Master Plan projects. These control strategies are expected to reduce construction-related emissions." The mitigation elements presented in LAX-AQ-2 were derived from LAX Master Plan Mitigation Measure MM-AQ-2. "Specific measures applicable to the Project are below:"

2a "All diesel-fueled equipment used for construction will be outfitted with the best available emission control devices, where technologically feasible, primarily to reduce emissions of diesel particulate matter (PM), including fine PM ($PM_{2.5}$), and secondarily, to reduce emissions of NO_X. This requirement shall apply to diesel-fueled off-road equipment (such as construction machinery), diesel-fueled on-road vehicles (such as trucks), and stationary diesel-fueled engines (such as electric generators). (It is unlikely that this measure will apply to equipment with Tier 4 engines.) The emission control devices utilized in construction equipment shall be verified or certified by California Air Resources Board or US Environmental Protection Agency for use in on-road or off-road vehicles or engines. For multi-year construction projects, a reassessment shall be conducted annually to determine what constitutes a best available emissions control device."

2b "Watering (Watering (per SCAQMD Rule 403 and CalEEMod default) – three times daily."

2c "Pave all construction access roads at least 100 feet onto the site from the main road."

2d "To the extent feasible, have construction employees' work/commute during off-peak hours."

2e "Make available on-site lunch trucks during construction to minimize off-site worker vehicle trips."

2f "Utilize on-site rock crushing facility, when feasible, during construction to reuse rock/concrete and minimize off-site truck haul trips."

2g "Specify combination of electricity from power poles and portable diesel- or gasoline-fueled generators using "clean burning diesel" fuel and exhaust emission controls."

2h "Suspend use of all construction equipment during a second- stage smog alert in the immediate vicinity of LAX."

2i "Utilize construction equipment having the minimum practical engine size (i.e., lowest appropriate horsepower rating for intended job)."

2j "Prohibit tampering with construction equipment to increase horsepower or to defeat emission control devices."

2k "The contractor or builder shall designate a person or persons to ensure the implementation of all components of the construction-related measure through direct inspections, record reviews, and investigations of complaints."

2l "LAWA will locate rock-crushing operations and construction material stockpiles for all LAX-related construction in areas away from LAX-adjacent residents, to the extent possible, to reduce impacts from emissions of fugitive dust."

2m "LAWA will ensure that there is available and sufficient infrastructure on-site, where not operationally or technically infeasible, to provide fuel to alternative-fueled vehicles to meet all requests for alternative fuels from contractors and other users of LAX. This will apply to construction equipment and to operations-related vehicles on-site. This provision will apply in conjunction with construction or modification of passenger gates related to implementation of the LAX Master Plan relative to the provision of appropriate infrastructure for electric GSE."

2n "On-road trucks used on LAX construction projects with a gross vehicle weight rating of at least 19,500 pounds shall, at a minimum, comply with USEPA 2007 on-road emissions standards for PM10 and NOX."

WAMA Status → Ongoing:

The status of these measures during the reporting period is as follows:

2a Not Applicable. The remaining component of the WAMA project in 2016 (i.e., completion of the Qantas hangar), did not require new/additional diesel construction equipment; all equipment used onsite was not reviewed/cleared in prior years.

2b The vast majority of grading and other notable dust generating activities at the WAMA site were completed in 2015 and the site was paved/stabilized prior to the 2016 reporting period. As such, the need for dust control measures in 2016 was minimal; nevertheless, the dust control program requirements for WAMA were met in 2016..

2c Complete. The entrance to the construction area is paved with asphalt.

2d For the WAMA project, in general, standard construction shift hours did not coincide with the heaviest commuter traffic periods during the 2016 reporting period. However, due to construction requirements, some specialty workers worked longer shifts that ended during the evening peak period; however, this was not typical and consisted of a very limited crew (e.g., 2 to 4 workers).

2e Lunch trucks visited the construction site or nearby construction staging/office area on a regular basis.

2f Not Applicable. The vast majority of paving for the WAMA project was completed prior to 2016 and there was no need for a rock crushing facility in 2016.

2g For the Qantas component of the WAMA project, construction equipment and offices used clean-burning generators during early part of 2016, until the necessary grid power connections by LADWP were completed and the use of generators was no longer needed.

2h Not applicable during the 2016 reporting period.

2i This requirement is a condition of the Qantas lease.

2j This requirement is a condition of the Qantas lease.

2k Project staff, including both LAWA personnel and construction contractor personnel, are responsible for implementing construction-related mitigation

measures. Compliance with these measures is discussed at weekly project meetings and at pre-activity meetings prior to starting new construction activities. A number of people are responsible for ensuring implementation of all components of the construction-related measure, including LAWA inspectors and mitigation monitors. Monitoring includes direct inspections, reviews of monthly reports, and investigation of complaints.

2l Not Applicable. The rock-crushing operation and related stockpiles were not needed, and did not occur, in the 2016 reporting period.

2m Sweepers are fueled by alternative fuels (compressed natural gas). In addition, many staff and some construction contractor vehicles are alternative-fueled vehicles. There is available and sufficient infrastructure to provide fuel to these alternatively-fueled vehicles.

2n Not applicable. The remaining component of the WAMA project in 2016 (i.e., completion of the Qantas hangar), did not require new/additional on-road trucks with a gross vehicle weight rating of at least 19,500 pounds that were not reviewed/cleared in previous years.

8.0.J LAX-AQ-4 Operations-Related Control Measures (WAMA)

The WAMA MMRP states in part:

4a. "This measure requires the conversion of LAX GSE to low and ultra-low emission technology (e.g., electric, fuel cell, and other future low-emission technologies)."

Status → Completed:
In April 2015 LAWA's Board of Airport Commissioners adopted a Ground Support Equipment Emissions Policy to reduce emissions. This requirement is in effect at LAX and applies to WAMA, once the project is operational. Also, it should be noted that as part of the WAMA project, electric Ground Support Equipment (eGSE) charging stations were installed in the western portion of the site to support the use of eGSE on aircraft being serviced and/or parked in the nearby area.

New state-of-the-art eGSE charging stations were installed as part of the WAMA Project

Other measures required by LAX-AQ-4 include the following:

4d. LAWA will require the use of electric lawn mowers and leaf blowers, as these unites become available for commercial use, for landscape maintenance

4e. LAWA will require the conversion of sweepers to alternative fuels or electric power for ongoing airfield and roadway maintenance. HEPA filters will be installed on airport sweepers where technologically and financially feasible without posing a safety hazard to airport operations.

4f. LAWA will ensure that there is available and sufficient alternative-fuel infrastructure.

Status → No action required at this time:
Components 4d, 4e, and 4f were not applicable during the 2016 reporting period because the WAMA project was not operational relative to those requirements.

8.0.K MM-AQ (WAMA)-1

The WAMA MMRP states:

"On-road trucks used on LAX construction projects with a gross vehicle weight rating of at least 19,500 pounds shall, at a minimum, comply with USEPA 2010 on-road emissions standards for PM10 and NOX. Contractor requirements to utilize such on-road haul trucks or the next cleanest vehicle available will be subject to the provisions of LAWA Air Quality Control Measure 2"x" (part of LAX Master Plan Commitment LAX-AQ-2, LAX Master Plan - Mitigation Plan for Air Quality; Construction-Related Measures). All off-road diesel-powered construction equipment greater than 50 horsepower shall meet, at a minimum, USEPA Tier 3 off-road emission standards. In addition, all off-road diesel-powered construction equipment greater than 50 hp with engines meeting USEPA Tier 3 off-road emission standards shall be retrofitted with a CARB-verified Level 3 Diesel Emissions Control Strategies (DECS). Any emissions control device used by the Contractor shall achieve emissions reductions that are no less than what could be achieved by a Level 3 diesel emissions control strategy for a similarly sized engine as defined by CARB regulations. In the event the Contractor is using off-road diesel-powered construction equipment with engines meeting USEPA Tier 4 off-road emission standards and is already supplied with a factory-equipped diesel particulate filter, no retrofitting with DECS is required. Contractor requirements to utilize Tier 3 equipment or next cleanest equipment available will be subject to the provisions of LAWA Air Quality Control Measure 2"x" (part of LAX Master Plan Commitment LAX-AQ-2, LAX Master Plan - Mitigation Plan for Air Quality; Construction-Related Measures). LAWA will encourage construction contractors to apply for SCAQMD "SOON" funds to accelerate clean-up of off-road diesel engine emissions."

WAMA Status → No action required at this time:
The remaining component of the WAMA project in 2016 (i.e., completion of the Qantas hangar) did not require new/additional diesel construction equipment that was not reviewed/cleared in prior years.

8.0.L LAX-AQ-1 General Air Quality Control Measures (MSC)

The MSC MMRP states in part:

"This measure describes a variety of specific actions to reduce air quality impacts associated with projects at LAX, and applies to all projects. Specific measures are identified below:"

1a "Watering (per SCAQMD Rule 403 and CalEEMod default) – twice daily"
1b "Ultra-low sulfur diesel (ULSD) fuel will be used in construction equipment.
1c "Post a publicly visible sign with the telephone number and person to contact regarding dust complaints; this person shall respond and take corrective action within 24 hours."
1d "Prior to final occupancy, the applicant demonstrates that all ground surfaces are covered or treated sufficiently to minimize fugitive dust emissions."
1e "All roadways, driveways, sidewalks, etc., being installed as part of the project should be completed as soon as possible; in addition, building pads should be laid as soon as possible after grading."
1f "Prohibit idling or queuing of diesel-fueled vehicles and equipment in excess of five minutes. This requirement will be included in specifications for any LAX projects requiring on-site construction."
1g "Require that all construction equipment working on-site is properly maintained (including engine tuning) at all times in accordance with manufacturers' specifications and schedules."

MSC Status → Ongoing:
Construction activities in 2016 included the demolition of the former Qantas Hangar and grading of the MSC-North construction site. The status of these measures during the reporting period is as follows:

1a Watering for dust control during construction activities, particularly the demolition of the former Qantas hangar, was conducted in accordance with SCAQMD Rule 403.
1b ULSD is the only fuel commercially available and is used in all construction equipment. No shortage of ULSD was experienced within Southern California during the 2016 reporting period, and no substitution of ULSD occurred on the MSC project.
1c Partially completed. A project information sign for demolition of the former Qantas hangar was posted by the entrance road. While the sign included a phone number to call in the event there was an issue or emergency related to the project site, it did not specifically indicate to call that number if dust is observed coming off the site. Notwithstanding, no dust-related phone calls were received at the number posted on the sign and no dust complaints related to the subject site (i.e., the Qantas Hangar Demolition Project site) were received on the LAWA Construction Hotline during the 2016 reporting period.
1d Not applicable during the 2016 reporting period.
1e Not applicable during the 2016 reporting period.
1f This requirement is included in the construction specifications for the MSC project**.** There were no written violations in 2016.
1g This requirement is included in the construction specifications for the MSC project**.** There were no written violations in 2016.

8.0.M LAX-AQ-2 – Construction-Related Measures (MSC)

The MSC MMRP states:

"This measure describes numerous specific actions to reduce fugitive dust emissions and exhaust emissions from on-road and off-road mobile and stationary sources used in construction. Some components of LAX-AQ-2 are not readily quantifiable, but would be implemented as part of LAX projects. Specific measures are outlined below:"

2a *"All diesel-fueled equipment used for construction will be outfitted with the best available emission control devices, where technologically feasible, primarily to reduce emissions of diesel particulate matter (PM), including fine PM ($PM_{2.5}$), and secondarily, to reduce emissions of NO_X. This requirement shall apply to diesel-fueled off-road equipment (such as construction machinery), diesel-fueled on-road vehicles (such as trucks), and stationary diesel-fueled engines (such as electric generators). (It is unlikely that this measure will apply to equipment with Tier 4 engines.) The emission control devices utilized in construction equipment shall be verified or certified by California Air Resources Board or US Environmental Protection Agency for use in on-road or off-road vehicles or engines. For multi-year construction projects, a reassessment shall be conducted annually to determine what constitutes a best available emissions control device."*

2b *"Watering (Watering (per SCAQMD Rule 403 and CalEEMod default) – three times daily."*

2c *"Pave all construction access roads at least 100 feet onto the site from the main road."*

2d *"To the extent feasible, have construction employees' work/commute during off-peak hours."*

2e *"Make available on-site lunch trucks during construction to minimize off-site worker vehicle trips."*

2f *"Utilize on-site rock crushing facility, when feasible, during construction to reuse rock/concrete and minimize off-site truck haul trips."*

2g *"Specify combination of electricity from power poles and portable diesel- or gasoline-fueled generators using "clean burning diesel" fuel and exhaust emission controls."*

2h *"Suspend use of all construction equipment during a second- stage smog alert in the immediate vicinity of LAX."*

2i *"Utilize construction equipment having the minimum practical engine size (i.e., lowest appropriate horsepower rating for intended job)."*

2j *"Prohibit tampering with construction equipment to increase horsepower or to defeat emission control devices."*

2k *"The contractor or builder shall designate a person or persons to ensure the implementation of all components of the construction-related measure through direct inspections, record reviews, and investigations of complaints."*

2l *"LAWA will locate rock-crushing operations and construction material stockpiles for all LAX-related construction in areas away from LAX-adjacent residents, to the extent possible, to reduce impacts from emissions of fugitive dust."*

2m *"LAWA will ensure that there is available and sufficient infrastructure on-site, where not operationally or technically infeasible, to provide fuel to alternative-fueled vehicles to meet all requests for alternative fuels from contractors and*

other users of LAX. This will apply to construction equipment and to operations-related vehicles on-site. This provision will apply in conjunction with construction or modification of passenger gates related to implementation of the LAX Master Plan relative to the provision of appropriate infrastructure for electric GSE."

MSC Status → Ongoing:
Construction was ongoing in 2016, and included the demolition of the former Qantas Hangar and grading of the MSC-North Concourse construction site. The status of applicable measures during the reporting period is as follows:

2a For the 2016 reporting period, a total of thirty-four (34) pieces of equipment were evaluated for the MSC-North Concourse project. For on-road vehicles, one (1) truck was evaluated; this vehicle met or exceeded the EPA 2007 standards and was equipped with a factory installed VDECS. Relative to off-road diesel equipment, a total of thirty-three (33) pieces of construction equipment have undergone independent monitoring. Nineteen (19) were certified by the US EPA as compliant with Tier 4 or Tier 4-Interim Emissions Standards – this equipment is configured with a factory-installed diesel emission control system. Four (4) pieces of equipment were determined to not have a VDECS available at the time construction commenced. Ten (10) pieces of equipment were granted a "20-day" exemption in accordance with CBA Section X.F.4.

For the 2016 reporting period, a total of one hundred forty-four (144) pieces of equipment were evaluated for the Qantas Hangar Demolition project, of which one hundred forty-one (141) pieces were approved by LAWA for airfield use. (Note: That project was completed in December 2016). A total of ninety (90) on-road vehicles were evaluated; eighty-one (81) met or exceeded the EPA 2007 standards and were equipped with a Level 3 VDECS. Of these 81 vehicles, sixty-eight (68) were equipped with a factory-installed Level 3 VDECS, and thirteen (13) underwent retrofit with a Level 3 VDECS. Three (3) on-road vehicles were powered by Compressed Natural Gas (CNG). These vehicles are deemed to comply with the air quality provisions of CBA Section X.F. Two (2) on-road vehicles were rejected by LAWA, as they were not equipped with a VDECS and did not meet the requirements for an exemption in accordance with CBA Section C.F.4. Four (4) on-road vehicles were granted a "20-day" exemption in accordance with the CBA Section X.F.4.

Relative to off-road diesel equipment associated with the Qantas Hangar Demolition project in 2016, a total of fifty-four (54) pieces of off-road construction equipment underwent independent third party monitoring. Fifty-two (52) pieces of diesel construction equipment were certified by the US EPA as compliant with Tier 4 or Tier 4-Interim Emissions Standards - this equipment is configured with a factory-installed VDECS. One (1) piece of diesel off-road construction equipment was rejected by LAWA due to incomplete paperwork. Finally, one (1) piece of diesel equipment was granted a "20-day" exemption in accordance with CBA Section X.F.4.

2b Watering for dust control during construction activities was done in accordance with SCAQMD Rule 403.

2c Not applicable. For the Qantas Hangar Demolition Project, the road leading to the project site is an existing paved road (i.e., World Way West), and within the

project site, the areas immediately surrounding the hangar demolition subarea is also paved (i.e., aircraft apron areas).

2d The standard construction shift for the MSC project did not coincide with the heaviest commuter traffic periods during the 2016 reporting period. Worker shifts typically started around 5:00 a.m.

2e Lunch trucks periodically visited sites near the various MSC construction activity areas, as well as, the construction site office located near World Way West.

2g The majority of the power requirements for electrical tools and construction offices at the Qantas Hangar demolition site were provided by grid power during the 2016 reporting period.

2h Not applicable during the 2016 reporting period.

2i This requirement is included in the construction specifications for the MSC project. There were no written violations in 2016.

2j This requirement is included in the construction specifications for the MSC project. There were no written violations in 2016.

2k Project staff, including both LAWA personnel and construction contractor personnel, is responsible for implementing construction-related mitigation measures. Compliance with these measures is discussed at weekly project meetings and at pre-activity meetings prior to starting new construction activities. A number of people are responsible for ensuring implementation of all components of the construction-related measure, including LAWA inspectors and mitigation monitors. Monitoring includes direct inspections, reviews of monthly reports, and investigation of complaints.

2l The rock-crushing operation and related stockpiles were located away from adjacent residents.

2m Three (3) compressed natural gas (CNG) on-road vehicles were operated during the Qantas Hangar Demolition MSC enabling project. These vehicles were able to refuel at the CNG station located at LAX.

CAT 988H Loader with Tier 4-interim engine
used at the concrete crusher at the MSC Project

8.0.N LAX-AQ-4 Operations-Related Control Measures (MSC)

The MSC MMRP states in part:
"The principal feature of this measure is the conversion of LAX GSE to low and ultra-low emission technology (e.g., electric, fuel cell, and other future low-emission technologies). Specific measures are identified below:"

4a *"LAX GSE will be converted to low- and ultra-low emission technology (e.g., electric, fuel cell, and other future low-emission technologies). Both LAWA- and tenant-owned equipment will be included in this conversion program, which will be implemented in phases. LAWA will assign a GSE coordinator whose responsibility it will be to ensure the successful conversion of GSE in a timely manner. This coordinator will have adequate authority to negotiate on behalf of the City and have sufficient technical support to evaluate technical issues that arise during the implementation of this measure."*

4b "*All passenger gates newly constructed at LAX shall be equipped with and able to provide grid electricity to parked aircraft (for lighting and ventilation) from and after the date of initial operation. LAWA will ensure that all aircraft (unless exempt) use the gate-provided grid electricity in lieu of electricity provided by operation of an auxiliary or ground power unit. This provision applies in conjunction with construction or modification of passenger gates."*

4e *"LAWA will require the conversion of sweepers to alternative fuels or electric power for ongoing airfield and roadway maintenance. In the 2006 GSE inventory, two of ten sweepers were electric-powered and one was either CNG or LPG fueled. HEPA filters will be installed on airport sweepers where the use of HEPA filters is technologically and financially feasible and does not pose a safety hazard to airport operations."*

4f *"LAWA will ensure that there is available and sufficient infrastructure on-site, where not operationally or technically infeasible, to provide fuel to alternative-fueled vehicles to meet all requests for alternative fuels from contractors and other users of LAX. This will apply to construction equipment and to operations-related vehicles on-site. This provision will apply in conjunction with construction or modification of passenger gates related to implementation of the LAX Master Plan relative to the provision of appropriate infrastructure for electric GSE.*

MSC Status → No action required at this time:
This component was not applicable during the 2016 reporting period because the MSC project was not operational. In April 2015, LAWA's Board of Airport Commissioners adopted a Ground Support Equipment Emissions Policy to reduce emissions. This requirement is in effect at LAX and will apply to MSC once the project is operational.

8.0.O MM-AQ (MSC)-1

The MSC MMRP states in part:

2n *"On-road trucks used on LAX construction projects with a gross vehicle weight rating of at least 19,500 pounds shall, at a minimum, comply with USEPA 2010 on-road emissions standards for PM10 and NOx. Contractor requirements to utilize such on-road haul trucks or the next cleanest vehicle available will be subject to the provisions of LAWA Air Quality Control Measure 2p below.*

2o Prior to January 1, 2015, all off-road diesel-powered construction equipment greater than 50 horsepower shall meet, at a minimum, USEPA Tier 3 off-road emission standards. After December 31, 2014, all off-road diesel-power construction equipment greater than 50 horsepower shall meet USEPA Tier 4(final) off-road emissions standards. Tier 4(final) equipment shall be considered based on availability at the time the construction bid is issued. Contractor requirements to utilize Tier 4(final) equipment or the next cleanest equipment available will be subject to the provisions of LAWA Air Quality Control Measure 2p below. LAWA will encourage construction contractors to apply for SCAQMD "SOON" funds to accelerate clean-up of off-road diesel engine emissions

2p The on-road haul truck and off-road construction equipment requirements set forth in Air Quality Control Measures 2n and 2o above shall apply unless any of the following circumstances exist and the Contractor provides a written finding consistent with project contract requirements that:

- *The Contractor does not have the required types of on-road haul trucks or off-road construction equipment within its current available inventory and intends to meet the requirements of the Measures 2n and 2o as to a particular vehicle or piece of equipment by leasing or short-term rental, and the Contractor has attempted in good faith and due diligence to lease the vehicle or equipment that would comply with these measures, but that vehicle or equipment is not available for lease or short-term rental within 120 miles of the project site, and the Contractor has submitted documentation to LAWA showing that the requirements of this exception provision (Measure 2p) apply.*

- *The Contractor has been awarded funding by SCAQMD or another agency that would provide some or all of the cost to retrofit, repower, or purchase a piece of equipment or vehicle, but the funding has not yet been provided due to circumstances beyond the Contractor's control, and the Contractor has attempted in good faith and due diligence to lease or short-term rent the equipment or vehicle that would comply with Measures 2n and 2o, but that equipment or vehicle is not available for lease or short-term rental within 120 miles of the project site, and the Contractor has submitted documentation to LAWA showing that the requirements of this exception provision (Measure 2p) apply.*

- *Contractor has ordered a piece of equipment or vehicle to be used on the construction project in compliance with Measures 2n and 2o at least 60 days before that equipment or vehicle is needed at the project site, but that equipment or vehicle has not yet arrived due to circumstances beyond the Contractor's control, and the Contractor has attempted in good faith and due diligence to lease or short-term rent a piece of equipment or vehicle to meet the requirements of Measures 2n and 2o, but that equipment or vehicle is not available for lease or short-term rental within 120 miles of the project, and the Contractor has submitted documentation to LAWA showing that the requirements of this exception provision (Measure 2p) apply.*

- *Construction-related diesel equipment or vehicle will be used on the project site for fewer than 20 calendar days per calendar year. The Contractor shall*

not consecutively use different equipment or vehicles that perform the same or a substantially similar function in an attempt to use this exception (Measure 2p) to circumvent the intent of Measures 2n and 2o.

In any of the situations described above, the Contractor shall provide the next cleanest piece of equipment or vehicle as provided by the step down schedules in Table 4.1-45 for Off-Road Equipment and Table 4.1-46 for On-Road Equipment. (Tables provided in MMRP)"

MSC Status → Ongoing:
Construction activities in 2016 included the demolition of the former Qantas Hangar and grading of the MSC-North Concourse construction site. The status of applicable measures during the reporting period is as follows:

2n A total of ninety (91) on-road vehicles were evaluated for both the Qantas Hangar Demolition project and the MSC-North Concourse project during the 2016 reporting period; eighty-two (82) met or exceeded the EPA 2007 standards and were equipped with a Level 3 VDECS. Of these 82 vehicles, sixty-nine (69) were equipped with a factory-installed Level 3 VDECS, and thirteen (13) underwent retrofit with a Level 3 VDECS. Three (3) on-road vehicles were powered by compressed natural gas (CNG). These vehicles are deemed to comply with the air quality provisions of CBA Section X.F. Two (2) on-road vehicles were rejected by LAWA, as they were not equipped with a VDECS and did not meet the requirements for an exemption in accordance with CBA Section C.F.4.

2o A total of eighty-seven (87) pieces of off-road construction equipment were evaluated for both the Qantas Hangar Demolition project and the MSC-North Concourse project during the 2016 reporting period; seventy-one (71) were certified by the US EPA as compliant with Tier 4 or Tier 4-Interim Emissions Standards. One (1) piece of off-road construction equipment was rejected by LAWA due to incomplete paperwork. Four (4) pieces of construction equipped were determined to be incompatible with a CARB or EPA-verified VDECS. (Eleven pieces of equipment were exempted; see 2p below.)

2p For both the Qantas Hangar Demolition project and the MSC-North Concourse project during the 2016 reporting period, a total of eleven (11) pieces of off-road construction equipment were granted airfield access under the provision of a 20-day exemption. This is in accordance with CBA Section X.F.4.

9.0 Hydrology and Water Quality

9.0.A HWQ-1 Conceptual Drainage Plan

The LAX Master Plan MMRP states in part:

*"**Conceptual Drainage Plan.** Once a Master Plan alternative is selected, and in conjunction with its design, LAWA will develop a conceptual drainage plan of the area within the boundaries of the Master Plan alternative (in accordance with FAA guidelines and to the satisfaction of the City of Los Angeles Department of Public Works, Bureau of Engineering). The purpose of the drainage plan will be to assess area-wide drainage flows as related to the Master Plan project area, and at a level of detail sufficient to identify the overall improvements necessary to provide adequate drainage capacity to prevent flooding."*

Status → Completed:
LAWA completed a Conceptual Drainage Plan which was adopted in conjunction with the SAIP.

9.0.B MM-HWQ-1 Update Regional Drainage Facilities

The LAX Master Plan MMRP states:

*"**Update Regional Drainage Facilities.** Regional drainage facilities should be upgraded, as necessary, in order to accommodate current and projected future flows within the watershed of each stormwater outfall resulting from cumulative development. This could include upgrading the existing outfalls, or building new ones. The responsibility for implementing this mitigation measure lies with the Los Angeles County Department of Public Works and/or the City of Los Angeles Department of Public Works, Bureau of Engineering. A portion of the increased costs for the upgraded flood control and drainage facilities would be paid by LAX tenants and users in accordance with the possessory interest tax laws and other legal assessments, consistent with federal airport revenue diversion laws and regulations and in compliance with state, county and city laws. The new or upgraded facilities should be designed in accordance with the drainage design standards of each agency."*

Status → Ongoing:
Although not responsible for implementing this mitigation measure, LAWA evaluates the post-construction drainage conditions for ongoing and future projects to determine if regional drainage facilities should be upgraded.

10.0 Historical/Architectural and Archaeological/Cultural Resources

10.0.A HR-1 Preservation of Historic Resources

The LAX Master Plan MMRP states:

"Preservation of Historic Resources. *In implementing the LAX Plan and conducting ongoing activities associated with operation of the airport, LAWA will support the preservation of identified significant historic/architectural resources through careful review of design and development adjacent to those resources and by undertaking any modifications to those resources in a manner consistent with the Secretary of the Interior's Standards for the Treatment of Historic Properties. Additionally, where sound insulation is proposed for identified significant historic/architectural resources under the Aircraft Noise Mitigation Program, LAWA will ensure that methods are developed with the approval of a qualified architectural historian or historic architect, who meets the Secretary of the Interior's Professional Qualifications Standards, in compliance with the Secretary of the Interior's Standards for Rehabilitation."*

Status → No additional action required at this time:
Any project at LAWA involving a designated City of Los Angeles Historic-Cultural Monument is required to be reviewed by the Office of Historic Resources of the City of Los Angeles before any changes to the resource are approved. The historic preservation architect within this division of the Department of City Planning is charged with this responsibility. No action was required during the 2016 reporting period as there were no LAX Master Plan projects in 2016 that triggered this measure.

However, a historic resources survey of property owned by LAWA at LAX was conducted in 2015 to identify any potential historic resources at the airport and a Preservation Plan for historic resources at LAX was adopted in 2016. The Preservation Plan provides appropriate guidance for the future repair, maintenance, and alteration of historic resources; and creates an appropriate process for review of future projects with respect to historic resources.

10.0.B MM-HA-1 Historic American Buildings Survey (HABS) Document

The LAX Master Plan MMRP states in part:

*"**Historic American Buildings Survey (HABS) Document.*** *For historic properties eligible at the federal, state or local levels that are proposed for demolition or partial demolition (i.e., the International Airport Industrial District), a Historic American Buildings Survey (HABS) document shall be prepared by LAWA in accordance with the Secretary of the Interior's Guidelines for Architectural and Engineering Documentation Standards. The level of documentation (I, II, III) shall be determined by the National Park Service (NPS)."*

Status → No additional action required at this time:
No action was required during the 2016 reporting period as no historic buildings were proposed for demolition or partial demolition in 2016.

10.0.C MM-HA-2 Historic Educational Materials

The LAX Master Plan MMRP states in part:

Historic Educational Materials. *For the significant historic resources proposed for demolition or partial demolition, educational materials suitable for the general public, secondary school use, and/or aviation historians and enthusiasts shall be designed with the assistance of a qualified historic preservation professional and implemented by LAWA.*

Status → No additional action required at this time:
No action was required during the 2016 reporting period as no historic buildings were proposed for demolition or partial demolition in 2016.

10.0.D MM-HA-4 Discovery

The LAX Master Plan MMRP states in part:

*"**Discovery.** The FAA shall prepare an archaeological treatment plan (ATP), in consultation with SHPO, that ensures the long-term protection and proper treatment of those unexpected archaeological discoveries of federal, state, and/or local significance found within the APE of the selected alternative."*

Status → Completed:
Subsequent to the adoption of this measure, LAWA prepared an Archaeological Treatment Plan (ATP) in June 2005. In addition to fulfilling the requirements of MM-HA-4, the ATP incorporates the requirements of LAX Master Plan Mitigation Measures MM-HA-4 through MM-HA-10 and provides details regarding compliance with these measures. Master Plan projects comply with the ATP and thus comply with Mitigation Measure MM-HA-4.

10.0.E MM-HA-5 Monitoring

The LAX Master Plan MMRP states in part:

*"**Monitoring.** Any grading and excavation activities within LAX proper or the acquisition areas that have not been identified as containing redeposited fill material or having been previously disturbed shall be monitored by a qualified archaeologist."*

Status → Ongoing:
Monitoring of grading and excavation activities is required on all Master Plan projects with the potential for encountering archaeological resources. Each project at LAX undergoes environmental analysis and clearances before grading and excavation activities are performed, and this environmental clearance identifies the potential need for a project archeologist. LAWA and project archeologists adhere to the guidelines provided in the Archeological Treatment Plan (ATP), in compliance with Section 106 of the National Historic Preservation Act (NHPA), the California Environmental Quality Act (CEQA), and the environmental guidelines of local agencies regarding the treatment of

unexpected archeological discoveries of federal, state, and/or local significance that may be encountered during construction activities.

10.0.F MM-HA-6 Excavation and Recovery

The LAX Master Plan MMRP states:

*"**Excavation and Recovery**. Any excavation and recovery of identified resources (features) shall be performed using standard archaeological techniques and the requirements stipulated in the ATP. Any excavations, testing, and/or recovery of resources shall be conducted by a qualified archaeologist selected by LAWA."*

BWP Status → Completed

WAMA Status → Ongoing:
WAMA's compliance with this measure is accomplished through implementation of ARCHAEO-1. See measure 10.0.L ARCHAEO-1, below.

MSC Status → Ongoing:
MSC's compliance with this measure is accomplished through implementation of MM-HA (MSC)-1. See measure 10.0.M MM-HA (MSC)-1 Conformance with LAX Master Plan Archaeological Treatment Plan, below.

10.0.G MM-HA-7 Administration

The LAX Master Plan MMRP states:

*"**Administration.** Where known resources are present, all grading and construction plans shall be clearly imprinted with all of the archaeological/cultural mitigation measures. All site workers shall be informed in writing by the on-site archaeologist of the restrictions regarding disturbance and removal as well as procedures to follow should a resource deposit be detected."*

BWP Status → Completed

WAMA Status → Ongoing:
WAMA's compliance with this measure is accomplished through implementation of ARCHAEO-1. See measure 10.0.L ARCHAEO-1, below.

MSC Status → Ongoing:
MSC's compliance with this measure is accomplished through implementation of MM-HA (MSC)-1. See measure 10.0.M MM-HA (MSC)-1 Conformance with LAX Master Plan Archaeological Treatment Plan, below.

10.0.H MM-HA-8 Archaeological/Cultural Monitor Report

The LAX Master Plan MMRP states in part:

*"**Archaeological/Cultural Monitor Report.** Upon completion of grading and excavation activities in the vicinity of known archaeological resources, the Archaeological/Cultural monitor shall prepare a written report. The report shall include the results of the fieldwork and all appropriate laboratory and analytical studies that were performed in conjunction with the excavation."*

BWP Status → Completed

WAMA Status→ Ongoing:
WAMA's compliance with this measure is accomplished through implementation of ARCHAEO-1. See measure 10.0.L ARCHAEO-1, below.

MSC Status → Ongoing:
MSC's compliance with this measure is accomplished through implementation of MM-HA (MSC)-1. See measure 10.0.M MM-HA (MSC)-1 Conformance with LAX Master Plan Archaeological Treatment Plan, below.

10.0.I MM-HA-9 Artifact Curation

The LAX Master Plan MMRP states:

*"**Artifact Curation.** All artifacts, notes, photographs, and other project-related materials recovered during the monitoring program shall be curated at a facility meeting federal and state standards."*

BWP Status → Completed

WAMA Status → Ongoing:
WAMA's compliance with this measure is accomplished through implementation of ARCHAEO-1. See measure 10.0.L ARCHAEO-1, below.

MSC Status → Ongoing:
MSC's compliance with this measure is accomplished through implementation of MM-HA (MSC)-1. See measure 10.0.M MM-HA (MSC) -1 Conformance with LAX Master Plan Archaeological Treatment Plan, below.

10.0.J MM-HA-10 Archaeological Notification

The LAX Master Plan MMRP states:

*"**Archaeological Notification.** If human remains are found, all grading and excavation activities in the vicinity shall cease immediately and the appropriate LAWA authority shall be notified: compliance with those procedures outlined in Section 7050.5(b) and (c) of the State Health and Safety Code, Section 5097.94(k) and (i) and Section 5097.98(a)*

and (b) of the Public Resources Code shall be required. In addition, those steps outlined in Section 15064.5(e) of the CEQA Guidelines shall be implemented."

BWP Status → Completed

WAMA Status → Ongoing:
WAMA's compliance with this measure is accomplished through implementation of ARCHAEO-1. See measure 10.0.L ARCHAEO-1, below.

MSC Status → Ongoing:
MSC's compliance with this measure is accomplished through implementation of MM-HA (MSC)-1. See measure 10.0.M MM-HA (MSC)-1 Conformance with LAX Master Plan Archaeological Treatment Plan, below.

10.0.K MM-HA (BWP)-1 Conformance with LAX Master Plan Archaeological Treatment Plan

The Bradley West Project MMRP states in part:

*"**Conformance with LAX Master Plan Archaeological Treatment Plan.** Prior to initiation of grading and construction activities, LAWA will retain an on-site Cultural Resource Monitor (CRM), as defined in the LAX Master Plan MMRP ATP, who will determine if the proposed project area is subject to archaeological monitoring."*

BWP Status → Completed:
LAWA retained an on-site Cultural Resource Monitor for the Bradley West Project. Archaeological resource monitoring was conducted during the excavation phase, which was completed in June 2011.

10.0.L ARCHAEO-1

The WAMA MMRP states in part:

"Prior to initiation and construction activities, LAWA will retain an on-site Cultural Resources Monitor (CRM), as defined in the LAX Master Plan Mitigation Monitoring and Reporting Program (MMRP) Archaeological Treatment Plan (ATP), who will determine if the project site is subject to archaeological monitoring. If the CRM determines that the Project site is subject to archaeological monitoring, a qualified archaeologist… shall be retained by LAWA to inspect excavation and grading activities that occur within native material."

WAMA Status → Ongoing:
Prior to the initiation of construction of the WAMA project (including both the LAWA project component and the Qantas hangar component), LAWA retained an on-site Cultural Resource Monitor (CRM). During the 2016 reporting period, there was no excavation/grading that extended down into native material " (where the potential exists for encountering archaeological resources); hence, no CRM monitoring was warranted or occurred during the 2016 reporting period.

10.0.M MM-HA (MSC)-1 Conformance with LAX Master Plan Archaeological Treatment Plan

The MSC MMRP states in part:

"Conformance with LAX Master Plan Archaeological Treatment Plan. Prior to initiating grading and construction activities, LAWA will retain an on-site Cultural Resource Monitor (CRM), as defined in the LAX Master Plan Mitigation Monitoring and Reporting Program Archaeological Treatment Plan (ATP), who will determine if the proposed project area is subject to archaeological monitoring."

MSC Status → Ongoing:
During the reporting period, an on-site Cultural Resource Monitor (CRM) was retained for the MSC project who determined that archaeological monitoring would be required for those portions of the project that require deep excavation into native materials" (where the potential exists for encountering archaeological resources). However, during the 2016 reporting period, excavation into native materials did not occur.

11.0 Paleontological Resources

11.0.A MM-PA-1 Paleontological Qualification and Treatment Plan

The LAX Master Plan MMRP states:

*"**Paleontological Qualification and Treatment Plan.** A qualified paleontologist shall be retained by LAWA to develop an acceptable monitoring and fossil remains treatment plan (that is, a Paleontological Management Treatment Plan - PMTP) for construction-related activities that could disturb potential unique paleontological resources within the project area. This plan shall be implemented and enforced by the project proponent during the initial phase and full phase of construction development. The monitoring and treatment plan shall be subject to approval by the Vertebrate Paleontology Section of the Natural History Museum of Los Angeles County to comply with paleontological requirements, as appropriate."*

Status → Completed:
The Paleontological Management Treatment Plan (PMTP) was prepared and revised in December 2005. In addition to fulfilling the requirements of MM-PA-1, the PMTP incorporates the requirements of LAX Master Plan Mitigation Measures MM-PA-2 through MM-PA-7 and provides details regarding compliance with these measures. Master Plan projects comply with the PMTP and thus comply with Mitigation Measure MM-PA-1.

11.0.B MM-PA-2 Paleontological Authorization

The LAX Master Plan MMRP states:

*"**Paleontological Authorization.** The paleontologist shall be authorized by LAWA to halt, temporarily divert, or redirect grading in the area of an exposed fossil to facilitate evaluation and, if necessary, salvage. No known or discovered fossils shall be destroyed without the written consent of the project paleontologist."*

BWP Status → Completed

WAMA Status → Ongoing:
WAMA's compliance with this measure is accomplished through implementation of PALEO-1. See measure 11.0.J PALEO-1, below.

MSC Status → Ongoing:
MSC's compliance with this measure is accomplished through implementation of MM-PA (MSC)-1. See measure 11.0.L MM-PA (MSC)-1 Conformance with LAX Master Plan Paleontological Management Treatment Plan, below.

11.0.C MM-PA-3 Paleontological Monitoring Specifications

The LAX Master Plan MMRP states:

"Paleontological Monitoring Specifications. *Specifications for paleontological monitoring shall be included in construction contracts for all LAX projects involving excavation activities deeper than six feet."*

BWP Status → Completed

WAMA Status → Ongoing:
WAMA's compliance with this measure is accomplished through implementation of PALEO-1. See measure 11.0.J PALEO-1, below.

MSC Status → Ongoing:
MSC's compliance with this measure is accomplished through implementation of MM-PA (MSC)-1. See measure 11.0.L MM-PA (MSC)-1 Conformance with LAX Master Plan Paleontological Management Treatment Plan, below.

11.0.D MM-PA-4 Paleontological Resources Collection

The LAX Master Plan MMRP states:

"Paleontological Resources Collection. *Because some fossils are small, it will be necessary to collect sediment samples of promising horizons discovered during grading or excavation monitoring for processing through fine mesh screens. Once the samples have been screened, they shall be examined microscopically for small fossils."*

BWP Status → Completed

WAMA Status → No action required at this time:
WAMA's compliance with this measure is accomplished through implementation of PALEO-1. See measure 11.0.J PALEO-1, below.

MSC Status → No action required at this time:
MSC's compliance with this measure is accomplished through implementation of MM-PA (MSC)-1. See measure 11.0.L MM-PA (MSC)-1 Conformance with LAX Master Plan Paleontological Management Treatment Plan, below.

11.0.E MM-PA-5 Fossil Preparation

The LAX Master Plan MMRP states:

"Fossil Preparation. *Fossils shall be prepared to the point of identification and catalogued before they are donated to their final repository."*

BWP Status→ Completed

WAMA Status → No action required at this time:
WAMA's compliance with this measure is accomplished through implementation of PALEO-1. See measure 11.0.J PALEO-1, below.

MSC Status → No action required at this time:
MSC's compliance with this measure is accomplished through implementation of MM-PA (MSC)-1. See measure 11.0.L MM-PA (MSC)-1 Conformance with LAX Master Plan Paleontological Management Treatment Plan, below.

11.0.F MM-PA-6 Fossil Donation

The LAX Master Plan MMRP states:

"Fossil Donation. *All fossils collected shall be donated to a public, nonprofit institution with a research interest in the materials, such as the Los Angeles County Museum of Natural History."*

BWP Status → Completed

WAMA Status → No action required at this time:
WAMA's compliance with this measure is accomplished through implementation of PALEO-1. See measure 11.0.J PALEO-1, below.

MSC Status → No action required at this time:
MSC's compliance with this measure is accomplished through implementation of MM-PA (MSC)-1. See measure 11.0.L MM-PA (MSC)-1 Conformance with LAX Master Plan Paleontological Management Treatment Plan, below.

11.0.G MM-PA-7 Paleontological Reporting

The LAX Master Plan MMRP states:

"Paleontological Reporting. *A report detailing the results of these efforts, listing the fossils collected, and naming the repository shall be submitted to the lead agency at the completion of the project."*

BWP Status → Completed:

WAMA Status → No action required at this time:
WAMA's compliance with this measure is accomplished through implementation of PALEO-1. See measure 11.0.J PALEO-1, below.

MSC Status → No action required at this time:
MSC's compliance with this measure is accomplished through implementation of MM-PA (MSC)-1. See measure 11.0.L MM-PA (MSC)-1 Conformance with LAX Master Plan Paleontological Management Treatment Plan, below.

11.0.H MM-PA (BWP)-1 Conformance with LAX Master Plan PaleontologicalManagement Treatment Plan

The Bradley West Project MMRP states in part:

*"**Conformance with LAX Master Plan Paleontological Management Treatment Plan.** Prior to the initiation of grading and construction activities, LAWA will retain a professional paleontologist, as defined in the Final LAX Master Plan MMRP PMTP, who will determine if the project site exhibits a high or low potential for subsurface resources."*

BWP Status → Completed:
LAWA retained an on-site Paleontological Resource Monitor for the Bradley West Project. Paleontological resource monitoring was conducted during the excavation phase, which was completed in June 2011.

11.0.I MM-PA (BWP)-2 Construction Personnel Briefing

The Bradley West Project MMRPs states:

*"**Construction Personnel Briefing.** In accordance with the PMTP, construction personnel will be briefed by the consulting paleontologist in the identification of fossils or fossilferous deposits and in the correct procedures for notifying the relevant individuals should such a discovery occur."*

BWP Status → Completed

11.0.J PALEO-1 (WAMA)

The WAMA MMRP states in part:

"Conformance with LAX Master Plan Paleontological Management Treatment Plan: (PMTP): Prior to the initiation of grading and construction activities, LAWA will retain a professional paleontologist, as defined in the Final LAX Master Plan MMRP PMTP, who will determine if the Project site exhibits a high or low potential for subsurface resources."

WAMA Status → Ongoing:
Prior to the initiation of construction of the WAMA project (including both the LAWA project component and the Qantas hangar component), LAWA retained an on-site Paleontological Resource Monitor (PRM). During the 2016 reporting period, there was no excavation/grading that extended down into native material (where the potential exists for encountering archaeological resources); hence no PRM monitoring was warranted or occurred during the 2016 reporting period.

11.0.K PALEO-2 (WAMA)

The WAMA MMRP states:

"Construction Personnel Briefing: In accordance with the PMTP, construction personnel will be briefed by the consulting paleontologist in the identification of fossils or fossilferous deposits and in the correct procedures for notifying the relevant individuals should such a discovery occur."

WAMA Status → Completed:
LAWA's consulting paleontologist conducted construction personnel briefings for the WAMA LAWA project component personnel and the Qantas hangar component personnel on October 24, 2014 and November 18, 2014, respectively.

11.0.L MM-PA (MSC)-1 Conformance with LAX Master Plan Paleontological Management Treatment Plan

The MSC MMRP states in part:

"Conformance with LAX Master Plan Paleontological Management Treatment Pla*n. Prior to the initiation of grading and construction activities, LAWA will retain a professional paleontologist, as defined in the LAX Master Plan Mitigation Monitoring and Reporting Program Paleontological Management Treatment Plan (PMTP), who will determine if the project site exhibits a high or low potential for subsurface resources."*

MSC Status→ Ongoing:
During the 2016 reporting period, LAWA retained an on-site Paleontological Resource Monitor for the MSC Project. However, during the 2016 reporting period, there was no excavation/grading that extended down into native material (where the potential exists for encountering archaeological resources).

11.0.M MM-PA (MSC)-2 Construction Personnel Briefing

The MSC MMRP states:

"Construction Personnel Briefing*. In accordance with the PMTP, construction personnel will be briefed by the consulting paleontologist in the identification of fossils or fossiliferous deposits and in the correct procedures for notifying the relevant individuals should such a discovery occur."*

MSC Status→ Ongoing:
LAWA held a pre-construction training session in December of 2016 to brief key construction personnel on the paleontological monitoring plan and requirements.

12.0 Biotic Communities

12.0.A MM-BC-1 Conservation of State-Designated Sensitive Habitat Within and Adjacent to the El Segundo Blue Butterfly Habitat Restoration Area

The LAX Master Plan MMRP states in part:

"Conservation of State-Designated Sensitive Habitat Within and Adjacent to the El Segundo Blue Butterfly Habitat Restoration Area. *LAWA or its designee shall take all necessary steps to ensure that state-designated sensitive habitats within and adjacent to the Habitat Restoration Area are conserved and protected during construction, operation, and maintenance."*

Status → In Progress:
LAWA continues to maintain and manage the El Segundo Blue Butterfly (ESBB) Habitat Restoration Area, including restoration, monitoring, and public awareness.

Restoration: LAWA's Maintenance Services Division conducted trash removal throughout the Dunes and along the fence perimeter during 2016. All LAWA Film Office and Airport Police activities were coordinated with LAWA's Environmental Programs Group to ensure that all parties stay on roads to prevent impacts to Coast Buckwheat (food source for ESBB). Training and film/photo shoots were not allowed during the 2016 ESBB flight season. LAWA Airport Police K-9 training occurred outside of the portion of the Dunes occupied by ESBB.

Monitoring: LAWA completed 2016 annual monitoring of the ESBB and the coast buckwheat host plant. It was the sixth consecutive year of severe drought conditions in Southern California which adversely affected the overall health of the coast buckwheat and resulted in a slightly lower population of ESBB over 2015 survey results. See Appendix C for the LAX El Segundo Blue Butterfly 2016 Report dated January 2017.

Public Awareness: Volunteer events to remove invasive, non-native weeds were coordinated by Friends of the LAX Dunes (FOLD). During 2016, 17 events were held, and 467 volunteers participated in weeding activities in targeted areas.

12.0.B MM-BC-2 Conservation of Floral Resources: Lewis' Evening Primrose

The LAX Master Plan MMRP states in part:

"Conservation of Floral Resources: Lewis' Evening Primrose. *LAWA or its designee shall prepare and implement a plan to compensate for the loss of individuals of the sensitive Lewis' evening primrose, currently located at the westerly end of the north runway and within the Habitat Restoration Area. LAWA or its designee shall collect seed from those plants to be removed, and properly clean and store the collected seed until used. If possible, seeds shall be collected in multiple years to ensure an adequate seed supply for planting. A mitigation site of suitable habitat equal to the area of impact shall be delineated within areas of the Los Angeles/El Segundo Dunes as described in MM-BC-13."*

Status → No action required at this time:
No LAX Master Plan projects affected Lewis' evening primrose during the 2016 reporting period.

12.0.C MM-BC-3 Conservation of Floral Resources: Mature Tree Replacement

The LAX Master Plan MMRP states in part:

"Conservation of Floral Resources: *Mature Tree Replacement. LAWA or its designee shall prepare and implement a plan to compensate at a ratio of 2:1 for the loss of approximately 300 mature trees, which would occur as a result of implementation of the LAX Northside project."*

Status → No action required at this time:
No LAX Master Plan projects resulted in the removal of mature trees during the 2016 reporting period.

12.0.D MM-BC-8 Replacement of Habitat Units

The LAX Master Plan MMRP states in part:

"Replacement of Habitat Units. *LAWA or its designee shall undertake mitigation for the loss of habitat units resulting from implementation of Alternative D. Implementation of Alternative D would result in the loss of 45.43 habitat units. These habitat units shall be replaced at a 1:1 ratio within the Los Angeles/El Segundo Dunes."*

Status → In Progress:
This measure was partially fulfilled by MM-BC (SA)-1, Replacement of Habitat Units Associated with the SAIP, with restoration of 16.8 habitat units in an offsite location in 2007. Construction staging activities for SAIP, CFTP, and BWP affected additional acreage, requiring a total of 21.43 habitat units to be provided as mitigation. Replacement of the remaining 4.63 habitat units commenced in 2013 with the LAX Coastal Dunes Improvement Project (CDIP) within the 48-acre LAX/El Segundo Dunes area north of Sandpiper Street. To date, approximately 6 acres of hardscape were removed and replaced with native seed, and approximately 2 acres of non-native plants were removed from portions of the site. Acacia was removed on a weekly basis in 2016 and given to the Los Angeles Zoo as fodder. In addition, LAWA's Maintenance Services Division conducted trash removal throughout the Dunes in 2016. Seventeen volunteer events with FOLD, yielding 467 volunteers, also helped with invasive, non-native weed removal. Completion of the CDIP will fulfill the remaining 4.63 habitat units associated with the SAIP, BWP, and CFTP projects, as well as the total 45.43 units required by the LAX Master Plan. By 2021, it is anticipated that a total of 48 acres will have been improved to a habitat value (HV) of 0.80 HV per acre, yielding approximately 35 habitat replacement units.

12.0.E MM-BC-9 Conservation of Faunal Resources

The LAX Master Plan MMRP states in part:

"Conservation of Faunal Resources. *LAWA or its designee shall develop and implement a relocation and monitoring plan to compensate for the loss of 1.34 habitat units of occupied western spadefoot toad habitat and for the loss of western spadefoot toad individuals currently in the southwestern portion of the AOA; 2.38 habitat units of occupied San Diego black-tailed jackrabbit habitat and for the loss of individuals of this species within the AOA; and 10.83 habitat units utilized by loggerhead shrike within the western airfield. LAWA shall minimize incidental take of active nests of loggerhead shrike though pre-construction surveys and construction avoidance measures. LAWA shall conduct pre-construction surveys for silvery legless lizard, San Diego horned lizard and burrowing owls and relocate individuals, if required."*

Status → Completed for the Bradley West Project

Status → No action required at this time:
No LAX Master Plan projects in 2016 resulted in impacts to species addressed in this measure.

12.0.F MM-BC-13 Replacement of State-Designated Sensitive Habitats

The LAX Master Plan MMRP states in part:

"Replacement of State-Designated Sensitive Habitats. *LAWA or its designee shall undertake mitigation for the loss of State-designated sensitive habitat within the Los Angeles/El Segundo Dunes, including the Habitat Restoration Area."*

Status → No action required at this time:
No LAX Master Plan projects in 2016 resulted in the loss of State-designated sensitive habitat within the Dunes Area.

12.0.G MM-BC (BWP)-1 Conservation of Floral Resources: Southern Tarplant

The Bradley West Project MMRP states in part:

*"**Conservation of Floral Resources: Southern Tarplant.*** *LAWA or its designee shall prepare a special status plant mitigation program for the southern tarplant. The loss of the southern tarplant individuals shall be mitigated through seed collection and seeding into a suitable mitigation site within undeveloped property owned by LAWA or at a suitable off-site location, determined based on habitat, soil type, moisture levels, and other relevant conditions … The monitoring plan shall include the following success criteria: germination, flowering and seed set of 100 percent of the original population size [300 plants] by year five. "*

Status → Completed:
This mitigation was completed in 2015, when the number of tarplants successfully achieved the success criteria of 329 germinating, flowering, or senesced individuals required for Year 5.

12.0.H MM-BC (BWP)-2 Conservation of Floral Resources: Lewis' Evening Primrose

The Bradley West Project MMRP states in part:

*"**Conservation of Floral Resources: Lewis' Evening Primrose.** Prior to any work activities (i.e., vegetation clearing, invasive species removal and/or spraying, and sediment removal) on the project site, including construction staging areas, pre-construction focused surveys shall be conducted during the period of March through May by a qualified biologist to determine the presence or absence of Lewis' evening primrose."*

Status → Completed:
Prior to the implementation of construction staging, laydown, and parking areas associated with the Bradley West Project, LAWA conducted focused plant surveys in November 2008 for the Lewis' evening-primrose *(Camissonia lewisii)* and California spineflower *(Mucronea californica)*. Neither species was observed during the focused surveys. No additional mitigation is required.

12.0.I MM-BC (BWP)-3 Conservation of Floral Resources: California Spineflower

The Bradley West Project MMRP states in part:

*"**Conservation of Floral Resources: California Spineflower.** Prior to any work activities (i.e., vegetation clearing, invasive species removal and/or spraying, and sediment removal) on the project site, including construction staging areas, pre-construction focused surveys shall be conducted during the period of March through July by a qualified biologist to determine the presence or absence of California spineflower."*

Status → Completed:
See status of MM-BC (BWP)-2 above.

12.0.J MM-BC (BWP)-4 Conservation of Faunal Resources: Burrowing Owl

The Bradley West Project MMRP states in part:

*"**Conservation of Faunal Resources: Burrowing Owl.** Prior to any work activities (i.e., vegetation clearing, invasive species removal and/or spraying, and sediment removal) within the Southeast Construction Staging/Parking Area (also known as the Continental City site), a survey for burrows by a qualified biologist will be conducted by walking through the suitable habitat within the site in accordance with CDFG-accepted protocols."*

Status → Completed:
Prior to the implementation of construction staging, laydown, and parking areas associated with the Bradley West Project, LAWA conducted focused surveys in June 2009 for the western burrowing owl *(Athene cunicularia hypugea)*. The burrowing owl was not observed during the spring surveys. However, based on previous reports of burrowing owl within the western portion of LAX, it was recommended that monthly surveys be conducted between September and January, during development of the West Construction Staging Area. These surveys were undertaken by the LAX USDA wildlife biologist under contract to LAWA. No burrowing owls were observed during these monthly surveys. No additional mitigation is required.

12.0.K MM-BC (BWP)-5 Conservation of Faunal Resources: Loggerhead Shrike

The Bradley West Project MMRP states in part:

*"**Conservation of Faunal Resources: Loggerhead Shrike.** If construction is scheduled to occur during the nesting season for the loggerhead shrike (March 15 to August 15), vegetation that will be impacted by the proposed project shall be removed outside the nesting season if feasible."*

Status → Completed:
Vegetation that was required to be removed to develop construction staging and parking areas associated with the Bradley West Project was removed in 2010 prior to the nesting season for the loggerhead shrike.

12.0.L MM-BC (BWP)-6 Conservation of Faunal Resources: San Diego Black-Tailed Jackrabbit

The Bradley West Project MMRP states in part:

*"**Conservation of Faunal Resources: San Diego Black-Tailed Jackrabbit.** Prior to the commencement of clearing operations or other activities involving significant soil disturbance at locations identified in Table 4.7-2 with suitable habitat, a survey shall be conducted to locate black-tailed jackrabbits within 100 feet of the outer extent of projected soil disturbance activities."*

Status → Completed:
Prior to clearing operations associated with development of construction staging and parking areas for the Bradley West Project, surveys for the presence of black-tailed jackrabbits were conducted by the LAX USDA wildlife biologist from September 2009 through February 2010 under contract to LAWA. No black-tailed jackrabbits were observed. No additional mitigation is required.

12.0.M MM-BC (BWP)-7 Conservation of Floral Resources: Mature Tree Replacement

The Bradley West Project MMRP states in part:

*"**Conservation of Floral Resources: Mature Tree Replacement.** LAWA or its designee shall compensate at a ratio of 2:1 for the loss of mature trees, which would occur as a result of implementation of Northwest Construction Staging/Parking Area."*

Status → Completed:
In conjunction with the implementation of the Bradley West Project's Northwest Construction Staging Area, LAWA entered into letters of agreement with TreePeople, a non-profit environmental organization, and funds were provided to plant 66 native mature trees at Westchester Park and 64 trees at Morningside High School and the adjacent, student-run Empowerment Community Garden. The mature tree plantings were initiated in 2010 and were completed by June 2012. As of June 2012, 67 trees had been planted at Westchester Park as part of the TreePeople project, 66 of which are associated with Mitigation Measure MM-BC (BWP)-7. In addition, TreePeople led six tree care events in Westchester Park in 2012.

The Morningside High School/Empowerment Community Garden project was expanded to encompass a large-scale greening plan in the City of Inglewood, in conjunction with the non-profit Social Justice Learning Institute. In addition to the 41 trees that had been planted in in 2011, TreePeople and community volunteers planted 32 trees at Vincent Park in Inglewood. As of June 2012, 73 trees had been planted as part of the TreePeople project in Inglewood, 64 of which are associated with Mitigation Measure MM-BC (BWP)-7. The trees were planted at the Empowerment Community Garden, Warren Lane Elementary School (a feeder school to Morningside High School), Queen Park and Vincent Park. The Orchard that was planted at the Empowerment Community Garden is growing and the trees are already bearing fruit. In addition, three Tree Care follow-up events were held in 2012.

12.0.N MM-BC (BWP)-8 Conservation of Faunal Resources: Nesting Birds/Raptors

The Bradley West Project MMRP states in part:

*"**Conservation of Faunal Resources: Nesting Birds/Raptors.** To comply with the Migratory Bird Treaty Act, for those areas of the project site that are not actively maintained and have a potential for nesting birds/raptors, if construction is scheduled to occur during the nesting season for birds/raptors (generally February 1 to June 30 for raptors and March 15 to August 15 for nesting birds), vegetation that will be impacted by the proposed project shall be removed outside the nesting season if feasible."*

Status → Completed:
Prior to the removal of trees associated with implementation of the North Construction Staging Area for the Bradley West Project, LAWA conducted surveys for nesting raptors in April 2010. No birds exhibiting breeding behavior or active nests were observed during the survey. Moreover, according to the LAX USDA wildlife biologist, the West Construction Staging Area does not contain suitable habitat for raptors to nest and no nesting raptors have been observed in this area in the past 8 years. As a result, surveys

for nesting raptors were not conducted for this construction staging area prior to the removal of vegetation. No additional mitigation is required.

13.0 Endangered and Threatened Species

13.0.A MM-ET-1 Riverside Fairy Shrimp Habitat Restoration

The LAX Master Plan MMRP states in part:

*"**Riverside Fairy Shrimp Habitat Restoration.** LAWA or its designee shall undertake mitigation for direct impacts to 0.04 acre (1,853 square feet) of degraded wetland habitat containing embedded cysts of Riverside fairy shrimp and potential indirect impacts to 1.26 acres of degraded wetland habitat containing embedded cysts of the Riverside fairy shrimp."*

Status → In Progress:
LAWA continues to coordinate with USFWS to find a suitable habitat for the Riverside Fairy Shrimp.

13.0.B MM-ET-3 El Segundo Blue Butterfly Conservation: Dust Control

The LAX Master Plan MMRP states:

*"**El Segundo Blue Butterfly Conservation: Dust Control.** To reduce the transport of fugitive dust particles related to construction activities, soil stabilization, watering or other dust control measures, as feasible and appropriate, shall be implemented with a goal to reduce fugitive dust emissions by 90 to 95 percent during construction activities within 2,000 feet of the El Segundo Blue Butterfly Habitat Restoration Area. In addition, to the extent feasible, no grading or stockpiling for construction activities should take place within 100 feet of occupied habitat of the El Segundo blue butterfly."*

Status → In Progress:
The majority of grading and other notable dust generating activities at the WAMA site was completed in 2015 and the site was paved/stabilized prior to the 2016 reporting period. No grading or stockpiling occurred within 100 feet of occupied habitat of the El Segundo Blue Butterfly in the 2016 reporting period.

13.0.C MM-ET-4 El Segundo Blue Butterfly Conservation: Habitat Restoration

The LAX Master Plan MMRP states in part:

*"**El Segundo Blue Butterfly Conservation: Habitat Restoration.** LAWA or its designee shall take all necessary steps to avoid the flight season of the El Segundo blue butterfly (June 14 - September 30) when undertaking installation of navigational aids and associated service roads proposed under Master Plan Alternative D within habitat occupied by the El Segundo blue butterfly. Installation of navigational aids within the Habitat Restoration Area should be required to take place between October 1st and May 31st.*
…As possible, depending on the location and condition of individual plants, FAA and LAWA shall salvage existing coast buckwheat plants and any larvae on the plant or

pupae in the soil below the plant that would be removed to accommodate the replacement navigational aids to further conserve this species. These plants shall be salvaged immediately prior to the installation of the replacement navigational aids outside of the butterfly flight season. These salvaged plants shall be transported in a suitable container and replanted after the onset of winter rains in subsite 23…"

Status → No action required at this time:
No action was required during the 2016 reporting period for these components of the measure.

"In conformance with the Biological Opinion, activities associated with navigational aids development shall be limited to the existing roads and proposed impact areas as depicted in the Final EIS/EIR. Coast buckwheat shall be planted a minimum of three years prior to the impact, not only to allow for establishment of the plants, but also to ensure that the plants are mature enough to bloom. The plantings of coast buckwheat shall be located within the southwest corner of subsite 23 of the Habitat Restoration Area, as depicted in Figure F5-5, and shall encompass 1.25 acres in conformance with the Biological Opinion. Coast buckwheat plants will be planted at an initial density of 200 plants per acre to ensure the long-term planting density target (130 plants per acre). Coast buckwheat plants will be placed in clusters or groupings based on microtopographic features present within subsite 23 to better support the El Segundo Blue Butterfly, which is known to prefer large clusters of plants for nectaring and shelter."

Status → In Progress:
LAWA continued to maintain Block 23, where 325 coast buckwheat plants were planted in 2011 in clusters of 3 to 5 plants. In 2015, a survey showed a 21 percent survival rate, and 69 plants. This does not meet the requirement for 1.25 acres of coast buckwheat at a long-term density of 130 plants per acre. Although the ESBB were observed in Block 23 in 2016, six continuous years of drought in Southern California have adversely affected the health of the coast buckwheat. Block 23 has been targeted as a priority for removal of invasive, non-native plants to allow for better exposure for coast buckwheat growth and seed germination.

"…LAWA shall coordinate with the USFWS to create educational materials on the El Segundo blue butterfly for integration into LAWA's public outreach program."

Status → Completed

13.0.D MM-ET (BWP)-1 Mitigation for Riverside Fairy Shrimp

The Bradley West Project MMRP states in part:

*"**Mitigation for Riverside Fairy Shrimp.** If Riverside fairy shrimp are found to be located on-site, LAWA shall coordinate with FAA and USFWS to initiate consultation under the federal Endangered Species Act and prepare a Mitigation Plan in consultation with the USFWS."*

Status → Completed:
Prior to the implementation of the Southeast Construction Staging/Parking Area associated with the Bradley West Project, two wet season surveys and one focused dry

season survey for Riverside fairy shrimp (*Streptocephalus woottoni)* were conducted in 2009 and 2010 in accordance with USFWS protocol guidelines. No federally-listed Riverside fairy shrimp were observed within the survey area.

14.0 Energy Supply

14.0.A E-1 Energy Conservation and Efficiency Program

The LAX Master Plan MMRP states in part:

"Energy Conservation and Efficiency Program. *LAWA will seek to continually improve the energy efficiency of building design and layouts during the implementation of the LAX Master Plan. Title 24, Part 6, Article 2 of the California Administrative Code establishes maximum energy consumption levels for heating and cooling of new buildings to assure that energy conservation is incorporated into the design of new buildings."*

BWP Status → Completed

WAMA Status → Ongoing:
Not applicable in 2016 reporting period - see explanation in Measure 11.0.C above.

MSC Status → Ongoing:
The design of the MSC North Concourse, which was underway during the 2016 reporting period will incorporate the energy efficiency requirements of the Los Angeles Green Building Code, which, in addition to compliance with Title 24 standards, serve to support the energy efficiency of the MSC.

14.0.B E-2 Coordination with Utility Providers

The LAX Master Plan MMRP states:

"Coordination with Utility Providers. *LAWA will implement Master Plan activities in coordination with local utility providers. Utility providers will provide input on the layout of utilities at LAX to assure that LAX and the surrounding region receive both safe and uninterrupted service. When service by existing utility lines could be affected by airport design features, LAWA will work with the utility to identify alternative means of providing equivalent or superior post-construction utility service."*

BWP Status → Completed

WAMA Status → Ongoing:
The utility design of the WAMA project, including the Qantas Hangar, was coordinated with affected utility providers, particularly LADWP, and such coordination continued during construction activities at the site in 2016, as appropriate.

MSC Status → Ongoing:
In 2016, the utility design for the MSC project included coordination with affected utility providers including, but not limited to, LADWP.

14.0.C PU-1 Develop a Utility Relocation Program

The LAX Master Plan MMRP states in part:

*"**Develop a Utility Relocation Program.** LAWA will develop and implement a utilities relocation program to minimize interference with existing utilities associated with LAX Master Plan facility construction."*

BWP Status → Completed

WAMA Status → Ongoing:
Design and construction plans for the WAMA project included the development of a utility relocation program, which was implemented during the project construction program. The most notable utility relocation that occurred during construction in the 2016 reporting period involved modifications to the existing storm drain lines within the project site to route storm water runoff to the new underground infiltration basin, which was successfully accomplished.

MSC Status → Ongoing:
Design and construction plans being formulated for the MSC Project include preparation of utility relocation plans. Construction (demolition) activities occurring in 2016 included relocation of electrical lines that previously served the former Qantas Hangar, and nearby buildings, and relocation of natural gas lines/facilities that also previously served that area. The subject utility relocations were accomplished with no notable disruption of existing utilities service at the airport.

15.0 Light Emissions

15.0.A LI-2 Use of Non-Glare Generating Building Materials

The LAX Master Plan MMRP states:

*"**Use of Non-Glare Generating Building Materials**. Prior to approval of final plans, LAWA will ensure that proposed LAX facilities will be constructed to maximize use of non-reflective materials and minimize use of undifferentiated expanses of glass."*

BWP Status → Completed

WAMA Status → Ongoing:
The exterior of the new Qantas Hangar was completed in 2016. The exterior utilizes non-reflective materials and minimal use of windows – see photos below.

Photos of Qantas Hangar (at completion) showing non-reflective finish and minimal use of windows

MSC Status → Ongoing:
In November 2016, the LAWA Board of Airport Commissioners approved funding to complete the design and construction of the MSC North Concourse. During the 2016 reporting period, the MSC Project design-build contractor continued work on developing the more detailed plans for construction of the project, which will include selection of exterior finish materials. Final selection of exterior finish materials will maximize use of non-reflective materials and minimize use of undifferentiated expanses of glass

15.0.B LI-3 Lighting Controls

The LAX Master Plan MMRP states in part:

"***Lighting Controls**. Prior to final approval of plans for new lighting, LAWA will conduct reviews of lighting type and placement to ensure that lighting will not interfere with aeronautical lights or otherwise impair Airport Traffic Control Tower or pilot operations."*

BWP Status → Completed

WAMA Status → Ongoing:
Construction on the WAMA project in 2016 included the installation of high-mast light standards (poles) for nighttime lighting within the WAMA apron area. The design of the lighting system was previously coordinated with LAWA Airfield Operations, which took into account non-interference with the Air Traffic Control Tower and pilot operations, and installation of the lighting system in 2016 occurred consistent with the approved plans.

MSC Status → No action required at this time:
As noted above in Measure 15.0.A, funding to complete the design and construction of the MSC North Concourse was approved in November 2016. Design of the exterior lighting system had not yet begun in the 2016 reporting period.

16.0 Solid Waste

16.0.A SW-1 Implement an Enhanced Recycling Program

The LAX Master Plan MMRP states in part:

"**Implement an Enhanced Recycling Program.** *"LAWA will enhance their existing recycling program, based on successful programs at other airports and similar facilities."*

Status → Plan Completed, Ongoing Implementation:
LAWA completed an enhanced recycling plan in 2011 for LAX. In 2016, LAWA and LA Sanitation (LASAN) entered into a new Memorandum of Understanding (MOU) for the collection, proper disposal and reporting of trash. The total recycling and source reduction achieved by LAWA's Facilities Maintenance & Utilities Group's Recycling and Source Reduction Program for calendar year 2016 was 408,537 tons.

LAX recycles corrugated boxes

Recycling bins throughout LAX terminals

Some notable achievements for the Recycling and Source Reduction Program include the following:

• Paper	675 tons
• Plastics	389 tons
• Metals	179 tons
• Wood/pallets	192 tons
• Green materials	146 tons
• Tires	14 tons
• Food Donations	19 tons
• Construction and demolition debris/ Processed miscellaneous base	405,360 tons
• Other-Mixed Recyclables (City Fibers)	1,650 tons
Total 2016 Recycling	408,537 tons
Total Master Plan construction concrete recycling[1]	181,880 tons

Features of the enhanced recycling program will include:
"..development of a recycling program at LAX Northside/Westchester Southside.."

Status → No action required at this time:
This provision was not applicable during the 2016 reporting period because the LAX Northside project had not been approved nor constructed.

"…lease provisions requiring that tenants meet specified division goals…"
"…and preference for recycled materials during procurement, where practical and appropriate."

Status→ Ongoing:
The LAX Procurement Services Division (PSD) promotes resource efficiency with contract language that includes recycling requirements and through direct purchase of products with sustainable attributes and certifications. Green Seal is the original independent ecolabeling organization in the United States. Green Seal-certification helps purchasers meet environmentally preferable product (EPP) purchasing requirements by identifying products that perform well and have less impact on health and environment, such as products that use recycled content. In fiscal year 2015-2016, LAWA purchased 31,500 liters of Green Seal Certified hand soap for use in the terminal areas, and other Green Seal certified janitorial products including 22,200 tons of multifold paper, 198 tons of paper towel rolls, 73 tons of paper seat covers, 421 tons of copier paper, and 11,484 liters of cleaner, all of which contained recycled content.

[1] Construction concrete recycled in 2016 for the Midfield Satellite Concourse (MSC)-North project included in construction and demolition debris/processed miscellaneous base total

16.0.B SW-2 Requirements for the Use of Recycled Materials During Construction

The LAX Master Plan MMRP states:

*"**Requirements for the Use of Recycled Materials During Construction.** LAWA will require, where feasible, that contractors use a specified minimum percentage of recycled materials during construction of LAX Master Plan improvements. The percentage of recycled materials required will be specified in the construction bid documents. Recycled materials may include, but are not limited to, asphalt, drywall, steel, aluminum, ceramic tile, cellulose insulation, and composite engineered wood products. The use of recycled materials in LAX Master Plan construction will help to reduce the project's reliance upon virgin materials and support the recycled materials market, decreasing the quantity of solid waste requiring disposal."*

BWP Status → Completed

WAMA Status → Ongoing:
The criteria applied in construction requirements for the Qantas Hangar Project for use of recycled materials during construction were based on the City's GreenBuild Tier 1 requirements; however, the hangar was not a Tier 1 building. Although some recycled materials were used in construction, the exact nature and amounts could not be quantified.

MSC Status → Not applicable at this time:
Activities related to the MSC in 2016 primarily involved demolition of the former Qantas Hangar (i.e., did not involve use of new/recycled building materials).

16.0.C SW-3 Requirements for the Recycling of Construction and Demolition Waste

The LAX Master Plan MMRP states:

*"**Requirements for the Recycling of Construction and Demolition Waste.** LAWA will require that contractors recycle a specified minimum percentage of waste materials generated during demolition and construction. The percentage of waste materials required to be recycled will be specified in the construction bid documents. Waste materials to be recycled may include, but are not limited to, asphalt, concrete, drywall, steel, aluminum, ceramic tile, and architectural details."*

BWP Status → Completed

WAMA Status → Ongoing:
Of the 4.34 tons of construction waste generated during construction of the Qantas Hangar, 77.21 percent (3.35 tons) was recycled.

MSC Status → Ongoing:
Demolition of the former Qantas hangar was preceded by remediation of hazardous building materials, which included stabilization/encapsulation of asbestos and lead-based paint, which combined with the demolition approach, limited the ability to feasibly sort and separate demolished materials for recycling. Although some demolition

materials, such as steel and wood, were recycled, the exact amount/percentage was not quantified.

16.0.D MM-SW-1 Provide Landfill Capacity

The LAX Master Plan MMRP states:

*"**Provide Landfill Capacity.** Additional landfill capacity in the Los Angeles region should be provided through the siting of new landfills, the expansion of existing landfills, or the extension of permits for existing facilities. As an alternative, or to augment regional landfill capacity, landfill capacity outside the region could be accessed by developing the necessary rail haul infrastructure. The responsibility for implementing this mitigation measure lies with state, county, and local solid waste planning authorities. The costs for implementing this mitigation measure will be passed on to LAX and other solid waste generators through increased solid waste disposal costs."*

Status→ No action required:
LAWA has no jurisdiction regarding this mitigation measure which must be implemented by state, county, and local solid waste planning authorities.

17.0 Construction Impacts

17.0.A C-1 Establishment of a Ground Transportation/Construction Coordination Office

The LAX Master Plan MMRP states in part:

*"**Establishment of a Ground Transportation/Construction Coordination Office.** Establish this office for the life of the construction projects to coordinate deliveries, monitor traffic conditions, advise motorists and those making deliveries about detours and congested areas, and monitor and enforce delivery times and routes."*

BWP Status → Completed

WAMA Status → Ongoing:
LAWA established the Coordination and Logistic Management (CALM) team to, among other responsibilities, coordinate logistics relating to LAX Master Plan construction projects, including construction-related traffic. In addition, LAWA monitors are responsible for monitoring construction activities, including construction-related traffic and deliveries. In 2016, the CALM team and LAWA monitors worked with the WAMA project staff and contractors, including staff of the LAWA WAMA component and staff of the Qantas component, to coordinate deliveries, monitor traffic conditions, and monitor and enforce delivery times and routes during the reporting period. There were no detours required for the WAMA project during the 2016 reporting period.

MSC Status → Ongoing:
LAWA established the Coordination and Logistic Management (CALM) team to, among other responsibilities, coordinate logistics relating to LAX Master Plan construction projects, including construction-related traffic. In addition, LAWA monitors are responsible for monitoring construction activities, including construction-related traffic and deliveries. In 2016, the CALM team and LAWA monitors worked with the MSC project staff and contractors to coordinate deliveries, monitor traffic conditions, and monitor and enforce delivery times and routes during the reporting period. It should be noted, however, that in the 2016 reporting period, construction activities associated with the MSC project were generally limited to several small enabling projects and to the demolition of the former Qantas Hangar. As such, the most notable construction deliveries in 2016 involved the transport of demolition-related construction equipment to and from the project site, and the removal/hauling of demolished building materials from the project site. Such activities were successfully coordinated with the CALM team and there were no notable MSC-related construction traffic problems, nor were there any detours required for the MSC project during the 2016 reporting period.

17.0.B C-2 Construction Personnel Airport Orientation

The LAX Master Plan MMRP states:

*"**Construction Personnel Airport Orientation.** All construction personnel will be required to attend an airport project-specific orientation (pre-construction meeting) that includes where to park, where staging areas are located, construction policies, etc."*

BWP Status → Completed

WAMA Status → Ongoing:
Pre-construction meetings were held in 2015 for the WAMA project to make contractors aware of parking areas, construction staging areas, and construction policies and the information and requirements coming out of those meetings were carried into the 2016 construction activities. In addition, weekly project status meetings in 2016 included discussion of issues relating to construction traffic, when/as appropriate.

MSC Status → Ongoing:
Pre-construction meetings were held for the MSC project in 2015, for the early enabling projects, to make contractors aware of parking areas, construction staging areas, and construction policies and the information and requirements coming out of those meetings were carried into the 2016 construction activities. In addition, weekly project status meetings in 2016 included discussion of issues relating to construction traffic, when/as appropriate.

18.0 Design, Art, and Architecture Applications/Aesthetics

18.0.A DA-1 Provide and Maintain Airport Buffer Areas

The LAX Master Plan MMRP states:

*"**Provide and Maintain Airport Buffer Areas.** Along the northerly and southerly boundary areas of the airport, LAWA will provide and maintain landscaped buffer areas that will include setbacks, landscaping, screening or other appropriate view-sensitive improvements with the goals of avoiding land use conflicts, shielding lighting, enhancing privacy and better screening views of airport facilities from adjacent residential uses. Use of existing facilities in buffer areas may continue as required until LAWA can develop alternative facilities."*

Status → No additional action required at this time:
In 2016, LAWA continued to provide and maintain all buffer areas surrounding the airport. The Street Frontage and Landscape Development Plan provides integrated and coordinated landscape design guidelines for new development along the perimeter areas of LAX consistent with the LAX Master Plan. Emphasis is placed on buffer areas between the airport and surrounding land uses to the north and south of the airport while incorporating all the necessary airport security guidelines and maximizing neighborhood compatibility.

Additionally, the LAX Northside subarea of the LAX Specific Plan was amended in June 2016 after undergoing a multi-year planning process. The amendment included an update to the 1989 Northside Design Plan and Development Guidelines. The updated guidelines include additional landscape guidelines and buffer areas to the northern boundary of LAX.

18.0.B DA-2 Update and Integrate Design Plans and Guidelines

The LAX Master Plan MMRP states in part:

*"**Update and Integrate Design Plans and Guidelines**. The following plans and guidelines will be individually updated or integrated into a comprehensive set of design-related guidelines and plans; LAX Street Frontage and Landscape Development Plan (June 1994), LAX Air Cargo Facilities Development Guidelines (April 1998; updated August 2002), and LAX Northside Design Plan and Development Guidelines (1989), including conditions addressing heights, setbacks and landscaping."*

Status → No additional action required at this time:
The Street Frontage and Landscape Plan was updated in March 2005. The LAX Air Cargo Facilities Development Guidelines were updated in August 2002. These plans include requirements to be incorporated into Master Plan projects.

With the California Green Building Code and the LA Green Building Ordinance now in effect, LAWA's program is: "All building projects with an Los Angeles Department of Building and Safety (LADBS) permit-valuation over $200,000 shall achieve LAGBC

Tier-1 conformance, to be certified by LADBS during Final Plan-Check (on the issued building permit) and validated by the LADBS inspector during Final Inspection (on the Certificate of Occupancy)." These guidelines were incorporated into LAWA's Design and Construction Handbook and the program went into effect on November 7, 2012.

The LAX Northside Design Plan and Development Guidelines (1989) were updated in 2016 and renamed the LAX Northside Design Guidelines and Standards. The LAX Northside Design Guidelines and Standards provide a framework for appropriately scaled development that is consistent with airport needs and neighborhood conditions. The design guidelines and standards address issues of urban design, architecture, landscape materials and design, pedestrian infrastructures, and signage.

Additionally, the LAX Design Guidelines were being developed in 2016 to establish LAWA's comprehensive vision for the passenger experience at LAX. They are intended to integrate the design of new and existing facilities and to create an improved passenger experience that honors LAX's history and Mid-Century Modern architecture, while providing design guidance for new construction and major renovations as part of the modernization of LAX.

18.0.C DA-3 Undergrounding of Utility Lines

The LAX Master Plan MMRP states:

*"**Undergrounding of Utility Lines**. In conjunction with the extension of the Century Freeway and other roadway/right-of-way improvement projects, LAWA will pursue opportunities to place existing overhead utility lines underground wherever feasible and appropriate."*

Status → No action required at this time:
There were no roadway projects during the 2016 reporting period that triggered this requirement.

18.0.D MM-DA-1 Construction Fencing

The LAX Master Plan MMRP states:

*"**Construction Fencing**. Construction fencing and pedestrian canopies shall be installed by LAWA to the degree feasible to ensure maximum screening of areas under construction along major public approach and perimeter roadways, including Sepulveda Boulevard, Century Boulevard, Westchester Parkway, Pershing Drive, and Imperial Highway west of Sepulveda Boulevard. Along Century Boulevard, Sepulveda Boulevard, and in other areas where the quality of public views are a high priority, provisions shall be made by LAWA for treatment of the fencing to reduce temporary visual impacts."*

BWP Status → Completed

MSC Status → Ongoing:
The MSC project site, located near the center of the airport, is well-removed from the roadways of interest and construction activities would not affect views from those roadways.

19.0 Hazardous Materials

19.0.A HM-1 Ensure Continued Implementation of Existing Remediation Efforts

The LAX Master Plan MMRP states in part:

"***Ensure Continued Implementation of Existing Remediation Efforts.*** *Prior to initiating construction of a Master Plan component, LAWA will conduct a pre-construction evaluation to determine if the proposed construction will interfere with existing soil or groundwater remediation efforts."*

BWP Status → Completed

WAMA Status → Ongoing:
LAWA conducted soil investigations prior to commencement of grading for the WAMA project. In addition, WAMA contractors comply with LAWA policies regarding the handling of impacted soils encountered during construction. No groundwater remediation wells are located on the WAMA project site. There are several groundwater monitoring wells near the eastern border of the LAWA WAMA site that are associated with a groundwater remediation effort located to the east. No wells were taken offline during construction. As such, WAMA construction activities in the 2016 reporting period did not adversely affect continued implementation of existing remediation efforts.

MSC Status → Ongoing:
LAWA conducted soil investigations prior to commencement of grading for the MSC project. In addition, MSC contractors comply with LAWA policies regarding the handling of impacted soils encountered during construction. There are no remediation systems at or adjacent to the MSC site. No contaminated soils were encountered at the MSC site during the 2016 reporting period. As such, MSC construction activities in the 2016 reporting period did not adversely affect continued implementation of existing remediation efforts.

19.0.B HM-2 Handling of Contaminated Materials Encountered During Construction

The LAX Master Plan MMRP states in part:

*"**Handling of Contaminated Materials Encountered During Construction.** Prior to the initiation of construction, LAWA will develop a program to coordinate all efforts associated with the handling of contaminated materials encountered during construction. The intent of this program will be to ensure that all contaminated soils and/or groundwater encountered during construction are handled in accordance with all applicable regulations."*

Status → Completed:
A Hazardous Materials Management Plan was developed and revised in December 2005, and all LAWA contractors are required to comply with its provisions as they apply to the different projects.

19.0.C MM-HAZ (WAMA)-1

The WAMA MMRP states:

Prior to construction at the Project site, additional research shall be undertaken to determine if abandoned/plugged wells at the Project site were abandoned per the current regulations. If necessary, these wells shall be properly abandoned per current regulations. Since the Division of Oil, Gas, and Geothermal Resources (DOGGR) maps are not guaranteed to be accurate, a magnetometer survey shall be completed to determine the exact location of these abandoned/plugged oil wells. If the magnetometer survey successfully determines the location of these oil wells, a subsurface investigation in coordination with the DOGGR and City of Los Angeles Fire Department, as applicable, will be performed to determine if the abandoned wells pose a risk during the grading and construction activities.

Specific DOGGR regulations and requirements for the inspection, testing, plugging, and abandonment of oil wells are contained within Chapter 4, Development, Regulation, and Conservation of Oil and Gas Resources, Article 3 of the State of California Code of Regulations. These regulations require a specific set of actions be taken, dependent on the found state of the abandoned oil wells (e.g. for open holes, a cement plug must extend from the total depth of the well or from at least 100 feet below the bottom of each oil or gas zone to at least 100 feet above the top of each oil or gas zone, for cased holes, all perforations are to be plugged with cement, with the plug extending at least 100 feet above the top of a landed liner, the uppermost perforations, the casing cementing point, the water shut-off holes, or the oil or gas zone, whichever is highest). Chapter V, Article 7, (Fire Code) (57.90.01-45) of the Los Angeles City Municipal Code further regulates the location, drilling safeguards, and abandonment of oil wells in the City. In the event oil wells are found that have not been properly abandoned, the procedures and agency oversight prescribed in these regulations would serve as performance standards to ensure that significant impacts associated with the potential migration of fluids and groundwater contamination would be avoided during construction of the proposed Project. Construction will comply with all applicable requirements of DOGGR and the City of Los Angeles Fire Department for the investigation and/or re-abandonment of the well(s).

WAMA Status → Completed:
The location of the abandoned oil well identified in 2014 was in a portion of the WAMA Project site that did not require paving or other improvements that would affect or be affected by the subject well – see aerial photo below. As such, no further measures were required in the 2016.

The abandoned oil well located within the WAMA site was not within a development area.

19.0.D MM-HM (MSC)-1 Asbestos-Containing Materials and Lead Based Paint

The MSC MMRP states:

*"**Asbestos-Containing Materials and Lead Based Paint.** Prior to construction activities, LAWA, or its contractors, will conduct an evaluation of all buildings (built prior to 1980) to be demolished to evaluate the presence of asbestos-containing materials and lead-based paint. Remediation will be implemented in accordance with the recommendation of these evaluations."*

MSC Status → Ongoing:
LAWA conducted a hazardous material survey of the former Qantas Hangar several years ago, and determined that asbestos containing building materials and lead-based paint were present in and on the subject structure. During the 2016 reporting period, those materials were removed/remediated prior to demolition of the hangar. Similarly, demolition of the American Airlines Maintenance (Non-Power) Shop in the 2016 reporting period was preceded by the removal/remediation of asbestos and lead-based paint.

19.0.E MM-HM (MSC)-2 Hazardous Materials Contingency Plan

The MSC MMRP states:

*"**Hazardous Materials Contingency Plan.** LAWA or its contractors will prepare a hazardous materials contingency plan addressing the potential for discovery of unidentified USTs, hazardous materials, petroleum hydrocarbons, or hazardous or solid wastes encountered during construction. The contingency plan will address UST decommissioning, field screening and materials testing methods, mitigation and contaminant management requirements, and health and safety requirements."*

MSC Status → Ongoing:
The construction contract specifications developed by LAWA for the MSC include provisions for addressing hazardous materials should they be unexpectedly encountered

during construction, including the requirement that the contractor prepare a Hazardous Materials Management Plan, for review and approval by LAWA, for such an event. For the main activity occurring at the MSC site in 2016 (i.e., the demolition of the former Qantas Hangar), no hazardous materials were unexpectedly encountered. For the hazardous materials known to exist at the site, those being the asbestos-containing building materials and lead-based paint within the hangar and associated structures, they were addressed in accordance with the applicable remediation plans and requirements.

19.0.F MM-HM (MSC)-3 Hazardous and Solid Waste Disposal

The MSC MMRP states:

*"**Hazardous and Solid Waste Disposal.** Construction contractors will dispose of all hazardous or solid wastes and debris encountered or generated during construction and demolition activities in accordance with all federal, state, and local laws and regulations."*

MSC Status → Ongoing:
Hazardous waste, in the form of asbestos-containing building materials and lead-based paint, and non-hazardous waste and debris generated during the 2016 reporting period, primarily in conjunction with demolition of the former Qantas Hangar, were disposed of off-site in accordance with all federal, state, and local laws and regulations.

20.0 Water Use

20.0.A W-1 Maximize Use of Reclaimed Water

The LAX Master Plan MMRP states:

*"**Maximize Use of Reclaimed Water.** To the extent feasible, LAWA will maximize the use of reclaimed water in Master Plan-related facilities and landscaping. The intent of this commitment is to maximize the use of reclaimed water as an offset for potable water use and to minimize the potential for increased water use resulting from implementation of the LAX Master Plan. This commitment will also facilitate achievement of the City of Los Angeles' goal of increased beneficial use of its reclaimed water resources. This commitment will be implemented by various means, such as installation and use of reclaimed water distribution piping for landscape irrigation."*

BWP Status → Completed

WAMA Status → Ongoing:
While the nature and design of the WAMA project does not involve the installation of landscaping, reclaimed water was used for dust control during project construction activities in the 2016 reporting period.

MSC Status → Ongoing:
While the nature and design of the MSC project does not involve the installation of landscaping, reclaimed water was used for dust control during project construction activities in the 2016 reporting period.

20.0.B W-2 Enhance Existing Water Conservation Program

The LAX Master Plan MMRP states:

*"**Enhance Existing Water Conservation Program**. "LAWA will enhance the existing Street Frontage and Landscape Plan for LAX to ensure the ongoing use of water conservation practices at LAX facilities. The intent of this program, to minimize the potential for increased water use due to implementation of the LAX Master Plan program, is also in accordance with regional efforts to ensure adequate water supplies for the future. Features of the enhanced conservation program will include identification of current water conservation practices and an assessment of their effectiveness; identification of alternate future conservation practices; continuation of the practice of retrofitting and installing new low-flow toilets and other water-efficient fixtures in all LAX buildings, as remodeling takes place or new construction occurs; use of Best Management Practices for maintenance; use of water efficient vegetation for landscaping, where possible; and continuation of the use of fixed automatic irrigation for landscaping."*

Status→ Completed:
The Street Frontage and Landscape Plan was updated in March, 2005 and it includes policies pertaining to the use of reclaimed water in Master Plan-related landscaping and new policies enhancing the ongoing use of water conservation practices at LAX.

Approximately 95 percent of toilets and urinals (out of 1,670 fixtures) in the Central Terminal Area at LAX are converted to low and ultra-low flow systems, which provides a savings of 1.25 gallons per flush, an equivalent of approximately 396,625 gallons of water every day.

LAWA's Design and Construction Handbook specifications for new and replacement water closets and urinals specify that the maximum water closet flush is to be limited to 1.28 gallons per flush and the maximum urinal flush is to be limited to 0.125 gallons per flush. In addition, water used in on-airport car wash facilities is recycled.

Potable water use per passenger at LAX decreased from 6.3 gallons in 2015 to 5.9 gallons in 2016. Additionally, reclaimed water use for landscaping increased more than 20 percent over 2015 levels.

In April 2016, LAWA completed the installation of a water conservation landscaping project at the front, east, and west sides of the Clifton A. Moore Administration Building. The project encompasses 1,340 square feet, and saves 19,000 gallons of water annually.

Clifton A. Moore Administration Building – Before Project

New Water Conserving Landscaping at Clifton A. Moore Administration Building

LAWA completed another water conservation landscaping project in November 2016 on the Little Century Median. This project encompasses 12,800 square feet, and saves 89,000 gallons of water per year.

Little Century Median – Before Project

New Water Conserving Landscaping on Little Century Median

21.0 Wastewater

21.0.A MM-WW-1 Provide Additional Wastewater Treatment Capacity to Accommodate Cumulative Flows

The LAX Master Plan MMRP states:

*"**Provide Additional Wastewater Treatment Capacity to Accommodate Cumulative Flows**. Additional wastewater capacity within the City of Los Angeles should be provided by the expansion/upgrade of the City's wastewater treatment systems via a combination of improvements to address the projected wastewater [capacity] shortfall resulting from cumulative development. Such improvements could include increasing capacity at the Hyperion Treatment Plant (HTP), building new reclamation capacity upstream of HTP, conservation of potable water, and infiltration/inflow reduction. Implementation of this mitigation measure is the responsibility of the City of Los Angeles Department of Public Works, Bureau of Sanitation. Specific improvements will be identified in the City's IPWP and Wastewater Facilities Plan component of the City's Integrated Resources Plan. The cost for implementing this mitigation measure would be passed on to LAX and other wastewater generators through increased wastewater fees."*

Status → No action required:
LAWA has no jurisdiction regarding this mitigation measure which will be implemented by the City of Los Angeles Department of Public Works, Bureau of Sanitation.

22.0 Fire Protection

22.0.A FP-1 LAFD Design Recommendations

The LAX Master Plan MMRP states in part:

*"**LAFD Design Recommendations**. During the design phase prior to initiating construction of a Master Plan component, LAWA will work with LAFD to prepare plans that contain the appropriate design features applicable to that component, such as those recommended by LAFD*."

BWP Status → Completed

WAMA Status → Ongoing:
The design of the WAMA project was coordinated with and reviewed by the LAFD, and construction of the project, including the new WAMA hangar, in 2016 complied with the approved plans.

MSC Status → No action required at this time:
Funding to complete the design and construction of the MSC North Concourse was approved by the Los Angeles Board of Airport Commissioners in November 2016. Project elements that involve LAFD had not yet begun design during the 2016 reporting period.

22.0.B PS-1 Fire and Police Facility Relocation Plan

The LAX Master Plan MMRP states:

*"**Fire and Police Facility Relocation Plan**. Prior to any demolition, construction, or circulation changes that would affect LAFD Fire Stations 51, 80, and 95, or on-airport police facilities, a Relocation Plan will be developed by LAWA through a cooperative process involving LAFD, LAWAPD, the LAPD LAX Detail, and other airport staff. The performance standards for the plan will ensure maintenance of required response times, response distances, fire flows, and a transition to new facilities such that fire and law enforcement services at LAX will not be significantly degraded. The plan will also address future facility needs, including details regarding space requirement, siting, and design."*

BWP Status → Completed

WAMA Status → Not Applicable:
Construction of the WAMA project does not affect the locations of LAFD Fire Stations 51, 80, and 95, or on-airport police facilities.

MSC Status → Not Applicable:
Construction of the MSC project does not affect the locations of LAFD Fire Stations 51, 80, and 95, or on-airport police facilities.

22.0.C PS-2 Fire and Police Facility Space and Siting Requirements

The LAX Master Plan MMRP states:

*"**Fire and Police Facility Space and Siting Requirements**. During the early design phase for implementation of the Master Plan elements affecting on-airport fire and police facilities, LAWA and/or its contractors will consult with LAFD, LAWAPD, LAPD, and other agencies as appropriate, to evaluate and refine as necessary, program requirements for fire and police facilities. This coordination will ensure that final plans adequately support future facility needs, including space requirements, siting and design."*

BWP Status→ Completed

WAMA Status→ Not Applicable:
Construction of the WAMA project does not affect the locations of LAFD Fire Stations 51, 80, and 95, or on-airport police facilities.

MSC Status→ Not Applicable:
Construction of the MSC project does not affect the locations of LAFD Fire Stations 51, 80, and 95, or on-airport police facilities.

23.0 Law Enforcement

23.0.A LE-1 Routine Evaluation of Manpower and Equipment Needs

The LAX Master Plan MMRP states:

*"**Routine Evaluation of Manpower and Equipment Needs.** LAWA will ensure that LAWAPD and LAPD LAX Detail continue to routinely evaluate and provide additional officers, supporting administrative staff, and equipment, to keep pace with forecasted increases in activity and development at LAX in order to maintain a high level of law enforcement services. This will be achieved through LAWA notification to LAWAPD and LAPD regarding pending development and construction and through LAWA review of status reports on law enforcement services at LAX."*

Status → Ongoing:
LAWAPD monitors law enforcement needs on an ongoing basis to adjust, as needed, law enforcement assignments and services at LAX in light of changes in conditions/circumstances including, but not limited to, passenger activity level increases. The ongoing monitoring and adjustments include officers, administrative staff, and equipment. Operational meetings are conducted regularly and steps are taken to adjust resources as needed. During 2016, which saw an eight percent increase in passenger activity levels at LAX over the previous year, staffing levels and assignments were monitored and adjusted as needed to maintain an acceptable level of law enforcement services at LAX.

In addition, the CALM team is responsible for coordinating with LAWAPD to ensure adequate law enforcement services associated with LAX Master Plan construction projects. In 2016, additional staffing was required for several Airport Operations Area (AOA) access posts used by construction vehicles.

23.0.B LE-2 Plan Review

The LAX Master Plan MMRP states:

*"**Plan Review**. During the design phase of terminal and cargo facilities and other major airport development, the LAPD, LAWAPD, and other law enforcement agencies will be consulted to review plans so that, where possible, environmental contributors to criminal activity, such as poorly-lit areas, and unsafe design, are reduced."*

BWP Status → Completed

WAMA Status → Ongoing:
During the design phase for the WAMA project, the LAPD, LAWAPD, and other law enforcement agencies, such as TSA, were consulted to review and approve, as appropriate, project plans and WAMA construction activities occurring in 2016 complied with the approved plans.

MSC Status → No action required at this time:
As noted above in Measure 15.0.A, funding to complete the design and construction of the MSC North Concourse was approved in November 2016. Project elements that involve LAPD, LAWAPD, and other law enforcement agencies had not yet begun design during the 2016 reporting period.

24.0 Project Design Features – West Aircraft Maintenance Area (WAMA)

24.0.A WAMA-PDF-1 Quarterly Reporting

The WAMA MMRP states in part:

"The tenants of the WAMA site will be required to provide to LAWA a quarterly report indicating the number, time of day, duration, and specific aircraft type of all aircraft engine high-power and low-power ground run-ups conducted during the reporting period….."

Status→ The WAMA site did not have a tenant during the reporting period, however, Airport Operations recorded the following run-ups:

7/10/16 – Virgin Australia, B777 , 80% power engine run from 2:48 pm to 3:12 pm

7/10/16 – Virgin Australia, B777 , 80% power engine run from 3:43 pm to 3:48 pm

8/14/16 – Saudi Airlines, B777, 70% power engine run, 20 minute duration

8/15/16 – Saudi Airlines, B777, 70% power engine run, 10 minute duration

8/23/16 – National Air Cargo, DC-8, block time from 3:30 pm to 7:00 pm

9/12/16 – Allegiant Airlines, A321, block time from 3:30 pm to 5:00 pm

12/03/16 – Fed Ex, MD10, block time from 5:45 pm to 6:55 pm

12/28/16 – Skywest, E170, block time from 4:40 pm to 5:45 pm

"In conjunction with application of a ground run-up reporting program, LAWA will develop a tiered penalty program applicable to violations of the LAX nighttime curfew for aircraft engine high-power ground run-ups….."

Status→The tiered penalty program had not been developed at this time:
There have been no violations of the curfew and therefore no need for enforcement. During 2016, LAWA was working on development of an enforcement program.

24.0.B WAMA-PDF-2 APU Usage While Aircraft is Parked

The WAMA MMRP states:

"Aircraft parked at the WAMA site shall not utilize on-board auxiliary power units (APUs) for aircraft electrical power or interior cooling at parking spaces where ground power and preconditioned air are available, with the exceptions being: (1) if an APU is being serviced or checked relative to those functions; or (2) for some limited time if APU is required to tug/tow aircraft to/from WAMA site (i.e., for proper operation of essential on-

board electronics while being moved). In addition to the proposed RON kits with ground power and preconditioned air for aircraft parking positions along the perimeter of the site (i.e., at hangar areas along World Way West and RON/RAD positions along Pershing Drive), the final WAMA site design will include additional aircraft ground power connect ports at the two interior RON/RAD positions within the site."

Status → In Progress:
Aircraft parked at the WAMA site were monitored in 2016 by Airfield Operations to determine if on-board auxiliary power units were used. No violations were noted.

24.0.C WAMA-PDF-3 Aircraft Taxiing

The WAMA MMRP states:

"All aircraft traveling to or from WAMA during nighttime hours (11:00 p.m. to 6:00 a.m.) must be tugged/towed and are not allowed to taxi under own power, unless otherwise directed by LAWA Airport Operations in situation-specific circumstances where taxiing is required to maintain airfield safety and efficiency."

Status → In Progress:
Aircraft traveling to or from WAMA during nighttime hours were monitored in 2016 by Airfield Operations to ensure they were not taxiing under their own power without approval by LAWA. No violations were noted.

24.0.D WAMA-PDF-4 Aircraft Engine Ground Run-Ups

The WAMA MMRP states:

"Aircraft engine high-power ground run-ups of any duration and low-power run-ups of five minutes or more can only occur at the onsite blast fence; and, all run-ups (high-power and low-power of any duration) are prohibited anywhere on the WAMA site between 11:00 p.m. and 6:00 a.m."

Status → In Progress:
Aircraft engine ground run-ups were monitored by Airfield Operations in 2016. No were violations noted.

24.0.E WAMA-PDF-5 Use of the WAMA Site

The WAMA MMRP states:

"Aircraft parking spaces at WAMA site cannot be used for passenger boarding or deplaning (i.e., cannot be used as remote gates), except during or as a result of emergency circumstances."

Status → In Progress:
Aircraft parking spaces at WAMA were monitored by Airfield Operations. No violations noted.

24.0.F WAMA-PDF-6 Automated Run-Up Monitoring System

The WAMA MMRP states:

"An aircraft engine ground run-up monitoring system, including a sound level meter and video camera, will be provided at the run-up area. LAWA will make all reasonable efforts to make data from the monitoring system accessible to the public via an internet link provided on LAWA's website (i.e., lawa.org)."

Status → Ongoing:
The ground run-up monitoring system was installed in 2015, and is accessible via LAWA's website at www.lawa.org/laxwamagru/.

24.0.G WAMA-PDF-7 Resurfacing a Portion of Imperial Highway

The WAMA MMRP states:

"LAWA will work with City of Los Angeles Bureau of Street Services (LABSS) to contribute its reasonable allocable share subject to FAA approval toward resurfacing of Imperial within the City of Los Angeles's jurisdiction; if the LABSS undertakes this resurfacing project, LAWA will also work with LABSS and the Council District 11 office to schedule resurfacing work. LAWA commits to meetings with Caltrans (alongside the City of El Segundo) to discuss improvements to areas under Caltrans control but cannot make any guarantees as to Caltrans' actions."

WAMA Status → No action required at this time:
Imperial Highway extends along the southern border of LAX from Pershing all the way to Aviation Boulevard. Along this segment, Imperial intersects with Sepulveda Boulevard (Highway 1), which is under Caltrans jurisdiction. No improvements were required in 2016 in areas under Caltrans jurisdiction. After making inquiries with the City of Los Angeles' Bureau of Street Services, LAWA knows of no pending resurfacing project for westbound Imperial Highway. The eastbound lanes were resurfaced approximately 6 years ago."

APPENDIX A

LAX MASTER PLAN MMRP AS ADOPTED DECEMBER 2004

REFERENCE

LAWA Website:
http://www.lawa.org/uploadedFiles/OurLAX/Past_Projects_and_Studies/Past_Publications/mmrp.pdf

for a copy of the document

APPENDIX B

LAX MASTER PLAN PROJECT-SPECIFIC MEASURES

(BWP, WAMA, AND MSC-SPECIFIC MEASURES)

REFERENCE

LAWA Website
for a copy of these documents:

BWP MMRP dated September 2009
http://www.lawa.org/ourLAX/Pastprojects.aspx?id=10040

WAMA MMRP dated February 2014
http://www.lawa.org/uploadedFiles/OurLAX/pdf/WAMA/EDR%20Attachment%203%20-%20MMRP.pdf

MSC MMRP dated June 2014
http://www.lawa.org/MSCNorth/projectdocuments.aspx

APPENDIX C

LOS ANGELES INTERNATIONAL AIRPORT
EL SEGUNDO BLUE BUTTERFLY
2016 FLIGHT SEASON MONITORING REPORT
DATED JANUARY 29, 2017

El Segundo Blue Butterfly 2016 Flight Season Monitoring Report

Los Angeles International Airport

29 January 2017

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Acronyms and Abbreviations

CNPS	California Native Plant Society
ESA	Endangered Species Act
ESBB	El Segundo Blue Butterfly
LAWA	Los Angeles World Airports
LAX	Los Angeles International Airport
GIS	Geographic Information Systems
GPS	Global Positioning System
USFWS	United States Fish and Wildlife Service
WCS	Wildlands Conservation Science, LLC.

1.0 Introduction

At 203 acres, the El Segundo Blue Butterfly Habitat Restoration Area (Preserve) was established in 1986 and is one of the last remaining relatively-intact stretches of the coastal sand dune habitat along the southern coast of California (Figure 1). The Preserve is managed by the Los Angeles World Airports (LAWA) and provides habitat for a variety of sensitive species such as the San Diego horned lizard (*Phrynosoma coronatum blainvillii*) and the Southern California legless lizard (*Anniella stebbinsi*), both state and federal Species of Special Concern; the California spineflower (*Mucronea californica*) a California Native Plant Society (CNPS) Rare Plant Rank of 4.2; Lewis' evening primrose (*Camissoniopsis lewisii*) a CNPS Rare Plant Rank of 3; the federally threatened coastal California gnatcatcher (*Polioptila californica californica*); and the Preserve's namesake, the federally endangered El Segundo blue butterfly (ESBB; *Euphilotes battoides allyni*).

A member of the gossamer-winged (Lycaenidae) family, the ESBB was listed as federally endangered on June 1, 1976 by the United State Fish and Wildlife Service (USFWS) under the Endangered Species Act (ESA; 41 FR 22041). At LAX, this dune obligate subspecies is reliant on seacliff buckwheat (*Eriogonum parvifolium*) at all life stages; as a larval host and as an adult nectar plant.

After a long history of land use and development, the ESBB population at the LAX dunes dwindled to only hundreds of adult butterflies. Pursuant to Section 4 of the ESA, LAWA has a duty to maintain and restore the ESBB population. Starting in 1986, the Preserve was set aside to protect and monitor the Los Angeles population of the butterfly and Dr. Rudi Mattoni was contracted to establish sampling methodologies. From 1996 to 2015, Dr. Richard Arnold of Entomological Consulting Services, Ltd. was contracted to further refine sampling methodologies and to monitor population trends. In 2016, Wildlands Conservation Science LLC (WCS) under subcontract from Polytechnique Environmental, maintained monitoring activities to effectively guide conservation strategies of the subspecies.

All survey activities were conducted under recovery permit TE-203081-2. This report summarizes WCS's monitoring activities during the 2016 ESBB flight season and provides Dr. Arnold's 2016 population estimate for the Preserve. Additionally, this report summarizes the ESBB specimens collected under authorization from USFWS recovery permit FWSVFWO-22 and provided to Dr. Daniel Rubinoff of the University of Hawaii at Manoa, an entomologist researching Lycaenidae systematics.

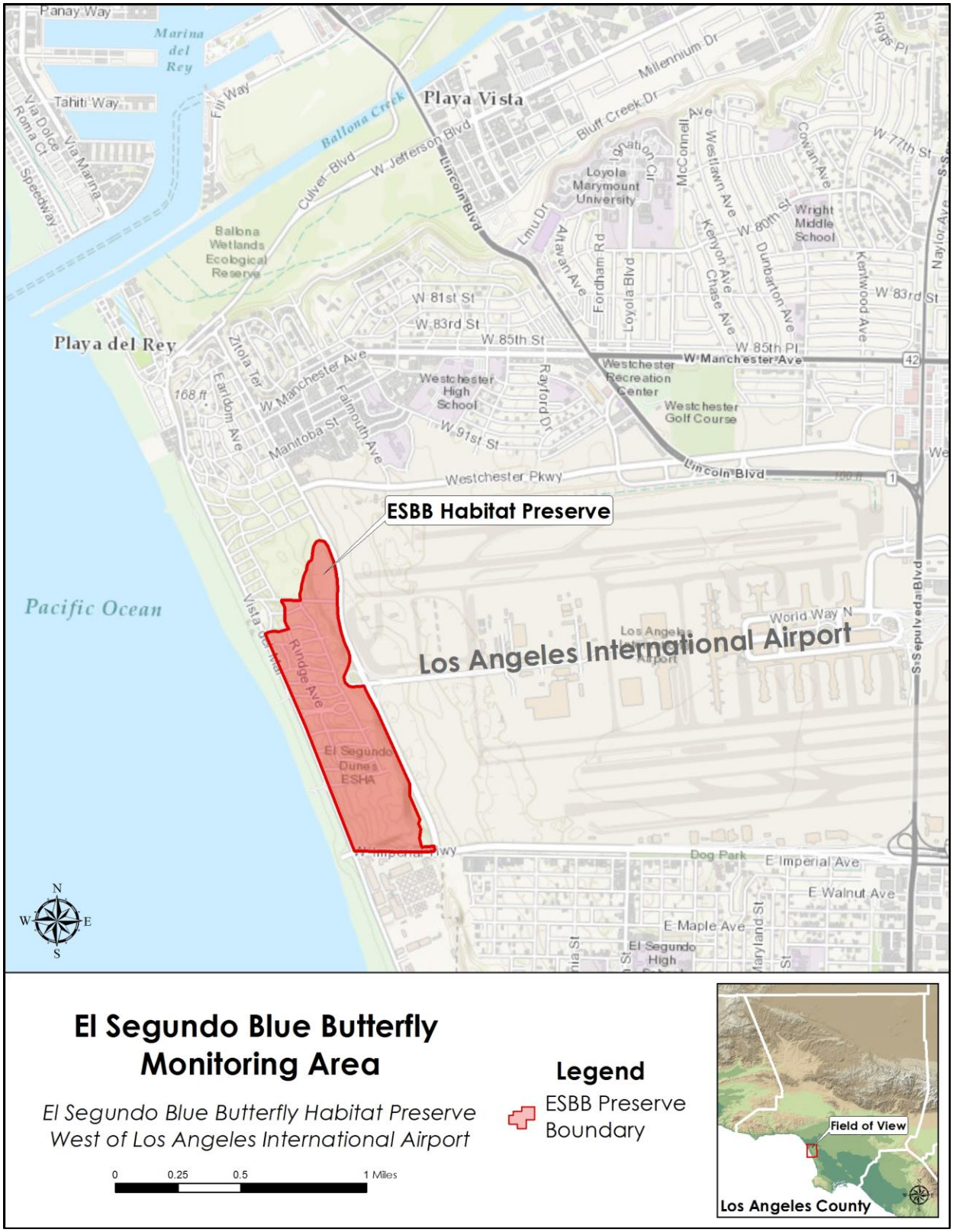

Figure 1. Regional location of the El Segundo Blue Butterfly Habitat Preserve in Los Angeles County and the site of the 2016 flight season monitoring activities.

1.1 El Segundo Blue Butterfly Life History and Range

The ESBB is one of eight subspecies comprising the polytypic square-spotted blue butterfly (*Euphilotes battoides;* Pelham 2008). *Euphilotes battoides* inhabits southern California, southern Nevada, Arizona, and northern Mexico. Extant populations of ESBB exist in Los Angeles County at the Ballona Wetlands, the Los Angeles International Airport (LAX), the Chevron Butterfly Preserve, Malaga Cove and scattered bluff locations of the Palos Verdes Peninsula, Dockweiler State Beach, the beach along Esplanade St. in Redondo Beach, and lastly, a disjunct population at and in the vicinity of Vandenberg Air Force Base in Santa Barbara County.

The ESBB belongs to Lycaenidae, the second-largest family of butterflies which constitutes approximately 30 percent of known butterfly species (Pierce et al. 2002). The taxonomy of the *Euphilotes* genus is complex. Species often converge on the same host plants and often exhibit convergent morphology to the degree that they appear superficially similar to one another than to more closely related species and subspecies occupying different niches (Pratt 2006). For example, coastal populations of the Bernadino blue (*Euphilotes bernardino*) and the square spotted blue (*Euphilotes battoides*) have demonstrated convergence of phenotypes when occupying similar habitats as have populations of Pacific dotted blue (*Euphilotes enoptes*) (Mattoni 1992, Pratt 2006). Preliminary genetic studies on the taxonomic status conducted in 2008 of the Santa Barbara County ESBB population have proven inconclusive and are currently under further investigation.

This species undergoes complete metamorphosis—four distinct phases of development from egg to larva to pupa to adult. The adult butterfly has a wingspan of 0.75 to 1.25 inches. The wings of males are a brilliant blue color with an orange border on the rear of the upper hindwings. The females have dull brown colored wings with an orange border on the upper distal surface of the hindwings (Figure 2).

Figure 2. El Segundo blue butterfly perched on a seacliff buckwheat flowerhead.

ESBB adults may be on wing from mid-June through September and are closely associated with their host plant, seacliff buckwheat (*Eriogonum parvifolium*). Eggs are deposited on buckwheat flowerheads where the larvae feed until maturation. Once mature, larvae burrow into the soil and pupate below the host plant. Most pupation occurs within the root and debris zone of seacliff buckwheat (Mattoni 1992). Pupae remain in diapause until the beginning of the flowering of seacliff buckwheat, typically in early June. The number that eclose on a given year is dependent on environmental conditions with most of the population remaining in diapause on any given year (Pratt pers. com.).

1.2 Site History

The Preserve occupies 203 acres in the El Segundo sand dunes, which used to be the largest coastal sand dune system between the mouth of the Santa Maria River in Santa Barbara County to Ensenada in Baja California, Mexico.

The Los Angeles coastal prairie was the predominant herbaceous plant community with extensive vernal pool habitat that covered about 37 square miles from Ballona Wetlands to the Palos Verdes Peninsula. The last significant remnant existed at the Preserve but was completely extirpated in the late 1960's (Mattoni et al. ND).

The current native plant communities at El Segundo sand dunes include southern foredune, southern dune scrub and valley needlegrass grassland; however, nearly all native vegetation communities have been degraded by past land use activities and invasive plant infestations.

2.0 Monitoring Methodology

In order to generate an accurate ESBB population estimate, a combination of monitoring measures has been developed and refined over the history of monitoring at the Preserve. These include surveying a 1.1-mile historical transect nearly every week of the ESBB's flight season and a population census conducted at the peak of flight season.

2.1 Historical Transect Survey

A transect route established by Dr. Mattoni in 1984 was slightly modified in 1996 to better survey suitable and non-suitable ESBB habitat and has been used for monitoring in subsequent years. The historical transect is divided by 35 intervals of varying lengths and traverses portions of the Preserve where seacliff buckwheat has been abundant in previous years, areas where buckwheat is currently abundant, some hillside areas where native flora have self-recruited, areas where non-native plants have been removed, areas infested with invasive plants, and portions where restoration has occurred in prior years.

An observer walked the historical transect from beginning to end (Intervals 1 through 35; Figure 3) approximately once during every seven-day period during the flight season with the exception at the height of flight season when surveys were intended to capture the peak numbers of ESBB observed. At peak flight season, three transect surveys were conducted over the course of five to six consecutive days to estimate the date of peak flight season to the greatest extent possible.

Prior to beginning the surveys, an Xplore Technologies XC6 ruggedized tablet operating ESRI ArcPad 10.2 Geographic Information Systems (GIS) software and equipped with a global positioning system (GPS) was loaded with the transect route overlaid on a high-resolution orthophotograph of the Preserve. The number and sex of adult ESBBs that were observed along the route within ten feet on either side of the transect were recorded. Behaviors including flying, perching, basking, courting, mating, nectaring and ovipositing were also recorded. No ESBBs were captured or handled except those permitted by USFWS for scientific collection in 2016 only.

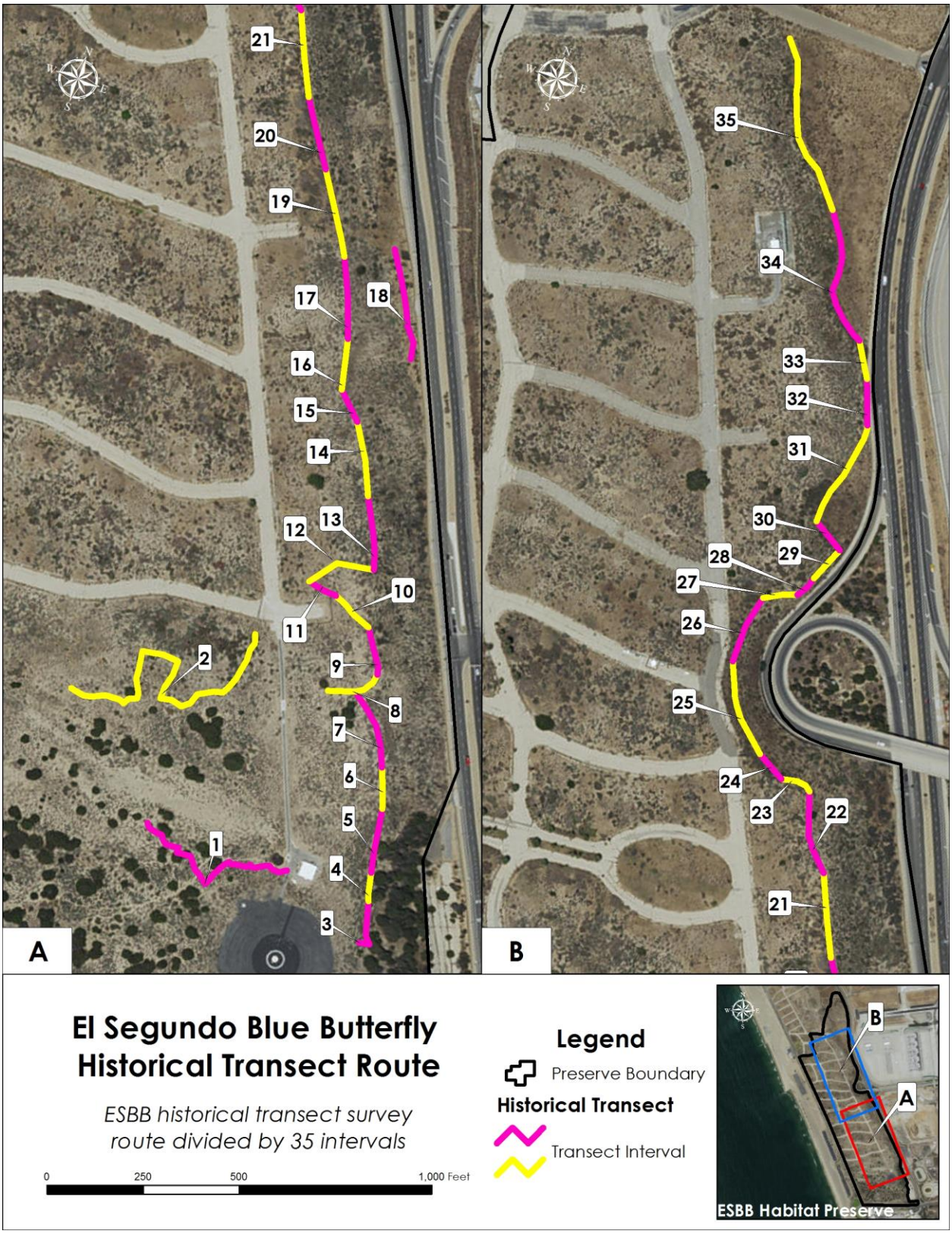

Figure 3. Location of the historical transect route within the Preserve divided by 35 intervals.

2.2 Block Count Census

In 1996, a census survey was added to the sampling design to represent all varying habitat conditions and the total area of the Preserve. During the peak of flight season, ESBB localities and counts have been conducted in 62 blocks, which are distributed across the entirety of the 203-acre Preserve (Figure 4). The approximate peak of the ESBB flight season was estimated while the ESBB season was in progress by examining the trend in the numbers of butterflies observed on the transect counts and the sex ratio of males to females.

Prior to block counts, an Xplore Technologies XC6 tablet was loaded with the block boundaries overlaid on a high-resolution orthophotograph of the Preserve. During the block count, an observer walked meandering transects and systematically searched each of the 62 blocks while visiting every buckwheat once. The number and sex of adult ESBBs that were observed was recorded for each block. Behaviors including flying, perching, basking, courting, mating, nectaring and ovipositing were also recorded. No ESBBs were captured or handled except those permitted by USFWS for scientific collection in 2016 only.

The block count totals are used in conjunction with the historical transect count data to estimate the seasonal population size of the ESBB for the Preserve.

Figure 4. Location of the block count boundaries across the Preserve.

2.3 Buckwheat Monitoring

In order to quantify the distribution and the health of buckwheat and the general flowerhead production, 126 transects were stratified throughout the blocks of the Preserve (Figure 5). An Xplore technologies XC6 tablet was loaded with the 126 transects overlaid on a high-resolution orthophotograph of the Preserve. An observer walked the centerline of the buckwheat transects and recorded all plants within ten feet of either side of the transect line. Buckwheat age class, number of flowerheads and GPS locations were recorded at each plant during the peak of the flight season which corresponded to the peak blooming period of the ESBB. A total of 10.1 miles of transects were surveyed.

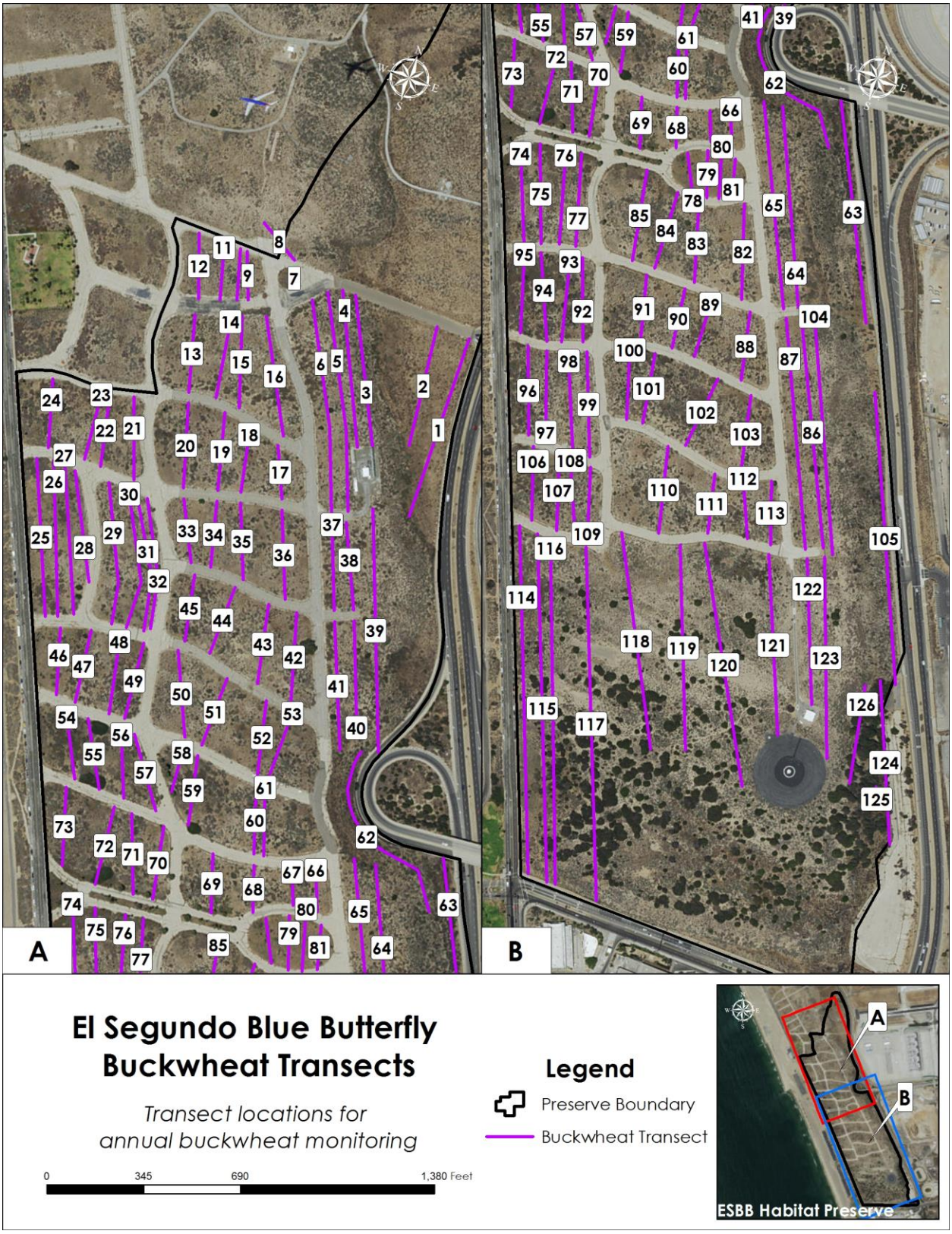

Figure 5. Locations of the 126 seacliff buckwheat transects distributed throughout the Preserve.

2.4 Seasonal ESBB Population Estimate

Using data from both the historical transect and block counts, two estimates of seasonal (or adult generation) ESBB population sizes were calculated using two methods. The first method, developed by Huang and Arnold, has been used for the past several years at the Preserve to estimate seasonal population sizes of the butterfly (Huang and Arnold 1998). The second method, developed by Holmes and Arnold (2015), is an extension of the Huang and Arnold method, but also incorporates actual adult lifespan frequencies from an earlier capture-recapture study of the ESBB, which enables this method to more accurately estimate the seasonal population size of the butterfly (Holmes and Arnold 2015, Arnold 1986).

A detailed description of the calculations used in the Huang-Arnold method is presented in prior ESBB annual monitoring reports. Similarly, Appendix A describes the Holmes and Arnold method and presents the formulas used for calculations of the seasonal (or generation) population size. Holmes and Arnold also provide computer program code for use with the R-statistical package to perform this method's calculations (Holmes and Arnold 2015).

Both methods first estimate the seasonal population numbers for the area of the historical transect route. This population size is then scaled up to estimate the seasonal population size for the 203-acre portion of the Preserve where ESBB occur. Since the block count data was obtained at or near the peak of the flight period, the scaling factor is simply the ratio of the block count to the peak count of observed ESBB on the historical transect. Thus, the ESBB seasonal population size for the Preserve is obtained by multiplying the estimated seasonal population size of the transect survey by this scaling factor.

3.0 Results and Discussion

WCS conducted the first survey of the ESBB flight season starting on May 25, 2016 and the last survey August 15, 2016. The first ESBB were observed in the Preserve on June 7; however adult butterflies were not detected on the transect until June 15, 2016. The ESBB 2016 flight season lasted for approximately 64 days and was marked by the sixth consecutive year of drought in Southern California.

3.1 Historical Transect Survey Results and Discussion

Between late May and mid-August 2016, WCS conducted a total of 14 transect surveys. ESBB were observed on 12 of the transect surveys with a total of 456 ESBB on the historical transect; 316 males and 140 females (Table 1, Figure 8). Most observations (84.9 percent) occurred while ESBB were flying. Other behaviors observed included 7.5 percent perching, 0.4 percent basking, 4.4 percent courting, 0.9 percent mating, 1.3 percent nectaring and 0.7 percent of females ovipositing. WCS also observed a higher ratio of males to females than in previous seasons; approximately 2.25 males were observed per female in 2016 as compared to 1.5 males observed per female in 2015. Transect ESBB localities are strongly correlated to the presence of seacliff buckwheat and expectedly, ESBB were not observed far distances from buckwheat plants (Figure 8).

The number of observed ESBB during transect surveys is a 15 percent decrease in observed butterflies between 2015 and 2016 and is 77 percent below the transect mean of 2,000 butterflies, calculated from 1996 to current (Figure 6). Annual transect differences from year-to-year are assessed from 1996, the year the historical transect survey was slightly modified to accommodate additional ESBB habitat, through 2016 to reflect consistency between the transect area surveyed between years.

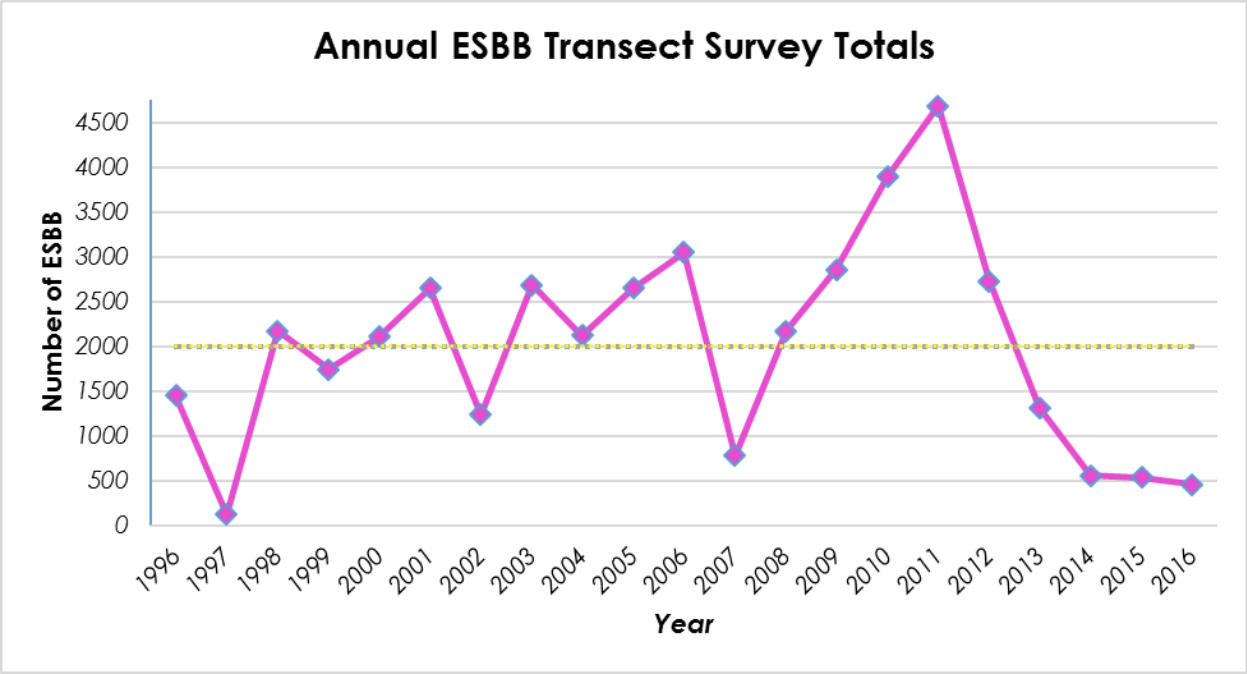

Figure 6. Annual numbers of ESBB observed while conducting the historical transect.

It is well established that most faunal populations (and specifically single-generation insect populations) experience wide fluctuations in annual population estimates above and below the mean (Varley et al. 1974). Therefore, it is expected to see large variation above and below the mean. Although it is too soon to determine a statistical trend, the development of a potential trend for multiple consecutive seasons below the mean is cause for closer examination and monitoring (Figure 6).

ESBB populations are affected by predatory and parasitism pressures, invasive species, and the health of their food plant, seacliff buckwheat. Due to the persisting California drought, buckwheat health and flowerhead production has declined in recent years and potentially more so along the length of the transect due to aging plants and extensive incursion of invasive plants.

Additionally, the infestation of invasive species such as veldt grass (*Ehrharta calycina)* and iceplant (*Carpobrotus edulis* and *Carpobrotus chilensis*) along the transect route and elsewhere throughout the Preserve threaten the existence of seacliff buckwheat and are actively reducing available habitat for ESBB (Figure 7).

Due to the combination of reduced rainfall, senescing buckwheat, and various invasive species infestations, ESBB transect detections are likely to continue to decline unless a targeted effort at combating invasive species is pursued in combination with the cessation of California's drought.

Figure 7. Veldt grass and iceplant infestations crowding out native seacliff buckwheat plants along the historical transect. These infestations can smother native plants and reduce the food availability and pupation requirements of ESBB.

Table 1. Summary of ESBB observed and behavior on the historical transect in 2016.

Date of Transect Survey	Total M Flying	Total F Flying	Total M Perching	Total F Perching	Total M Basking	Total F Basking	Total M Courting	Total F Courting	Total M Mating	Total F Mating	Total M Nectaring	Total F Nectaring	Total F Ovipositing	Total M Observed on Transect	Total F Observed on Transect
Wednesday, May 25, 2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thursday, June 2, 2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tuesday, June 7, 2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wednesday, June 15, 2016	4	0	0	0	0	0	0	0	0	0	0	0	0	4	0
Monday, June 20, 2016	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Wednesday, June 29, 2016	32	10	0	0	1	0	4	4	0	0	0	3	0	37	17
Thursday, July 7, 2016	54	10	4	11	0	0	2	2	0	0	0	1	0	60	24
Monday, July 11, 2016	76	18	1	2	0	0	2	2	0	0	0	0	0	79	22
Wednesday, July 13, 2016	53	25	0	8	0	0	1	1	1	1	0	1	1	55	37
Tuesday, July 19, 2016	49	20	0	8	0	1	0	0	0	0	0	0	0	49	29
Tuesday, July 26, 2016	23	6	0	0	0	0	1	1	0	0	0	1	2	24	10
Thursday, August 4, 2016	3	0	0	0	0	0	0	0	1	1	0	0	0	4	1
Wednesday, August 10, 2016	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Monday, August 15, 2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			m = males	*f = females*										316 males	140
											2016 Grand Total of ESBB Observed on Transect			***456***	

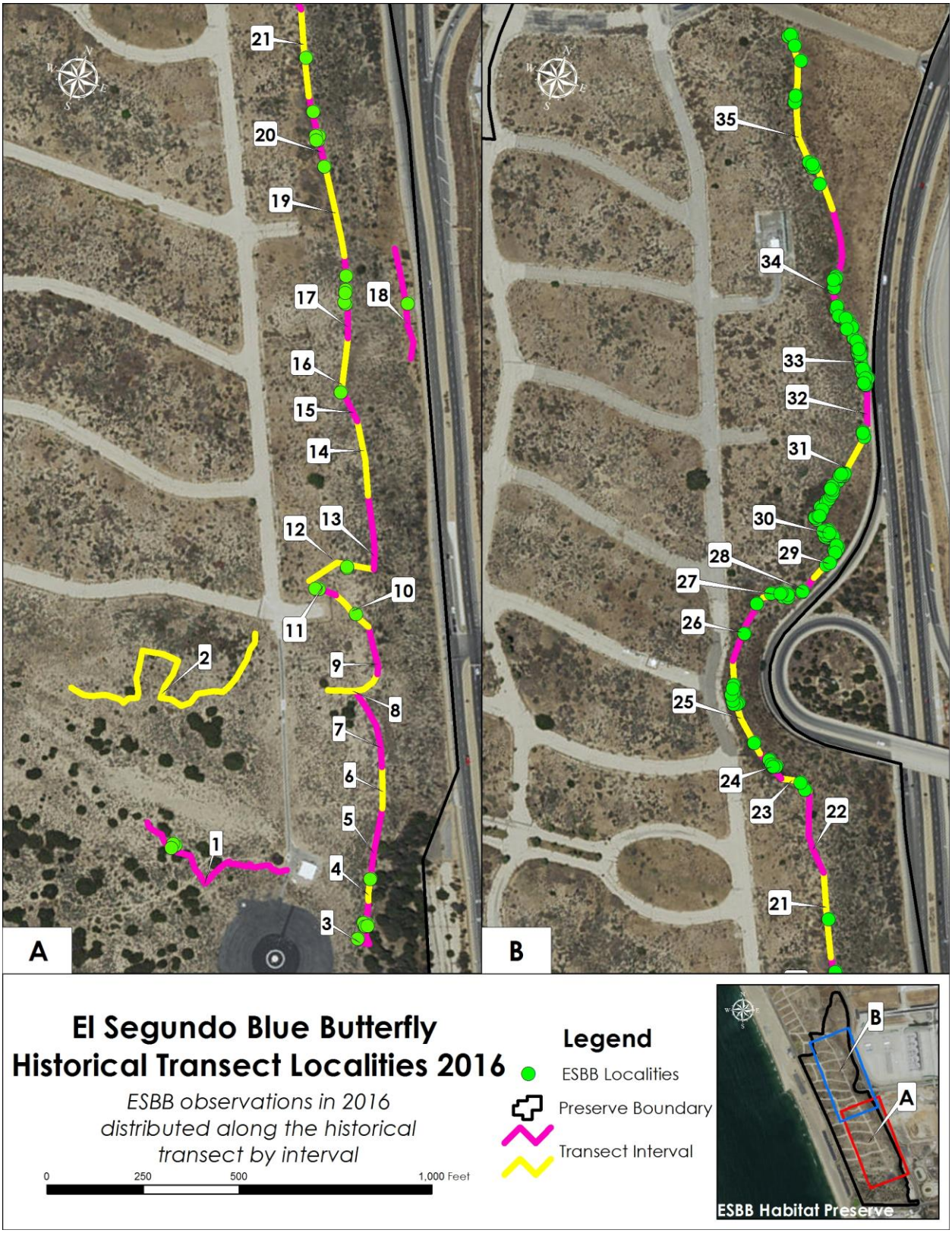

Figure 8. Locations of ESBB observations along the historical transect in 2016. Butterfly locations are strongly correlated to the location of healthy seacliff buckwheat plants. Note: Localities may indicate more than a single butterfly observation.

3.2 Block Count Results and Discussion

The block count census was performed over a three-day period from July 11, 2016 to July 13, 2016 and coincided with the peak of ESBB flight season as estimated from the transect surveys (Table 1). During the three-day count period, WCS observed a total of 890 ESBB across the area of the Preserve (Table 2, Figure 14).

Similar to transect detections, most observations occurred while ESBB were flying (87 percent). Other behaviors observed included 2.5 percent perching, 0.9 percent basking, 4.0 percent courting, 1.3 percent mating, and 4.2 percent nectaring. No females were observed ovipositing (Table 2).

The number of observed ESBB during block counts is a 35 percent decrease in observed butterflies between 2015 and 2016 and is a 75 percent decrease from the block count mean of 3,540 butterflies, calculated from 1996 to current. Annual block count differences from year-to-year are assessed from 1996 through 2016 (Figures 11 and 12).

Localities of ESBB are strongly correlated to the presence of seacliff buckwheat and expectedly, ESBB were not observed far distances from buckwheat plants (Figure 14). Conducting counts and documenting ESBB localities across the entirety of the Preserve localities serves as an excellent representation of the ESBB's distribution and range and can indicate potential future restoration areas. For example, the southern portion of the Preserve has extensive growth of acacia (*Acacia retinodes*, *A. cyclops*, *A.* spp.) and reduced cover of seacliff buckwheat. Thus, Blocks 17 through 27 saw reduced ESBB detections as compared to other areas of the Preserve and indicate the need for acacia control, in addition to other invasive species (Figures 8, 9 and 13). Additionally, species such as iceplant and veldt grass have seen expansion across the entire area of the Preserve and are out-competing native species and likely rare species such as Lewis' evening primrose (*Camissoniopsis lewisii*; Figure 9).

Because ESBB are not marked and it is not feasible to conduct a true census across the entire Preserve simultaneously, some individuals may have been missed and/or counted more than once. It is nearly impossible to obtain a precise count of a dynamic insect population because birth and death rates are continual and may go unobserved. Regardless, the block counts are essential to extrapolate an accurate population estimate for the entire Preserve. Although the transect and block counts can be used separately to estimate the ESBB population size to make comparisons from year-to-year; however, when used together these two sampling methodologies provide a seasonal population estimate for the entire Preserve.

Like the wide fluctuation in year-to-year transect observations, there are wide fluctuations in year-to-year block count observations as well. Although these fluctuations are to be expected, any development of a trend well below the mean is cause for closer examination and necessary monitoring to determine if a population is at risk (Figures 11 and 12). Not only do the transect surveys possibly establish a trend toward a declining ESBB population, but the block counts conducted across the Preserve also confirm a decrease in the species' presence. This may be attributed to increased pressures from invasive species, parasitism, predation, disease, the prolonged California drought, or a combination thereof.

One factor established by Arnold to influence annual ESBB population numbers is rainfall, which in turn influences flower production of seacliff buckwheat (Arnold 2015). Figure 13 illustrates the positive correlation between ESBB numbers obtained during block counts and annual rainfall during a 21-year period. While dramatic fluctuations in this population have previously been observed and may be within normal variation for a single generation insect population, a consecutive annual trend toward the species' decline has developed over the last six years and appears to be correlated to the drought (Figures 11-13). However, increased pressure from consecutive years of a declining population and reduced rainfall, declining buckwheat flowerhead production, and the expansion of various invasive species in combination pose substantial threats to the LAX ESBB population if left unchecked.

Figure 9. Beach primrose, a species closely related to Lewis' evening primrose, encroached upon by iceplant. Iceplant roots at the nodes, has a creeping habit, and often forms deep mats covering large areas that can quickly outcompete native plants.

Figure 10. Veldt grass in the foreground, acacia in the background and iceplant largely dominate the landscape at the Preserve and threaten the ESBB's habitat.

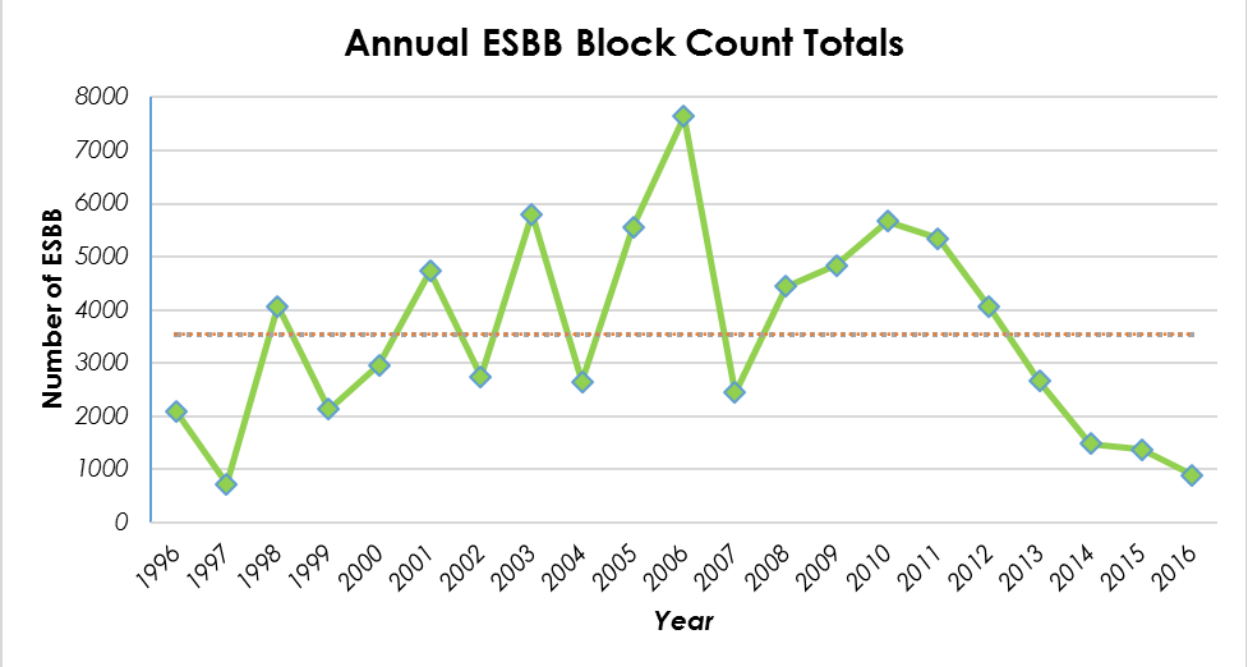

Figure 11. Summary of block count totals from 1996 to 2016.

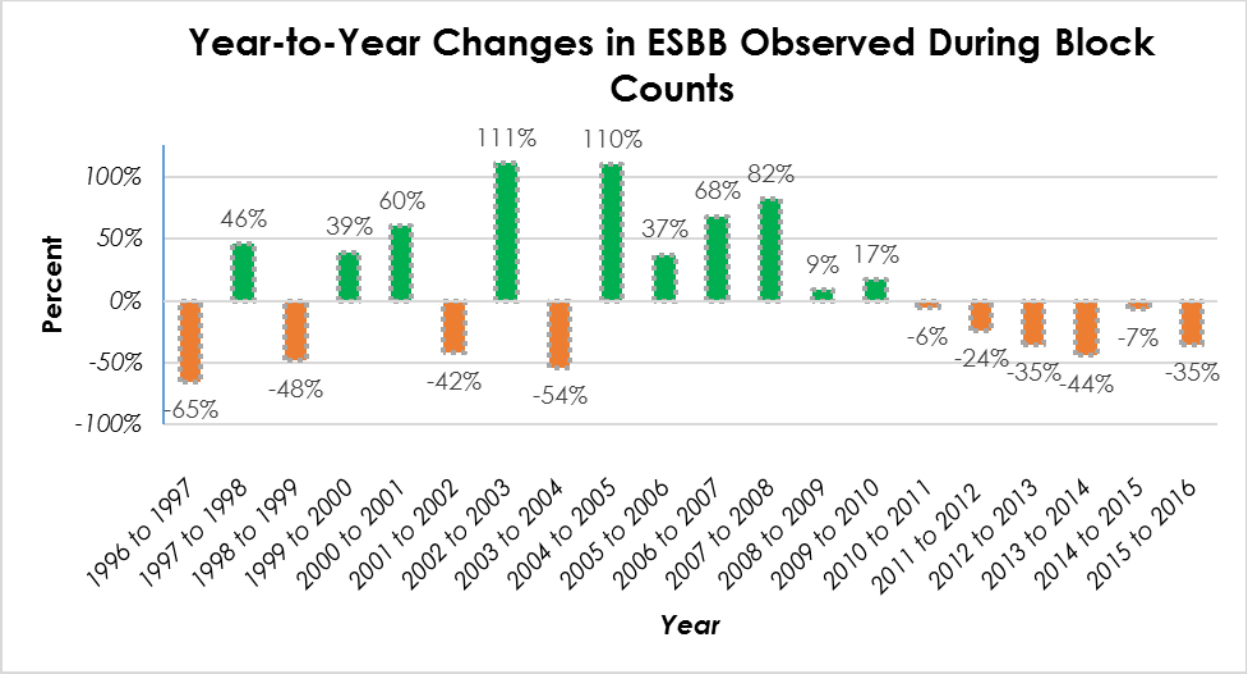

Figure 12. Year-to-year changes between block count totals.

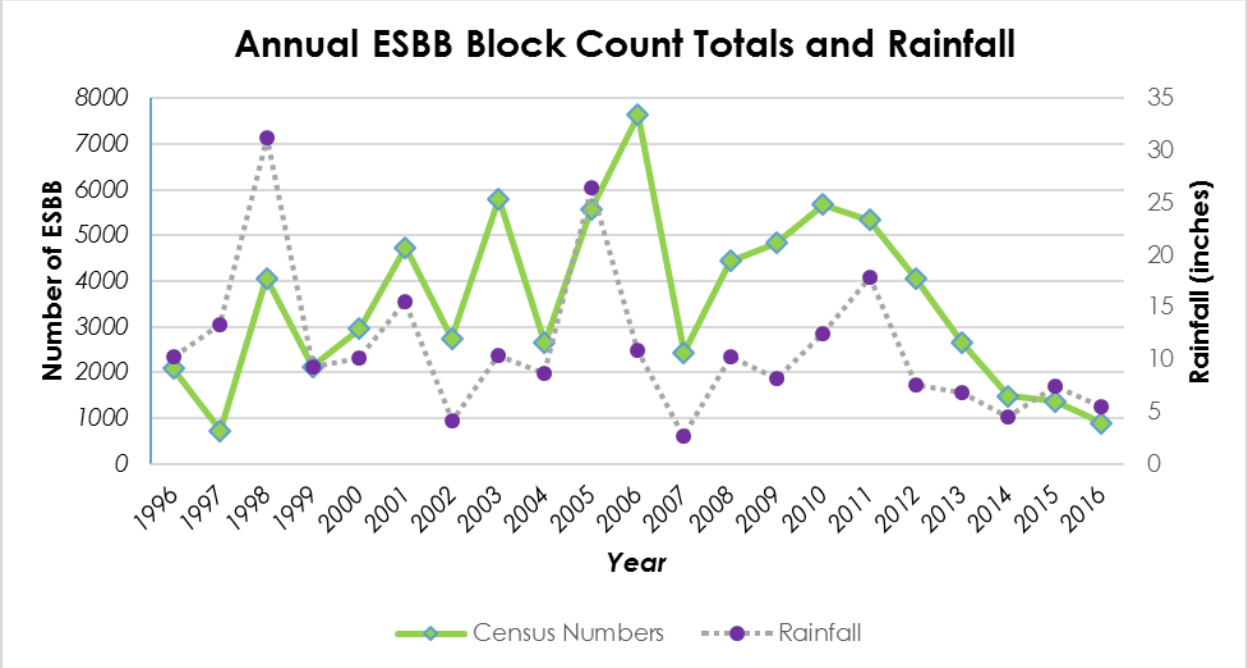

Figure 13. Relationship between rainfall and observed butterflies.

Table 2. Summary of ESBB observed and behavior during block counts in 2016.

Date of Block Count	Block ID	Total M Flying	Total F Flying	Total M Perching	Total F Perching	Total M Basking	Total F Basking	Total M Courting	Total F Courting	Total M Mating	Total F Mating	Total M Nectaring	Total F Nectaring	Total F Ovipositing	Total M Observed in Block	Total F Observed in Block
11-Jul-16	*10*	9	10	0	1	0	0	0	0	0	0	0	0	0	9	11
	11	2	1	0	0	0	0	0	0	0	0	0	0	0	2	1
	12	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0
	14	21	10	1	4	0	0	2	2	0	0	0	0	0	24	16
	16	39	24	6	1	0	0	3	3	0	0	0	0	0	48	28
	19	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1
	23	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	31	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1
	35	10	4	0	0	0	0	0	0	1	1	0	2	0	11	7
	36	15	7	0	0	0	0	0	0	0	0	1	0	0	16	7
	38	33	10	0	0	0	0	0	0	0	0	1	4	0	34	14
	39	8	6	0	0	0	0	1	1	0	0	1	0	0	10	7
	42	6	9	0	0	0	0	0	0	1	1	0	0	0	7	10
	43	7	8	0	0	0	0	0	0	0	0	1	0	0	8	8
12-Jul-16	*7*	5	3	0	0	0	0	0	0	0	0	0	0	0	5	3
	9	34	9	0	0	0	0	1	1	0	0	0	0	0	35	10
	13	12	4	0	2	0	0	1	1	0	0	0	0	0	13	7
	36	30	17	0	0	1	0	0	0	1	1	0	1	0	32	19
	37	34	16	0	0	0	1	0	0	2	2	0	4	0	36	23
	40	26	13	0	0	0	0	1	1	1	1	1	1	0	29	16
	41	15	11	0	0	0	0	0	0	0	0	3	4	0	18	15
	43	2	2	0	0	0	0	0	0	0	0	0	1	0	2	3
	44	14	14	0	0	1	0	0	0	0	0	0	3	0	15	17
	45	3	3	0	0	0	0	1	1	0	0	0	0	0	4	4
13-Jul-16	*1*	65	22	0	1	0	0	3	3	0	0	0	1	0	68	27
	2	45	20	1	0	4	0	3	3	0	0	1	5	0	54	28
	4	8	2	0	0	0	0	0	0	0	0	0	0	0	8	2
	5	0	6	0	0	0	0	0	0	0	0	0	0	0	0	6
	6	2	1	0	0	0	0	0	0	0	0	0	0	0	2	1
	8	12	7	0	0	0	0	0	0	0	0	0	0	0	12	7
	15	23	18	0	5	0	0	0	0	0	0	0	0	0	23	23
	20	16	9	0	0	0	0	1	1	0	0	0	1	0	17	11
	21	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
	22	1	0	0	0	0	1	0	0	0	0	0	0	0	1	1
	24	2	0	0	0	0	0	0	0	0	0	0	1	0	2	1
	27	3	0	0	0	0	0	0	0	0	0	0	0	0	3	0
	31	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
					m = males		*f = females*						**2016 Grand Total of ESBB Observed in Blocks**		554	336
															890	

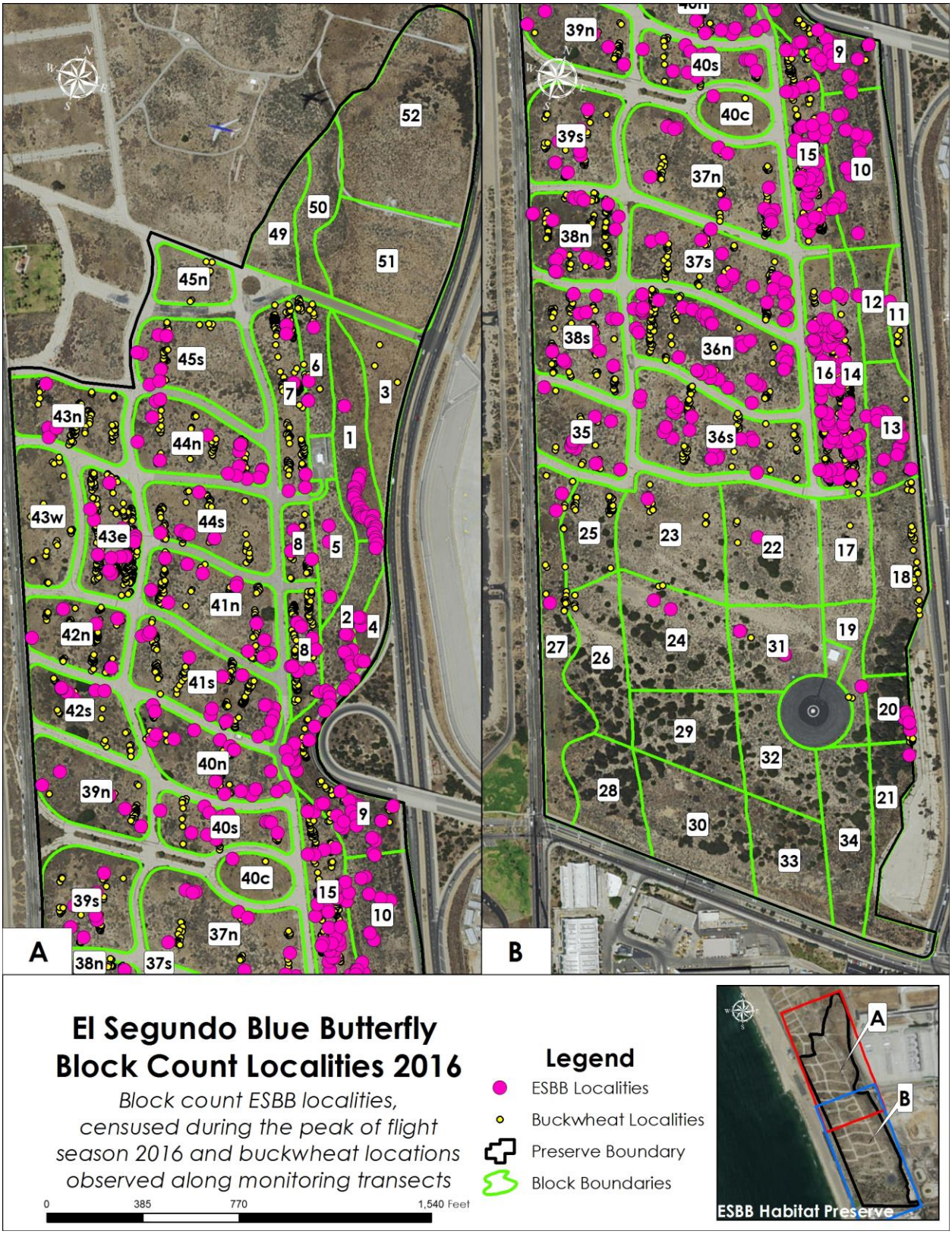

Figure 14. ESBB block count localities in 2016. Butterfly locations are strongly correlated to the location of healthy seacliff buckwheat plants. Note: Localities do not necessarily indicate single butterfly observations and buckwheat locations are from data gathered from buckwheat monitoring transects

3.3 Buckwheat Monitoring Results and Discussion

A total of 3,471 buckwheat plants were observed on 126 transects distributed across the Preserve (Figure 17). Of these, 3,008 were mature plants, 191 were juvenile, 196 were senescent, and 76 were seedlings. This represents a 19 percent increase in total plants from 2015; however, these 3,471 plants only produced a total of 810,000 flowerheads; a 37 percent decrease from the mean calculated from 2003 to 2016.

A positive correlation between buckwheat plant numbers, flowerhead numbers and ESBB has been well established (Arnold 1985, 2015). ESBB numbers closely track seacliff buckwheat's flower production, which in turn closely tracks annual rainfall, and therefore can be predictive of future ESBB numbers (Arnold 1985). The decline in buckwheat flowerhead counts also closely tracks the decline in butterfly numbers observed over the last six years (Figures 15 and 16).

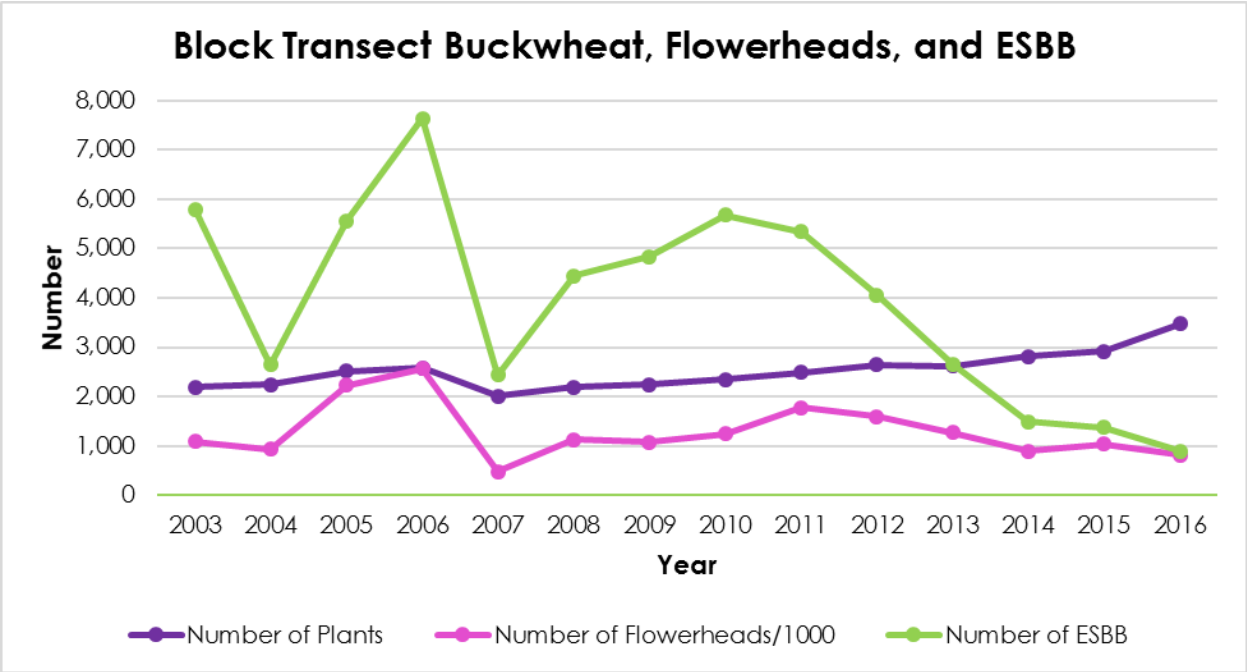

Figure 15. Buckwheat, butterflies and flowerheads.

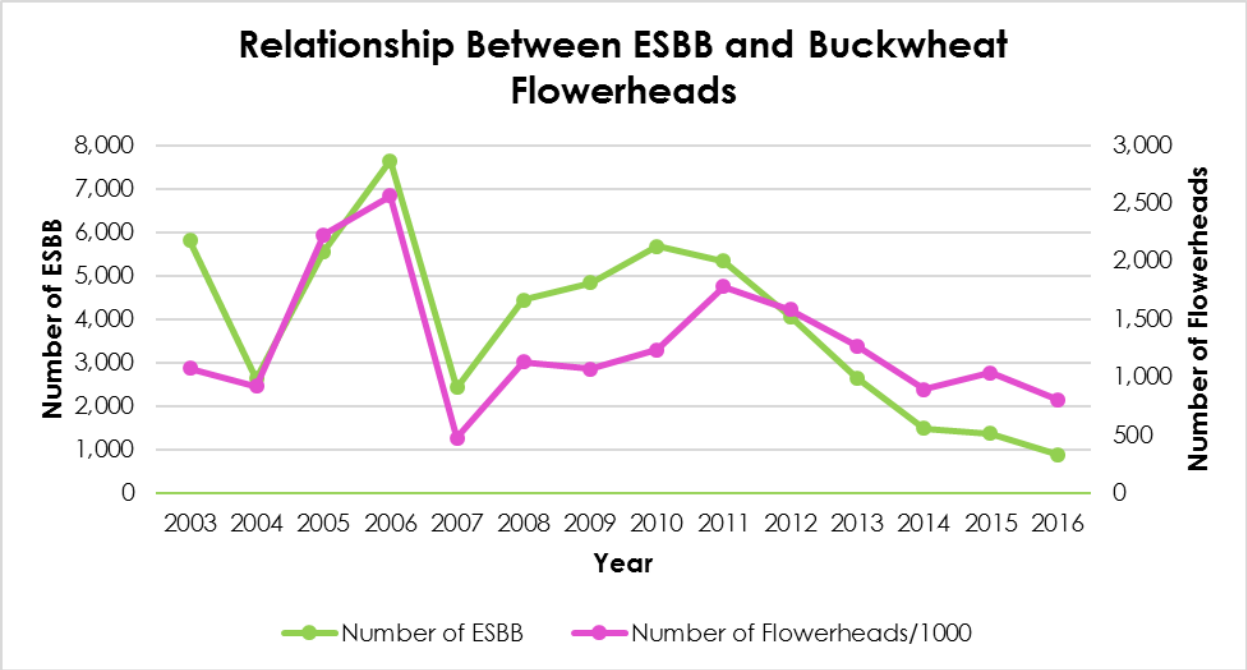

Figure 16. Butterflies and flowerhead relationship.

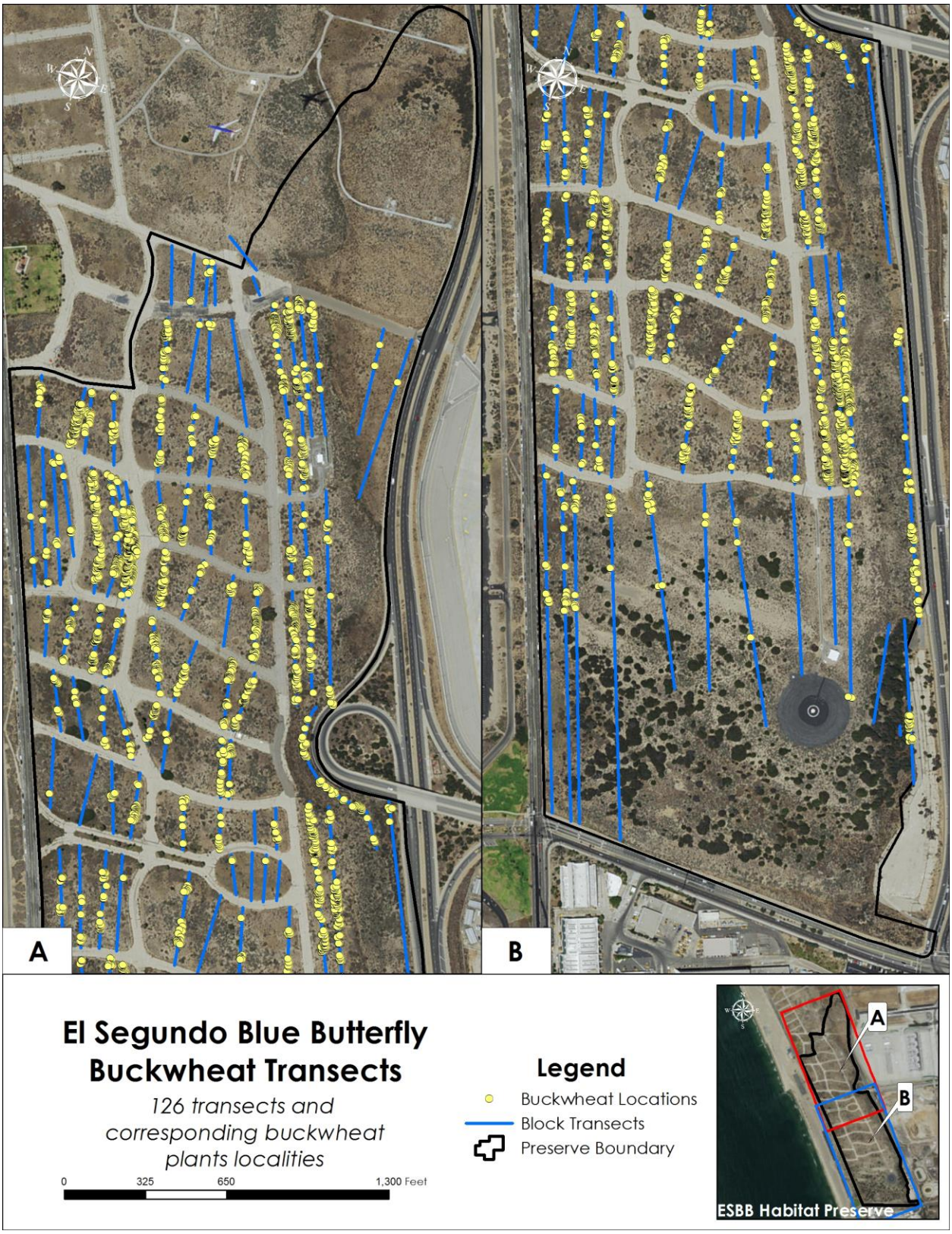

Figure 17. Buckwheat transects distributed across the Preserve and corresponding localities.

3.4 Seasonal ESBB Population Estimate Results

Two methods were utilized to calculate annual population estimates at the Preserve, the Huang and Arnold method which has been in use at the Preserve since 1998, and the Holmes and Arnold method (Huang and Arnold 1998, Holmes and Arnold 2015).

Using the trapezoidal numerical integration method described by Huang, the seasonal population estimate for the ESBB population throughout the Preserve ranged from 24,963 to 26,062 individuals in 2016 (Figure 19). Using the Holmes and Arnold method, the ESBB's 2016 seasonal population estimate was between 10,084 and 11,224 individuals (Figure 20).

The seasonal population curve for 2016 created using the Holmes and Arnold is displayed in Figure 18. The open circles in this graph are the actual numbers of ESBB adults observed on the historical transect counts for each survey date. The line fitted to these counts is the seasonal population curve for the 2016 ESBB adult population. The area under the population curve represents the total number of butterflies during the adult flight season.

Seasonal population sizes for the ESBB using the Holmes and Arnold estimator were calculated for the years 2002 through 2016 and compared to population sizes generated by Huang's (1998) estimator (Figures 19 and 20). The trends in seasonal population sizes during this 15-year period are essentially identical except that the Huang estimates are approximately 2.30 to 2.44 times greater than Holmes and Arnold estimates. The primary reason for this differential is due to the use of actual lifespan frequencies in the Holmes and Arnold estimator. Since the observed lifespans from an earlier capture-recapture study of the ESBB were longer than those estimated by Huang, this results in lower population size estimates (Arnold 1986). For this reason, we recommend that only the Holmes and Arnold estimator should be used to estimate future seasonal population sizes of the ESBB at LAX.

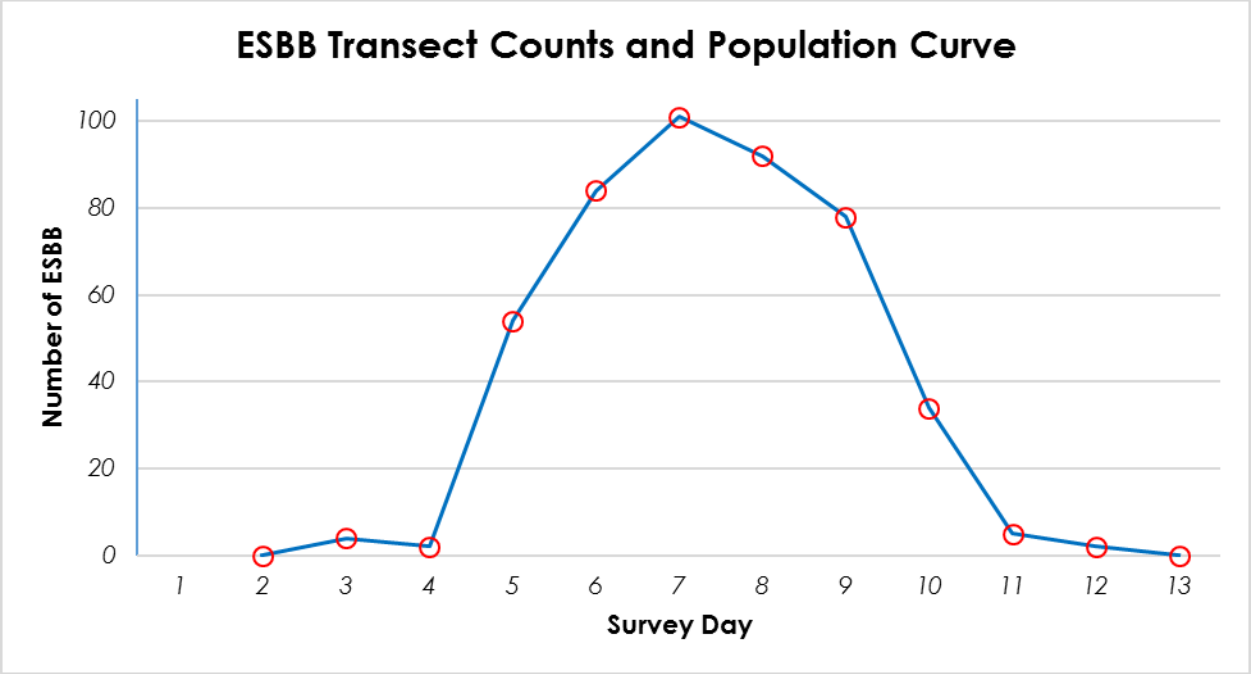

Figure 18. ESBB population curve for 2016 historical transect surveys at the Los Angeles Habitat Restoration Area.

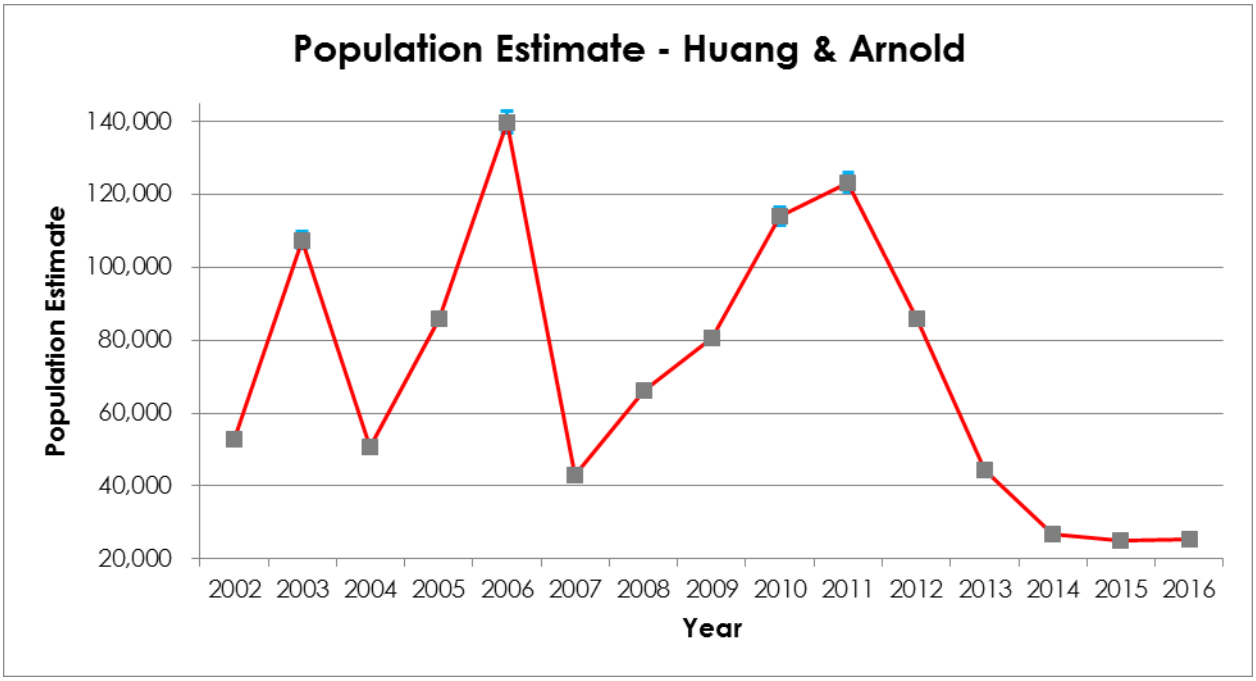

Figure 19. Population estimate generated using the Huang and Arnold method.

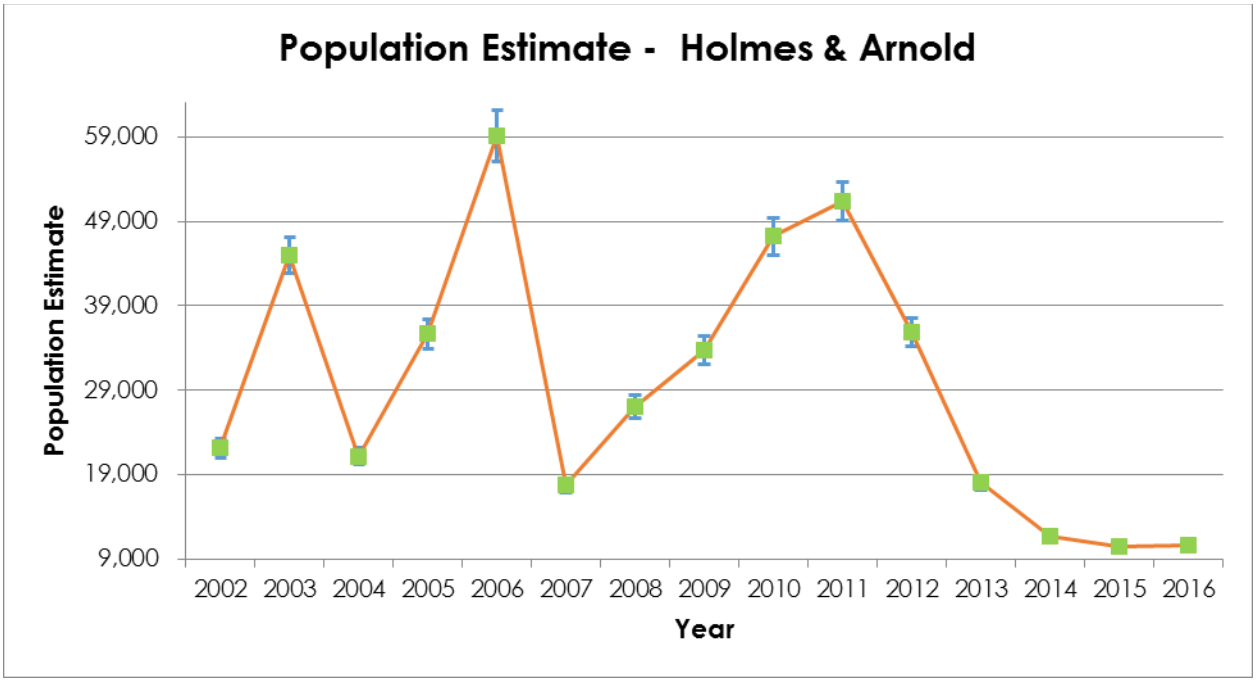

Figure 20. Population estimate generated using the Holmes and Arnold method.

3.5 Scientific Collection Results

A total of 10 specimens were collected under authorized permit, three female and seven male butterflies (Table 3). No larvae were collected or disturbed. All specimens were collected opportunistically while walking throughout the Preserve and were not concentrated in specific areas to limit disturbance to localized populations and increase variation in the collection sample. All ESBB specimens were submitted in November 2016 to Dr. Daniel Rubinoff, an entomologist at the University of Hawaii Manoa (Figure 21).

Figure 21. All ten ESBB collected and preserved for systematics research at the University of Hawaii.

Table 3. ESBB collections submitted to University of Hawaii under authorization from USFWS.

Date Collected	Scientific Collector	Specimen ID	Lifestage	Sex	Behavior	Associated Plant	Plant Condition
6/15/2016	John LaBonte	JLS 517	Adult	M	Flying	*Eriogonum parvifolium*	Late bud/early peak
6/29/2016	Katrina Olthof, Alice Abela	JLS 538	Adult	M	Flying	*Eriogonum parvifolium*	Early peak
6/29/2016	Katrina Olthof, Alice Abela	JLS 549	Adult	F	Flying	*Eriogonum parvifolium*	Early peak
6/29/2016	Katrina Olthof, Alice Abela	JLS 537	Adult	F	Flying	*Eriogonum parvifolium*	Early peak
7/11/2016	Katrina Olthof	JLS 529	Adult	M	Flying	*Eriogonum parvifolium*	Peak
7/11/2016	Katrina Olthof	JLS 547	Adult	M	Flying	*Eriogonum parvifolium*	Peak
7/11/2016	Katrina Olthof	JLS 551	Adult	M	Flying	*Eriogonum parvifolium*	Peak
7/13/2016	Katrina Olthof	JLS 543	Adult	M	Flying	*Eriogonum parvifolium*	Peak
7/13/2016	Katrina Olthof	JLS 545	Adult	M	Flying	*Eriogonum parvifolium*	Peak
7/13/2016	Katrina Olthof	JLS 548	Adult	F	Flying	*Eriogonum parvifolium*	Peak

4.0 Management Recommendations

Coastal dunes are dynamic interfaces between the land and the sea and boast unique assemblages of life found in no other habitats. Many species are restricted to this system and rely on shifting, un-stabilized sand sheets and flourish in the interdunal basins within an otherwise apparently arid landscape. Ecologically sensitive species such as the silvery legless lizard burrow into loose sandy soil. The San Diego horned lizard feeds on harvester ants which in turn disperse seacliff buckwheat seed throughout the dunes. Rare and sensitive plants such as the California spineflower and Lewis' evening primrose provide forage for pollinator species not yet described as at risk. Unfortunately, as with many other unique habitats in California, dunes have been tremendously impacted and affected by habitat fragmentation and development. The El Segundo Blue Butterfly Habitat Restoration Area is one of the last remaining coastal dune remnants in Southern California and should be protected, conserved and enhanced.

The ESBB is emblematic of the conservation success story at the Preserve—a charismatic subspecies brought back from the brink of extinction and is heralded as the unofficial mascot of LAX. However, species-specific conservation may happen at the expense of other taxa and an entire system can be left vulnerable. Although seacliff buckwheat still supports a relatively robust

butterfly population, buckwheat and many other plant and animal species are at risk of displacement due to the incursion of invasive species. Not only do invasive plants displace rare and common native plants, but because most of these species form dense colonies, they impede the natural processes of dune movement. In natural communities, dunes continually move in response to wind pressure and wave action, typically forming morphologically and floristically distinct smaller foredune and larger backdune communities which has been prevented at the Preserve. Invasive species such as iceplant prevent natural migration of sand, which leads to an impoverished native vegetation community and a subsequent decrease in value of this system to wildlife.

In 1992 and 1994, the City of Los Angeles officially protected the 203 acre Preserve by re-zoning it for nature preservation-related land uses only (City of Los Angeles Ordinances No. 167,940 and 169,676). The Preserve is currently protected as an Environmentally Sensitive Habitat Area by the California Coastal Commission under the California Coastal Act of 1976, as habitat for sensitive species of concern by the California Department of Fish and Wildlife (CDFW) under various California laws, and of course as part of the El Segundo Blue Butterfly Preserve by the USFWS under the ESA.

Therefore, management objectives must be clearly defined to protect the vulnerable, last-remaining dune system and its sensitive species contained within based on current, quantifiable data.

4.1 Invasive Management Strategies

4.1.1. Invasive Plant Map

In an effort to define management objectives clearly and beyond the conservation of a single species, baseline inventories of the threats against these species should be gathered. Invasive plant distribution and cover are critical to accurately and responsibly identifying the species that are threats to the Preserve at LAX. Geospatial invasive plant occurrence data assists landscape managers in determining which species and populations should be targeted for control (or eradication when possible) based off the current management objectives, available resources, and threatened natural resources. These baseline data and maps also give landscape managers a quantifiable way to show measurable progress towards achieving defined management goals.

An up-to-date and complete invasive species map should be generated for the ESBB Preserve to effectively determine which species are posing the greatest risks on the landscape. Maps should include a combination of point and polygon data in addition to grid cover density estimates. Grid density estimates should be used for species that are widespread, do not have discernable population boundaries that are easily delineated, such as iceplant species and *Salsola* spp., or are diffuse across the landscape. Two examples are included in Figures 22 and 23 that display point and polygon data as well as grid cover estimates. These maps were generated for Guadalupe National Wildlife Refuge, a similar dune system, to further define their management objective of returning the refuge to natural dune processes.

4.1.2. Invasive Plant Prioritization

Newly introduced invasive species often spread quickly. Early detection and monitoring can help land managers prioritize species likely to cause the most ecological damage before species become entrenched and too costly to effectively control.

The Invasion Curve is a concept in conservation biology that shows that eradication of an invasive species becomes less likely and control costs increase as an invasive species spreads over time (Figure 24). Prevention is the most cost-effective solution, followed by eradication if conducted in a timely manner. If a species is not detected and removed early, intense and long-term control efforts become unavoidable and are done as asset-based protection, for instance in the case of the ESBB.

Identifying where a species falls on the invasion curve is the first step to taking management action, followed by defining quantifiable characteristics of each invasive species. Once invasive species inventories and baseline data are acquired and an understanding of where species fall on the invasion curve, an accompanying prioritization is necessary to manage multiple invasive species at the landscape level in an ecologically sensitive manner. This requires a systematic and transparent methodology that is easily communicated to all management stakeholders.

Identifying quantifiable invasive plant characteristics that can be subjected to a ranking scheme allows for the consistent prioritization of key elements to be objectively compared across all species. These ranking elements can then be compared to the management objectives to develop customizable management prioritization schemes in a cost-effective way.

An example of a Prioritization Ranking Scheme is presented in Table 4. A series of index values ranging from 1 to 3 were developed for each prioritization variable. An index rank of 3 was assigned to variables that correlate with high priority treatment conditions such as small number and size of infestations; small net and gross acreages; California Invasive Plant Council's inventory rating for ecological damage caused by each species; invasive plants infesting high quality or high priority habitat areas; and other site-species variables. An index ranking of 1 was designated for inverse conditions that correlate with low priority treatment conditions. These various index values were then compiled to develop an overall invasive plant priority ranking system to determine species from highest to lowest priority for management action.

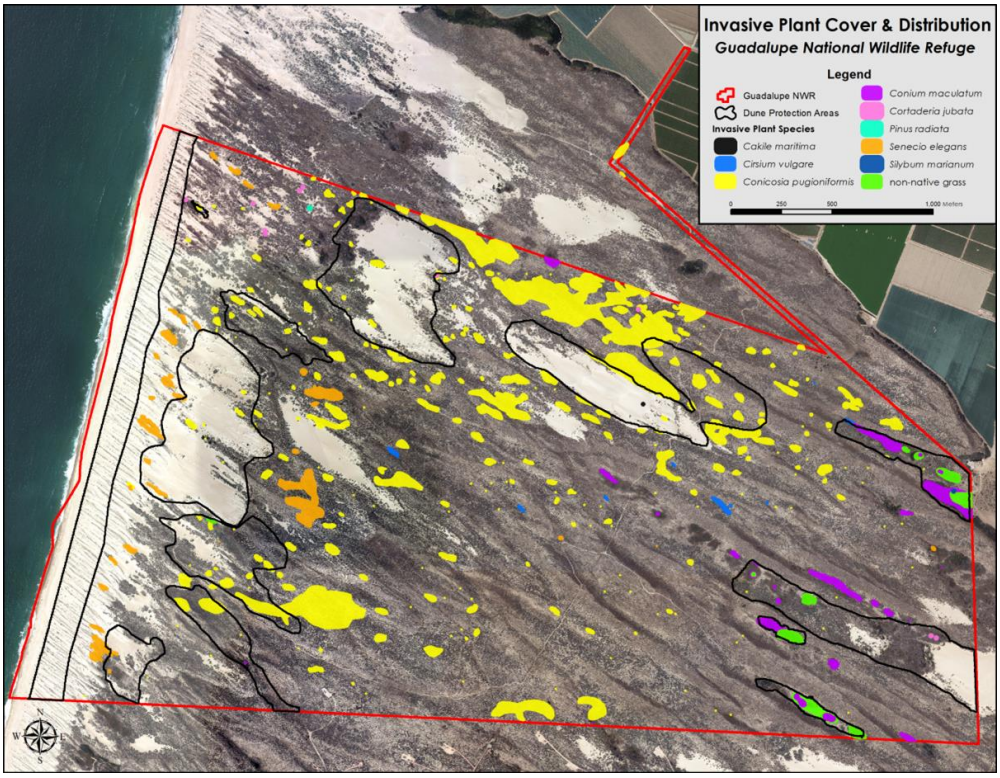

Figure 22. Sample invasive plant cover and distribution map generated by WCS for Guadalupe National Wildlife Refuge.

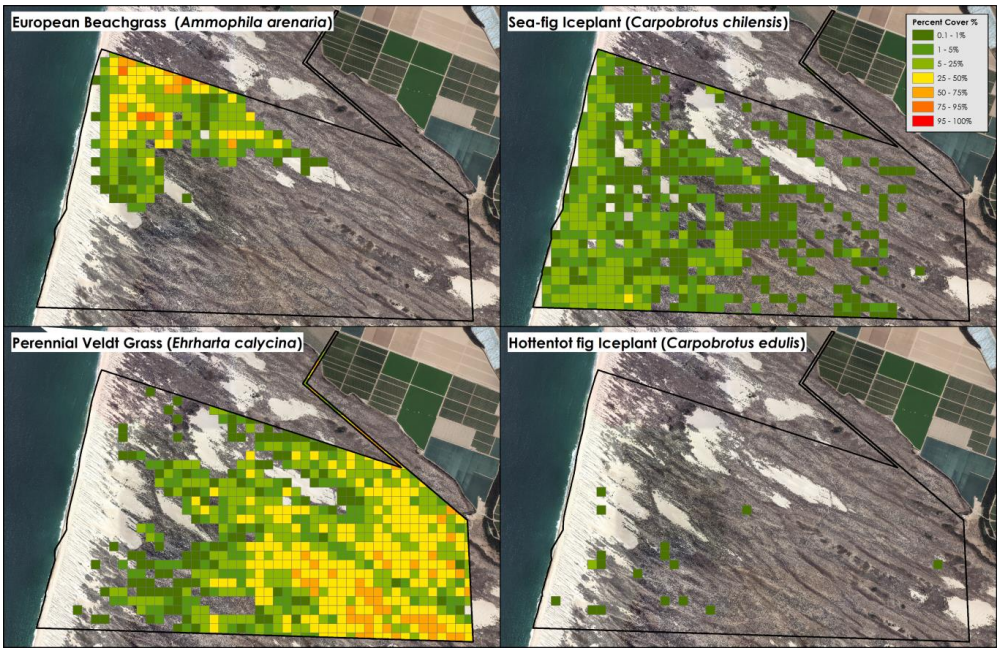

Figure 23. Sample grid cover densities of selected invasive plant species generated by WCS for Guadalupe National Wildlife Refuge.

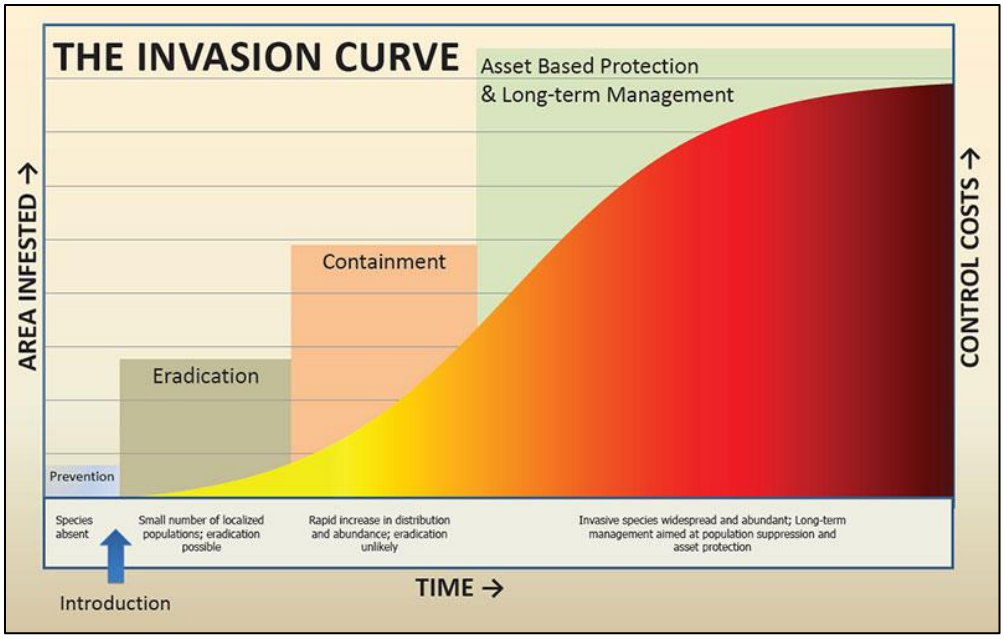

Figure 24. View of the classic *Invasion Curve* showing the relationship between invasive plant infestation "size" and control costs. Photo courtesy of the North American Invasive Species Network (http://www.naisn.org).

Table 4. Example of a customizable invasive plant prioritization index that guides management decisions on treatment strategies for various invasive plants.

Species Name	Common Name	Stand Total Index Weighting Factor	Stand Total Index	Gross Area Index Weighting Factor	Gross Area Index	Net Area Index Weighting Factor	Net Area Index	Cal-IPC Rank Index Weighting Factor	Cal-IPC Rank Index	Habitat Priority Index Weighting Factor	Habitat Priority Index	Life Cycle Index Weighting Factor	Life Cycle Index	Fecundity Index Weighting Factor	Fecundity Index	Seed Longevity Weighting Factor	Seed Longevity	Additive Priority Score	Weighted Priority Score
Conium maculatum	poison hemlock		3		3		3		2		2.63		3		3		2	21.63	23.63
Cirsium vulgare	bull thistle		3		3		3		2		2.01		3		3		2	21.01	23.01
Senecio elegans	red-purple ragwort		3		3		3		2		1.97		3		3		2	20.97	22.97
non-native grasses	non-native grasses		3		3		3		2		2.12		3		3		1	20.12	22.12
Cortaderia jubata	jubata grass		3		3		3		3		2.07		1		3		1	19.07	22.07
Silybum marianum	milk thistle		3		3		3		1		3.00		3		3		2	21.00	22.00
Carpobrotus edulis	hottentot fig iceplant	x1	3	x1	3	x1	3	x2	3	x1	1.98	x1	1	x1	2	x1	2	18.98	21.98
Cakile maritima	European searocket		3		3		3		1		2.00		3		3		2	20.00	21.00
Conicosia pugioniformis	slender-leaved iceplant		1		2		3		1		1.98		3		2		2	15.98	16.98
Ehrharta calycina	perennial veldt grass		1		1		1		3		1.72		1		3		2	13.72	16.72
Pinus radiata	Monterey Pine		3		3		3		1		2.51		1		1		1	15.51	16.51
Carpobrotus chilensis	sea-fig iceplant		1		1		2		2		1.96		1		2		2	12.96	14.96
Ammophila arenaria	European beachgrass		2		1		1		3		1.81		1		1		1	11.81	14.81

Cal-IPC Rank Index values displayed in RED are species that have yet to be assessed by Cal-IPC. Instead, the rankina value was inferred based on WCS observations on the GNWR and the central coast reaion of California as a whole.

4.1.3. Management Plans

After invasive plant data have been acquired, compiled, and analyzed, multi-phase management plans with thorough treatment methodologies compliant with National Environmental Policy Act and California Environmental Quality Act constraints should be established. Invasive plant control activities should be treated as the beginning stages of a management plan, followed by a second-phase or concurrent restoration plan.

While executing various stages of invasive plant removal work, previously denuded areas cleared of infestations will be primed for restoration efforts as a second phase. While conducting invasive plant removal work, efforts should be made to identify good propagule material of rarer species so they can be spread throughout the dune system that have been denuded through time.

At present, it appears that some rare native plant species are present in extremely limited numbers or not at all, but a persistent seedbank may still exist. Dunes are prone to self-healing if invasive plants can be managed first and foremost.

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APPENDIX A

Generalized Generation Population Size Estimation of Endangered Insects via Parsimonious, Flexible Integration of Transect Counts with Mark–Release–Recapture Data

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ABSTRACT Mark–release–recapture methods (MRR) can provide reliable estimates of an insect population's vital parameters; however, transect counts are becoming preferred for endangered taxa due to concerns about potential damage to their habitats that may occur due to intensive sampling and adverse effects of handling on behavior and survival. Yet transect counts, when used without supplemental data on population parameters, have inherent limitations that lessen their usefulness for rigorous population monitoring, in particular for the estimation of generation population sizes. We revise and extend a method for estimating generation population size that parametrically couples models of abundance measurements from transect counts conducted annually with models of survival data from MRR studies only performed in some years. Extensions encompass 1) semiparametric modeling of count data, 2) accounting for spatial sampling error via two alternative formulations, and 3) a fully generalized approach to adjustment for imperfect detectability of individuals. Application of the basic estimator is illustrated using two endangered insects: *Euphilotes battoides allyni* (Shields) (Lepidoptera, Lycaenidae) and *Trimerotropis infantilis* Rentz (Orthoptera, Acrididae). Adult life span of the butterfly is no more than a couple of weeks, while adults of the grasshopper may live for several months. Despite these pronounced differences, our method proved flexible enough to fit the MRR and count data from each species and generate stable estimates of their respective generation population sizes. Simulation studies were also conducted and generally revealed low bias, with close agreement between actual and estimated population sizes.

KEY WORDS transect count, mark–release–recapture, generation population size, population monitoring

Introduction

Trends in population size over multiple generations are often important criteria for measuring the success of conservation programs and recovery efforts of endangered insects. Mark–release–recapture (MRR) methods (also referred to as capture–recapture and mark–recapture methods in the literature) have long been used to estimate daily and total generation population numbers, survival and recruitment rates, detection probabilities, and other vital population parameters of insects, especially butterflies (Southwood and Henderson 2000, Samways et al. 2010). Numerous MRR statistical methods exist, and their performance for generating reliable estimates of a population's vital parameters have been extensively tested under a wide variety of conditions and data types.

Increasingly, fixed-width transect counts (Pollard 1977, Pollard and Yates 1993) are being used for monitoring populations of insects, especially rare or endangered species. This is due to concerns that include the adverse effects of marking and repeated handling during MRR on behavior and survival (Haddad et al. 2008). Transect counts minimize harm, may cost less to perform, and can be easier to implement than MRR methods, but without supplemental information they only provide a nebulous "index" of population abundance rather than specifically an estimate of current generation population size. The relationship between transect counts of adults and generation population size is dynamic, being governed by two opposing processes—the emergence of new adults and the loss of adults through death—all within the milieu of an oftentimes highly stochastic environment and variable detectability. Only a fraction of the individuals that comprise a single, discrete generation of the insect's population are present on any day, especially if the life span of the average individual is much shorter than the length of the total flight period (Pfeifer 2003, Pfeifer et al. 2007). Immigration and emigration also contribute to population dynamics, but, for present purposes, migration is assumed to be negligible.

We revise, extend, and provide a more formal and generalized mathematical development of a method that originated with Huang (Arnold 1999) for estimating the total number of adult insects in a single, discrete generation flight period. This method permits estimation of generation population size by parametrically coupling models for transect counts made

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annually with models for MRR studies that are only performed in some years, permitting estimation of generation population size while minimizing harm to a species. Capture histories of the marked individuals from MRR studies are used to provide estimates of the adult life span distribution, while transect counts provide measurement of adult abundance at intervals throughout the entire flight period. Gross et al. (2007) combined these two sources of information for estimating generation population size using a Bayesian approach. In contrast, the method presented here performs estimation using these two sources of information in a purely frequentist setting, making the method accessible to a wider range of practitioners. Moreover, our approach is made efficient through use of a shared parameter between the models for the transect-count data and MRR data. Schultz and Dlugosch (1999) combined generation count and MRR measurements, but assumed that counts were constant between censuses, which could be several days apart. This approximation, which can be especially coarse for many species because flight seasons are often not long, is not needed. Instead, we allow expected counts to change from day to day. Moreover, unlike Gross et al. (2007) and others (Zonneveld 1991, Soulsby and Thomas 2012), the method developed here is not restricted to a narrow range of functional forms to describe the trajectory of expected counts over the flight season; rather a completely generalized class of discrete-time models is presented. Also, in practice, count data may need to be supplemented by special studies to estimate detectability of individuals (e.g., as a function of distance from the observer). Rather than providing a rough correction through a single multiplier (Gross et al. 2007), we offer an extension of the basic estimator that permits adjustment for variable detectability in a fully generalized way. Finally, while some sampling designs may consist of a single transect, the ability to sample from multiple transects distributed over the study site may be desirable, especially when sites cover large areas. As such, we offer two additional extensions of the basic estimator that account for spatial sampling error. The new method is illustrated through application to a population of the short-lived, endangered El Segundo Blue Butterfly (*Euphilotes battoides allyni* (Shields); Arnold 1986, 1999) and the longer-lived Zayante Band Winged Grasshopper (*Trimerotropis infantilis* Rentz). Table 1 provides a guide to all mathematical notation used in this paper.

Materials and Methods

Huang's Original Method. Let $M(t)$ and $M_0(t)$ be random variables denoting the count and quantity newly emerged, respectively, on day $1 \leq t \leq \tau$ of the flight season, τ assumed known from field observation. Huang (Arnold 1999) assumed geometric decay in survival of emergence cohort $M_0(t)$ to time $t + d$ of the form

$$M_0(t)\exp(-\alpha(d-1)), \tag{1}$$

for $\alpha \in \mathbb{R}^+$ and $d \in \mathbb{Z}^+$. Huang (Arnold 1999) makes three additional assumptions.

Table 1. Description of mathematical notation used in text

Symbol	Meaning	Symbol	Meaning
$M(t)$	Count of individuals	$M_0(t)$	Count of emerged
τ	Length of season in days	d, d_0, t	Time in days
α	Geometric decay parameter	$\in$	Is member of
$\mathbb{R}^+$	Positive real numbers	$\mathbb{Z}^+$	Positive real integers
$E[]$	Expectation operator	$\approx$	Equals approximately
ϖ, φ	Gaussian parameters	η	Scales mass to counts
$exp(), e$	Exponentiation base e	$\int$	Integration operator
$\ll$	Much less than	$\sum$	Summation operator
μ(t)	Expected count day t	$\forall$	For all
μ_0(t)	Expected emerged day t	$\boldsymbol{\mu}$, $\boldsymbol{\mu}_0$, $\mathbf{S}$	Defined in equation 6
$\mathbf{X^{-1}}$	Inverse of matrix X	$\mathbf{1}$	Column vector of 1's
n	Generation population size parameter	$\hat{n}$	Population size parameter estimate basic model
$\sigma(t)$	Variance in counts on day t	ϕ	Count overdispersion parameter
$P\{X\}$	Probability of event X	Var, Cov, Cor	Variance, covariance, and correlation operators
$\mathfrak{M}$	MRR sample	$\mathfrak{C}$	Sample of counts
Λ	Quantity of sampling units at site	l	Units sampled at site
Λ	Area of site	a_i	Area of i^{th} sampling unit
$\rightarrow$	Approaches	Z	Sample inclusion indicator
i, j	Index sampling units	$\overline{n}$	Population size parameter estimate (fixed-effect model)
H	$\eta + D_i$	D	Random variable
$\mathcal{F}$	Distribution of random variable D	$\sim N()$	Gaussian distribution
$\stackrel{\text{def}}{=}$	Equals by definition	$\tilde{n}$	Population size parameter estimate (fixed-effect model)
$\mathfrak{C}_t$	Detectable count	r	Indexes individuals
$I(t)$	Detection indicator time t	q	Detection probability
$\boldsymbol{\zeta}$	Triangular distribution parameter (knot location)	$\neq$	Does not equal
$\ni$	Such that	$\sim Bin()$	Binomial distribution
N	Binomial random variable	p_e	Probability of emergence
p_d	Probability of death	$\Gamma()$	Gamma function
ρ	Autocorrelation parameter	$K()$	Kernel function
h	Kernel bandwidth		

1. The total count $M(t)$ follows, in expectation, a rescaled Gaussian curve over the flight season. Namely,

$$E[M(t)] \approx \frac{\eta}{\sqrt{2\pi\varpi^2}} \exp\left(-\left(\frac{t-\varphi}{\varpi\sqrt{2}}\right)^2\right), \qquad (2)$$

where scaling factor η permits $1 < \int E[M(t)]\ dt$, $0 < \omega$, $1 \leq \varphi \leq \tau$, and $1 \leq \eta$.
2. The observed count is the quantity of adults present on that day (i.e., perfect detectability).
3. The quantity of newly emerged individuals per day is approximately constant over a retrospective moving window of d days, where d must be small relative to length τ of the flight season (i.e., individuals must be short-lived so that $0 < d \ll \tau$), and d is chosen such that only a very small proportion (e.g., 0.05) of those individuals that emerged d days ago remain alive. This allows the approximate factorization

$$M(t) \approx M_0(t) \sum_{s=1}^{d+1} e^{-\alpha(s-1)}. \qquad (3)$$

Schultz and Dlugosch's (1999) estimator of generation population size (which they referred to as density) takes a different form but, like Huang, assumed constancy of counts over a moving window.

A Revised Estimator

Take

$$E[M(t)] \stackrel{\text{def}}{=} \eta\mu(t) \qquad (4)$$

where $\mu(t)$ is any proper mass function on the positive integer-valued domain of $t \in \{1, 2, \ldots, \tau\}$, such that $\sum_{t=1}^{\tau} \mu(t) = 1$, $0 \leq \mu(t)\ \forall t$. Unlike Huang (Arnold 1999), we employ a mass rather than a density function because counts are daily and thus temporally discrete. To be clear, mass functions are *not* being employed as a representation of a probability distribution but rather as a general class of positive functions that, because they sum to unity over their domain, are useful for modeling the generation trajectory of expected counts up to a scaling constant, here represented by η. Careful selection of a mass function is crucial, as it will permit accurate interpolation to days not sampled, as illustrated through examples presented in the Results.

The second assumption of Huang's original method (Approximation 3) contradicts the first (Approximation 2), especially for smaller α. Fortunately, this second assumption is not needed for estimation. Instead, take $E[M_0(t)] \stackrel{\text{def}}{=} \mu_0(t)$ and write $E[M(t)]$ as a definite, discrete convolution,

$$\eta\mu(t) = \sum_{s=1}^{t} \mu_0(d) e^{-\alpha(t-d)}. \qquad (5)$$

Unlike Approximation 3, which is limited to a small moving window of b days, Equation 5 is exact over the entire flight season up to the current day t. Equation 5 in matrix notation is

$$\eta \begin{bmatrix} \mu(1) \\ \mu(2) \\ \mu(3) \\ \vdots \\ \mu(\tau-1) \\ \mu(\tau) \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & \ldots & 0 & 0 \\ e^{-\alpha} & 1 & 0 & \ldots & 0 & 0 \\ e^{-2\alpha} & e^{-\alpha} & 1 & \ldots & 0 & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ e^{-\alpha(\tau-2)} & e^{-\alpha(\tau-3)} & e^{-\alpha(\tau-4)} & \ldots & 1 & 0 \\ e^{-\alpha(\tau-1)} & e^{-\alpha(\tau-2)} & e^{-\alpha(\tau-3)} & \ldots & e^{-\alpha} & 1 \end{bmatrix} \begin{bmatrix} \mu_0(1) \\ \mu_0(2) \\ \mu_0(3) \\ \vdots \\ \mu_0(\tau-1) \\ \mu_0(\tau) \end{bmatrix}, \qquad (6)$$

which we can write compactly as $\eta\boldsymbol{\mu} = \mathbf{S}\boldsymbol{\mu}_0$, where $\boldsymbol{\mu}$ and $\boldsymbol{\mu}_0$ are column vectors each of length τ, and $\mathbf{S}$ is of dimensions $\tau \times \tau$. Then $\boldsymbol{\mu}_0 = \eta\,\mathbf{S}^{-1}\boldsymbol{\mu}$, assuming $\mathbf{S}$ is invertible. Define n as the total generation population size such that $n \stackrel{\text{def}}{=} \eta\,\mathbf{1}'\mathbf{S}^{-1}\boldsymbol{\mu}$, where $\mathbf{1}$ is a column vector of 1's of length τ. Solving,

$$\begin{aligned} n &= \eta \mathbf{1}' \begin{bmatrix} \mu(1) \\ -e^{-\alpha}\mu(1) + \mu(2) \\ -e^{-\alpha}\mu(2) + \mu(3) \\ \vdots \\ -e^{-\alpha}\mu(\tau-2) + \mu(\tau-1) \\ -e^{-\alpha}\mu(\tau-1) + \mu(\tau) \end{bmatrix} \\ &= \eta(e^{-\alpha}\mu(\tau) - e^{-\alpha} + 1). \end{aligned} \qquad (7)$$

In words, an estimate of the generation population size n is obtained via summation of the quantities of individuals that are expected to die on each day over the entire flight season. From Equation 7 we obtain a plug-in estimator defined as

$$\hat{n} \stackrel{\text{def}}{=} \hat{\eta}\left(e^{-\hat{\alpha}}\,\hat{\mu}\,(\tau) - e^{-\hat{\alpha}} + 1\right). \qquad (8)$$

Maximum likelihood estimation is employed to fit the count data to $\eta\mu(t)$ and obtain estimates of $\hat{\eta}$ and $\hat{\mu}(\tau)$, with $\mu(\tau)$ formulated in terms of the parameters of the selected mass function. Pairs of successive counts d days apart are modeled as bivariate normally distributed. This allows for autocorrelation ρ that can arise because adults from a prior count can survive to be counted again during the next count. Modeling also

specifies that

$$\sigma^2(t) = \phi\eta\mu(t). \tag{9}$$

This formulation allows for the known dependence of the variance σ on the mean for count processes; plus the constant $0 < \phi$ allows for overdispersion due to the stochasticity of population dynamics of insects (Gross *et al*. 2007).

The duration of an individual's survival after emergence is represented by random variable K. We assume K has a geometric distribution, as in Gross *et al*. (2007),

$$P\{K = k\} = (e^{-\alpha})^{k-1}(1 - e^{-\alpha}). \tag{10}$$

This model could be fit to the MRR data alone using standard maximum likelihood estimation (Rice 1995, pp. 253–272). However, gains in efficiency can be obtained by recognizing that the model for the counts over the flight season and the model for the MRR data share parameter α. Specifically, let $Z_{d_0} = 1$ if an individual is alive on day d_0 and $Z_{d_0} = 0$ if an individual is dead on day d_0. Define $\dot{p} \stackrel{\text{def}}{=} E[Z_{d_0}] = P\{Z_{d_0} = 1\}$. Then, for some quantity of elapsed days d,

$$\begin{aligned} Cov[Z_{d_0}, Z_{d_0+d}] &\stackrel{\text{def}}{=} E\left[\begin{array}{l}[(Z_{d_0} - E[Z_{d_0}]) \\ \times (Z_{d_0+d} - E[Z_{d_0+d}])]\end{array}\right] \\ &= (1-\dot{p})^{d_0}\left((1-\dot{p})^{d} - (1-\dot{p})^{d_0+d}\right). \end{aligned} \tag{11}$$

Of interest is the correlation between the current day $d_0 = 1$ and d days later; so, given

$$Cor[Z_{d_0}, Z_{d_0+d}] \stackrel{\text{def}}{=} \frac{(1-\dot{p})^{d_0}\left((1-\dot{p})^{d} - (1-\dot{p})^{d_0+d}\right)}{\sqrt{\left(\left(1-(1-\dot{p})^{d_0}\right)(1-\dot{p})^{d_0}\right)\left(\left(1-(1-\dot{p})^{d_0+d}\right)(1-\dot{p})^{d_0+d}\right)}}, \tag{12}$$

it follows that

$$Cor[Z_1, Z_{1+d}] = \sqrt{\frac{e^{\alpha} - 1}{e^{\alpha(d+1)} - 1}}, \tag{13}$$

where $1 - \dot{p} = e^{\alpha}$. We can write the joint likelihood as

$$\begin{aligned} &\mathcal{L}(\alpha, \eta, \phi, \boldsymbol{\theta}) = \\ &\quad \prod_{i \in \mathfrak{M}} (e^{-\alpha})^{k_i - 1}(1 - e^{-\alpha}) \\ &\quad \times \prod_{\{t-1,t\} \in \mathfrak{C}} \frac{1}{\left(\sqrt{2\pi}\right)^2 |\Sigma|^{1/2}} e^{-(\mathfrak{C}_t - \eta\boldsymbol{\mu}(t))\Sigma^{-1}(\mathfrak{C}_t - \eta\boldsymbol{\mu}(t))/2}, \end{aligned} \tag{14}$$

for MRR sample $\mathfrak{M}$ and count sample $\mathfrak{C}$ of temporally ordered observations (elements) $\mathfrak{C}_t$, $t = 1, 2, \ldots, \tau$. Here $\boldsymbol{\theta}$ encompasses any additional parameters that are necessary to define the particular mass function given by $\mu(t)$, and

$$\Sigma \stackrel{\text{def}}{=} \eta \begin{bmatrix} \phi\mu(t_{j-1}) & \rho(d)\phi\sqrt{\mu(t_{j-1})\mu(t_j)} \\ \rho(d)\phi\sqrt{\mu(t_{j-1})\mu(t_j)} & \phi\mu(t_j) \end{bmatrix}. \tag{15}$$

where $\rho(d) \stackrel{\text{def}}{=} Cor[Z_1, Z_{1+d}] = \sqrt{\frac{e^{\alpha}-1}{e^{\alpha(d+1)}-1}}$.

Estimates of the variances of the parameter estimates can be obtained in the usual way by inverting the Hessian matrix of $\mathcal{L}(\alpha, \eta, \phi, \boldsymbol{\theta})$ (Rice 1995). For an estimator of the variance of the estimator of n (Equation 8), an approximation can be derived using the delta method (Rice 1995), typically to second-order. The R (R Core Team, 2013) platform offers a general utility (`deltavar` in `emdbook`) for numerical application of the delta method.

Accounting for Spatial Sampling Error. *Sampling Unit-Specific Estimates: Fixed-Effect Model.* Our revised estimator presumes that we have counts over time on a sampling unit (e.g., transect) that spans the entire habitable area in which the population can reside. Suppose instead that the area to be sampled is partitioned into a finite population of Λ sampling units and counts are made on $i = 1, \ldots, l < \Lambda$ of those, with inequality due to sampling. Λ is known (e.g., based on known size of the site). To accommodate variation in counts among sampling units, we replace Equation 4 with

$$E[M_i(t)] \stackrel{\text{def}}{=} \eta_i\mu_i(t). \tag{16}$$

The count data are fit to $\eta_i\mu_i(t)$ separately for each sampling unit to obtain each estimate $\overline{\eta}_i$. This allows for variation in the shape of the curve $\mu_i(t)$ over the sampling area (e.g., due to corresponding variation in the density of the host plant, density of prey items, or variations in other habitat features). Assuming a simple random sampling without replacement (Thompson 1992) of units, as $\mu(\tau) \to 0$ an approximate estimator for the area total generation population size n is

$$\overline{n} \stackrel{\text{def}}{=} (1 - e^{-\hat{\alpha}}) \frac{\Lambda}{l} \sum_{i=1}^{l} \overline{\eta}_i. \tag{17}$$

Assuming that μ goes to zero at τ (last day of the flight season) introduces a minor approximation but one that facilitates construction of this version of the estimator (and appears to reduce bias in estimates of n, as described later in our simulation results). This formulation assumes that α is, at least approximately, spatially invariant over the site. Maximum likelihood estimation parallels that described in our revised estimator with the addition of a product across sampling units. Specifically, assuming observed counts vary independently among sampling units,

$$\begin{aligned} &\mathcal{L}_2(\alpha, \eta, \phi, \boldsymbol{\theta}) = \\ &\quad \prod_{i \in \mathfrak{M}} (e^{-\alpha})^{k_i - 1}(1 - e^{-\alpha}) \\ &\quad \times \prod_{i=1}^{l} \prod_{\{t-1,t\} \in \mathfrak{C}} \frac{1}{\left(\sqrt{2\pi}\right)^2 |\Sigma|^{1/2}} e^{-(\mathfrak{C}_t - \eta\boldsymbol{\mu}(t))\Sigma^{-1}(\mathfrak{C}_t - \eta\boldsymbol{\mu}(t))/2}. \end{aligned} \tag{18}$$

Equation 17 also assumes that all sampling units are of the same dimensions or, more specifically, that

habitable area for the target species within each sampling unit is the same across sampling units. Suppose instead that sampling units vary in habitable area, as indexed by a_i, and that total habitable area of the site is A, then $\overline{n} \stackrel{\text{def}}{=} (1 - e^{-\widehat{\alpha}}) \frac{\mathrm{A}}{\sum_{a_i}} \sum_{i=1}^{l} a_i \overline{\eta}_i$.

The variance of $\overline{n}$ can be obtained via application of the delta method. A component of this Taylor expansion is $Var[\frac{\Lambda}{l} \sum_{i=1}^{l} \overline{\eta}_i]$, which must account for finite-population correction, unless the quantity of observed sampling units is small compared with the total quantity that could be contained within the habitable site. Derivation of $Var[\frac{\Lambda}{l} \sum_{i=1}^{l} \overline{\eta}_i]$ is given in Appendix 1. As described in Appendix 1, substituting results of Appendix Equations A2 and A3 into Equation 14 gives

$$Var\left[\frac{\Lambda}{l}\sum_{i=1}^{l}\overline{\eta}_i\right] \approx \frac{\Lambda}{l}\sum_{i=1}^{\Lambda}\left(\left(1-\frac{l}{\Lambda}\right)\eta_i^2 + \sigma^2_{\overline{\eta}_i}\right) + 2\left(\frac{\Lambda(l-1)}{l(\Lambda-1)} - 1\right)\sum_{i=1}^{\Lambda}\sum_{i<j}\eta_i\eta_j \stackrel{\text{def}}{=} \sigma^2_{\eta}. \tag{19}$$

Notice the presence of the finite population corrections $1 - \frac{l}{\Lambda}$ and $\frac{\Lambda(l-1)}{l(\Lambda-1)}$ in Approximation 19. This will cause $\left(1 - \frac{l}{\Lambda}\right)\eta_i^2$ and $2(\frac{\Lambda(l-1)}{l(\Lambda-1)} - 1)\sum_{i=1}^{\Lambda}\sum_{i<j}\eta_i\eta_j$ to vanish as sampling goes to a census, $l \to \Lambda$, leaving only $\sigma^2_{\overline{\eta}_i}$ which is attributable to the sampling of days within the flight season, the MRR sampling of individuals, unexplained stochastic variation, and any measurement error. The $\sigma^2_{\overline{\eta}_i}$ are estimable from the inverse Hessian of $\mathcal{L}_2$ and likelihood estimates of the η_i can be plugged into Approximation 19. The delta approximation of the variance of $\overline{n}$ will include a component for covariance between estimates of α and η.

Common $\mu(t)$: Random-Effects Model. An alternative and parsimonious parameterization would be to use $E[M_i(t)|H_i] = H_i\mu(t)$ with $H_i = \eta + D_i$, such that $D_i \sim \mathcal{F}$, where $\mathcal{F}$ is some proper continuous distribution function. This formulation assumes a common expectation $\mu(t)$ throughout the area to be sampled; and we do not make the simplifying assumption $\mu(\tau) \to 0$ (although doing so might reduce bias as explained in our simulation methods). Fitting is via standard empirical Bayes (a type of shrinkage method with shrinkage here toward the average sampling unit) in the setting of nonlinear mixed effects models (Pinheiro and Bates 2000) to obtain estimate $\tilde{\eta}$, preferably using adaptive Gaussian quadrature but perhaps employing a Laplacian approximation (McCulloch and Searle 2001). Because counts are bounded below by zero, a Gaussian model $\mathcal{F} \stackrel{\text{def}}{=} N(0, \sigma_D^2)$ is admittedly approximate. Through incorporation of the inverse transformation method (Ross 1998, pp. 455–456), a distribution other than the Gaussian, such as the gamma, can also be specified for the D_i, using standard software. Assuming a simple random sampling of units (Thompson 1992), an estimator for the area total generation population size is

$$\tilde{n} \stackrel{\text{def}}{=} \Lambda\,\tilde{\eta}\left(e^{-\hat{\alpha}}\,\hat{\mu}(\tau) - e^{-\hat{\alpha}} + 1\right). \tag{20}$$

Here too a delta approximation of the estimator of the variance can be applied.

Because unlike 20, Estimator 17 is based on separate estimates for each sampling unit, one would expect $\overline{n}$ to have smaller bias and greater variance than $\tilde{n}$. Estimator 20 would benefit from a relatively large number of sampling units 1) so that a stable estimate of $\mathcal{F}$ may be obtained and 2) to facilitate assessment of the assumed distribution $\mathcal{F}$ by graphical means or a suitable goodness-of-fit test, although a large sample is not a necessity.

Adjustment for Variable Detectability. In the previous sections, the assumption was made that every individual present within a sampling unit was observed, preserving Huang's second assumption. However, in many settings, a sizable fraction may go unobserved.

In this context, distinguish the true count of all living individuals $M(t)$ on day t from the observed count $\mathfrak{C}_t$ on day t, where $0 \le \mathfrak{C}_t \le M(t)$, modifying some notation from Soulsby and Thomas (2012). Consider the expansion

$$\mathfrak{C}_t = \sum_{r=1}^{M(t)} i_r(t), \tag{21}$$

where $i_r(t)$ is the realization of a Bernoulli random variable $I_r(t)$ of $E[I_r(t)] = q_{rt}$.

All individuals are observed only when $q_{rt} = 1\,\forall\, r$; otherwise, $0 \le q_{rt} < 1$ for at least some q_{rt}. The q_{rt} are detection probabilities. Conditional upon the stochastic realizations $\mathfrak{C}_t$, an unbiased estimator of $E[M(t)]$ is

$$\widehat{E}[M(t)] = \sum_{r=1}^{\mathfrak{C}_t} \frac{1}{q_{rt}} \tag{22}$$

with an unbiased estimator of its sampling variance

$$\widehat{Var}\left[\widehat{E}[M(t)]\right] = \sum_{r=1}^{\mathfrak{C}_t} \frac{1 - q_{rt}}{q_{rt}^2} \tag{23}$$

per Thompson (1992). A necessary condition for Estimator 22 to be unbiased requires that $q_{rt} \neq 0\,\forall\, r$. That is, if some individuals are undetectable, then $\widehat{E}[M(t)]$ will necessarily underestimate $E[M(t)]$.

Estimator 22 assumes that all q_{rt} are known, but in nearly every application the q_{rt} will need to be estimated which will cause the true variance of estimates of population size n (Estimators 8, 17, and 20) to be underestimated. Various methods for estimating the q_{rt} are available, including many that employ distance from the observer as an auxiliary variable (Thompson 1992). The details of the methods and the resultant precise formulation of the inflated variance of population size estimate are inessential here, for we can

simply include a reminder in our notation by replacing $\sigma^2(t)$ of Equation 9 with

$$\sigma^{2*}(t) \stackrel{\text{def}}{=} \phi^* \eta \mu(t) \ni 0 < \phi \leq \phi^*, \tag{24}$$

which in turn recognizes the inflation in the variances of $\hat{\eta}$ and $\hat{\mu}(\tau)$ derived from the maximum likelihood fit to the estimates $\widehat{E}[M(t)]$ (see equation 22) in place of the observed counts.

Applications of the estimator of this section will be given in a subsequent paper. To solve the estimation problem of identification of n from the q_{rt} (Matechou et al. 2014), we advocate for collection of accurate, specific auxillary data (e.g., sighting distances) designed for estimation of detection probabilities. A minimally invasive technology for distance detection is currently under development by the authors; and that method is sufficiently complex to merit exposition in a separate paper.

Simulations. A series of 58 simulation studies were performed. Each iteration within a simulation study generated a distribution of counts over the flight season and, independently, a distribution of recaptures. The distribution of individuals over the flight season was simulated using the following stochastic recursion. Let $N_{e,t} \sim Bin(p_e, n - n_{e,t-1})$ and $N_{d,t} \sim Bin(p_d, n_{e,t-1} - n_{d,t-1})$, where $N_{e,t}$ and $N_{d,t}$ are the respective quantities emerged and dead on day t, $n_{e,t-1}$ and $n_{d,t-1}$ are the respective cumulative quantities emerged and dead through day $t-1$ (here lowercase is used to denote that these values are known and not stochastic on day t), p_e is the constant probability of emergence, and p_d is the constant probability of death. A count was sampled from this process on each seventh day to simulate counts made once every week. For each iteration, τ was set to the last day on which a nonzero count was observed for that iteration. Fitting was semiparametric, using a kernel smoother to estimate $\mu(t)$. Maximum-likelihood estimation was as described above in the Methods for parameters η, ϕ and α. Parameter τ is treated as known, as is true in real data sets because length of flight season is observed directly in the field. A MRR sample was generated by drawing recapture durations from a geometric distribution of parameter p_d. Maximum-likelihood estimation was as described above in the Methods, using the identity $p_d \stackrel{\text{def}}{=} e^{-\alpha}$. Simulation values for n, p_e and p_d are given in Table 2, along with estimates of bias, standard error, percent of error, and mean square error (squared bias + variance) for estimation of n, which are quantitative measures of how accurately the method is estimating the generation's population size. Each study was performed for different combinations of values of n, p_e, and p_d (Table 2). Values of n that were selected for the simulation studies were similar to known population sizes of the various rare or endangered insect taxa monitored by one of the authors (R.A.A.). Actual population sizes, n, tested during the simulations were 100, 300, 600, 2,700, 4,500, and 6,000, which are similar to generation size estimates using MRR for populations of the endangered insects discussed herein. High and low values for p_d were derived from average estimated daily survival rates ($p_d = 1 -$ survival rate) using different MRR statistical models. Runs were restricted to flight season durations (τ) that were similar to those observed during field monitoring of these insect populations. In early simulations, we found that bias could be reduced by taking $\mu(\tau) \to 0$, which was done for all simulation results reported below. For each combination of parameter values, 500 simulation iterations were run. The particle swarm algorithm was run for 500 iterations per simulation iteration. Simulations were performed at two kernel-smoother bandwidths, h and $2h$, to assess sensitivity of bias to bandwidth.

Results

Simulations. Results of the simulations revealed close agreement between actual and estimated population sizes with bias varying as a function of simulated population size. For 52 of 58 simulations estimated average biases were <2.7%, while the maximum observed average bias was 14.7%. Average percent bias ranged from −1.1 to −11.5% for $n = 100$, from −0.5 to −2.3% for $n = 300$, −14.7 to −0.01% for $n = 600$, −1.5 to 0.7% for $n = 2{,}700$, −1.3 to 1.8% for $n = 3{,}600$, −1.3 to 0.9% for $n = 4{,}500$, and −1.2 to 4.3% for $n = 6{,}000$. Results of simulations in which the bandwidth was doubled ($2h$) generally increased the average percent bias (Table 2) and mean square error compared with these values for h. The ratio of average percent bias for $2h$:h ranged from 0.82 to 4.91.

Examples. Code to perform the following analyses is available in the online supplement. All code is written in R (R Core Team, 2013).

Euphilotes battoides allyni. The basic estimator (Approximation 8) is illustrated using data collected on *E. battoides allyni* at Los Angeles International Airport (Arnold 1999). On 13 separate days spread over the entire 2009 flight season, all *E. battoides allyni* were counted (Fig. 1) that were visible from the same marked transect route. A nonparametric estimator for $\mu(t)$ was employed:

$$\hat{\mu}(t) \stackrel{\text{def}}{=} \frac{K(M^*(t),h)}{\sum_{t=1}^{\tau} K(M^*(t),h)}, \tag{25}$$

where $K(M^*(t),h)$ is a kernel smoother (Hastie et al. 2001) of the observed counts and bandwidth h. Here we employ a Gaussian kernel smoother, but others could be employed as well. The Epanechnnikov kernel may be an efficient choice (Kendall and Stuart 1973), which is an important factor because, to keep data collection on counts as noninvasive as possible, the quantity of days sampled will often be modest (e.g., only 13 of a 70-d flight season in this example). We regard bandwidth h as a known design parameter: specifically, we scale h so that the quartiles of the normal kernel are $\pm\frac{1}{4}\times$ the average sampling interval. Algorithm convergence was facilitated by the re-scaling $\hat{\eta}$ through multiplication by 1000 for fitting, so that estimates of $\hat{\eta}$

Table 2. Results of simulation studies (500 iterations per simulation for each combination of parameters and 500 cycles of the particle swarm algorithm per iteration)

Actual population size n	Estimated generation duration in days τ	Probability of emergence p_e	Probability of death p_d	Shared parameter α	Average estimated population size $\hat{n}$	Standard error (SE)	Percent error (SE/n)	Average percent bias	Mean square error	Double band width avg percent bias
100	110	0.050	0.065	0.0672	93.5	25.2	25.2	−6.5	679	−12.9
100	84	0.100	0.065	0.0677	96.7	16.8	16.8	−3.3	294	−10.5
100	77	0.150	0.065	0.0677	98.2	14.8	14.8	−1.8	224	−11.7
100	54	0.150	0.100	0.1057	88.5	32.4	32.4	−11.5	1,183	−6.0
100	98	0.150	0.050	0.0544	98.9	14.0	14.0	−1.1	198	−8.3
100	103	0.100	0.050	0.0515	98.4	14.8	14.8	−1.6	223	−8.0
300	132	0.050	0.065	0.0680	298.4	32.8	11.0	−0.5	1,083	−4.8
300	109	0.075	0.065	0.0676	297.5	26.6	8.9	−0.8	715	−6.8
300	100	0.100	0.065	0.0675	293.7	35.5	11.8	−2.1	1,300	−8.2
300	93	0.150	0.065	0.0677	295.4	32.8	10.9	−1.5	1,009	−4.3
300	104	0.050	0.124	0.1332	296.8	26.7	8.9	−1.1	725	−9.3
300	78	0.075	0.124	0.1335	296.2	27.4	9.1	−1.3	767	−10.4
300	66	0.100	0.124	0.1337	293.2	41.6	13.9	−2.3	1,775	−12.3
600	78	0.050	0.600	0.9209	512.1	214.7	35.7	−14.7	53,803	−24.8
600	84	0.050	0.450	0.6023	586.6	66.7	11.1	−2.2	4,624	−9.2
600	64	0.075	0.450	0.5996	596.4	71.2	11.9	−0.6	5,080	−7.5
600	49	0.100	0.450	0.6022	613.3	73.0	12.1	2.2	5,495	−6.4
600	93	0.050	0.300	0.3581	583.8	69.5	11.6	−2.7	5,086	−9.2
600	68	0.075	0.300	0.3592	591.7	59.5	9.9	−1.4	3,613	−10.5
600	54	0.100	0.300	0.3598	599.2	54.0	9.0	−0.01	2,916	−11.9
600	111	0.050	0.150	0.1639	593.2	52.4	8.7	−1.1	2,791	−8.8
600	82	0.075	0.150	0.1632	591.5	54.1	9.0	−1.4	3,002	−12.1
600	67	0.100	0.150	0.1639	587.6	78.3	13.1	−2.1	6,290	−12.7
600	117	0.050	0.124	0.1332	590.5	53.0	8.8	−1.6	2,903	−7.5
600	87	0.075	0.124	0.1329	591.4	51.2	8.5	−1.4	2,700	−9.5
600	73	0.100	0.124	0.1335	594.6	52.5	8.8	−0.9	2,788	−10.6
600	111	0.100	0.065	0.0676	593.8	53.6	8.9	−1.0	2,909	−9.2
600	104	0.150	0.065	0.0676	590.3	76.9	12.8	−1.6	6,000	−3.8
600	138	0.100	0.050	0.0516	593.0	68.1	11.3	−1.2	4,681	−6.3
2,700	107	0.075	0.124	0.1329	2,665	210.9	7.8	−1.3	45,684	−10.3
2,700	88	0.100	0.124	0.1329	2,660	186.8	6.9	−1.5	36,453	−10.2
2,700	72	0.150	0.124	0.1335	2,664	256.9	9.5	−1.3	67,321	−12.2
2,700	68	0.100	0.300	0.3604	2,720	207.5	7.7	0.7	43,420	9.1
2,700	122	0.050	0.300	0.3605	2,696	250.7	9.3	−0.1	62,875	−6.9
2,700	87	0.075	0.300	0.3575	2,687	203.5	7.5	−0.5	42,504	−8.5
3,600	84	0.100	0.150	0.1687	3,572	282.4	7.8	−0.8	62,309	−11.1
3,600	71	0.100	0.300	0.3589	3,614	271.2	7.5	0.4	73,735	9.5
3,600	78	0.100	0.200	0.2255	3,580	240.9	6.7	−0.6	58,451	−11.9
3,600	72	0.125	0.150	0.1642	3,573	233.4	6.5	−0.8	55,226	−12.4
3,600	65	0.125	0.200	0.2245	3,566	408.1	11.3	−0.9	107,690	−12.4
3,600	59	0.125	0.300	0.3614	3,663	210.9	5.9	1.8	48,474	7.2
3,600	74	0.150	0.124	0.1329	3,556	238.2	6.6	−1.2	58,640	−12.7
3,600	69	0.200	0.124	0.1330	3,567	280.0	7.8	−0.9	79,546	−12.2
3,600	127	0.200	0.065	0.6727	3,553	307.3	8.5	−1.3	96,720	−8.6
4,500	93	0.100	0.124	0.1330	4,452	292.2	6.5	−1.1	85,736	−10.4
4,500	113	0.075	0.124	0.1331	4,453	372.3	8.3	−1.1	140,847	−8.2
4,500	76	0.150	0.124	0.1331	4,442	369.8	8.2	−1.3	140,133	−12.7
4,500	94	0.075	0.300	0.3607	4,516	402.3	8.9	0.3	162,111	−8.2
4,500	132	0.050	0.300	0.3580	4,494	276.7	6.1	−0.1	76,589	−6.5
4,500	73	0.125	0.300	03581	4,542	334.6	7.4	0.9	121,812	9.2
6,000	129	0.050	0.450	0.6031	6,107	333.5	5.6	1.8	122,688	−1.8
6,000	91	0.075	0.450	0.6052	6,196	313.4	5.2	3.3	136,715	−0.8
6,000	71	0.100	0.450	0.6022	6,259	348.6	5.8	4.3	188,757	0.2
6,000	138	0.050	0.300	0.3599	6,012	383.9	6.4	0.2	147,549	−5.4
6,000	98	0.075	0.300	0.3591	6,009	426.4	7.1	0.2	181,866	7.7
6,000	76	0.100	0.300	0.3612	6,030	592.8	9.9	0.5	352,341	−9.4
6,000	89	0.100	0.150	0.1637	5,928	452.8	7.5	−1.2	270,219	−12.8
6,000	95	0.100	0.124	0.1334	5,940	477.2	8.0	−1.0	231,348	−10.2

Average bias was calculated by performing the subtraction $n - \hat{n}$ for each iteration and then averaging those differences.

prior to back-transformation are roughly of the same order of magnitude as $\hat{\phi}$ and $\hat{\alpha}$. Small sample size also means that a good choice of initial values for the parameter estimates is especially important to facilitate convergence of the fitting algorithm to the global optimum. We initialized $\hat{\phi}$ to 1, no overdispersion, and $\hat{\alpha}$ to 1/10.

In a prior year (1984), a 33-d MRR study was conducted on site (Arnold 1986). Table 3 summarizes the capture-history data from that study. This table gives

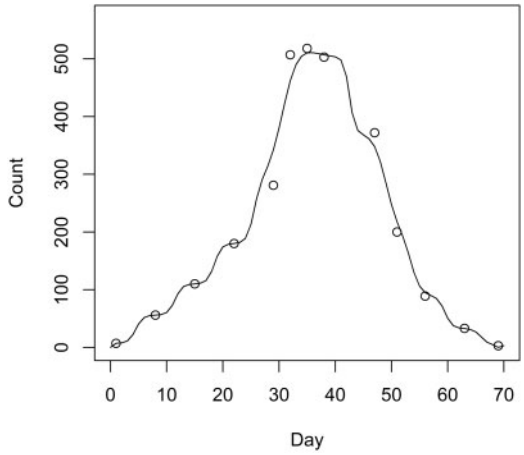

Fig. 1. Results of field data. The open circles ∘ denote the observed counts of adult *E. battoides allyni* over the 2009 flight season. The fitted model for $\eta\mu(t)$ is given by the solid line.

Table 3. Observed adult life spans from MRR data for *E. battoides allyni*

Day	Quantity of adult *E. battoides allyni*
1	124
2	93
3	55
4	47
5	20
6	17
7	13
8	10
9	3
10	1
11	3
12	2

Table 4. Parameter estimates for fit of model to the data of *E. battoides allyni*

Parameter	Estimate	Standard error	Percentage error
α	0.296	0.015	5.1
η	14,090	1,582	11.2
ϕ	56.2	17.1	30.4

Note: percentage error = standard error/estimate for each parameter.

quantities of butterflies by maximum number of days observed. For example, 93 butterflies were last observed on the second day after initial capture. The assumption is made here that death occurred at the end of the last day observed. Data are for individuals captured early-season to mid-season, which avoids including any right-censored lifetimes in the sample. (Alternatively, the first term in $\mathcal{L}$ could have been formulated to allow for right censoring.)

Maximum likelihood estimation of $\mathcal{L}(\alpha, \eta, \phi)$ was performed using a particle swarm algorithm (Parsopoulos et al. 2002), which is derivative-free and which we found to be robust in its ability to identify optima (optima which should be global because, as a likelihood, $\log\mathcal{L}(\alpha, \eta, \phi)$ should be convex). The resultant fit of the model appears to be quite good (solid line in Fig. 1). All parameter estimates and their standard errors are given in Table 4. Applying these point estimates and their estimated covariance matrix to Approximation 8, we obtained an estimate of generation population size of 3,607 individuals with an estimated standard error of 435, or a 12.1% error in the estimate of generation population size.

Trimerotropis infantilis. To demonstrate its wide utility, we also applied the new method to an endangered orthopteran, *T. infantilis*. Unlike *E. battoides allyni*, individuals of *T. infantilis* are relatively long-lived, as is evident from the MRR data of Table 5 (R.A.A., unpublished data from 2000). Fig. 2 shows the observed counts of adult *T. infantilis* over the 2003 flight season (R.A.A., unpublished data). We employed a triangular distribution for $\mu(t)$ with a knot at day ζ and the observed $\tau = 95$. The solid line of Fig. 2 is the fit of the model for $\eta\mu(t)$ to the count data. Parameter estimates from maximum likelihood estimation via $\mathcal{L}(\alpha, \eta, \phi, \zeta)$ are shown in Table 6. The variance constant ϕ is <1 at 0.53, indicating underdispersion in counts about the mean $\eta\mu(t)$, which contrasts with the pronounced overdispersion $(1 < \phi)$ estimated for *E. battoides allyni* (Table 4). From Approximation 8, the estimate of generation population size is 265 adult grasshoppers with a small estimated standard error of 7.5, or a 2.8% error in the estimate of generation population size.

Discussion

Our methodology estimates generation population size by parametrically coupling models for transect counts made annually with models for MRR studies that are only performed in some years. The estimates of population parameters generally exhibit low bias and standard errors. Furthermore, potential harm to the insect population being monitored and its habitat are minimized.

This method does make important assumptions. As mentioned above, negligible migration is assumed. This assumption may be met approximately for many endangered insect species, as often their endangered status derives from the rarity or absence of replenishing immigration due to their restriction to fragmented and isolated habitat remnants. Another assumption is that a sampling of days is selected without regard to weather conditions, in contrast to the original recommendations of Pollard (1977). A random sampling of days helps to minimize bias because estimation is based on a summation across all days of the flight season (Equation 4), not just days of favorable weather. This is motivated by the fact that the population experiences all days. Finally, the method assumes that the life span distribution estimated by the MRR study applies throughout the entire flight season under study. If conditions at the site change, for

Table 5. Observed adult life spans from MRR data for *T. infantilis*

Day	Quantity of adult *T. infantilis*
1	74
2	73
3	72
4	70
5	69
6	68
7	67
8	65
9	65
10	63
11	62
12	61
13	59
14	58
15	57
16	56
17	54
18	52
19	51
20	50
21	48
22	47
23	46
24	45
25	44
26	43
27	42
28	41
29	39
30	35
31	33
32	31
33	31
34	30
35	29
36	28
37	27
38	26
39	25
40	24
41	24
42	23
43	22
44	21
45	20
46	19
47	19
48	18
49	17
50	16
51	15
52	14
53	13
54	12
55	11
56	10
57	9
58	7
59	7
60	6
61	5
62	4
63	3
64	2
65	1
66	1
67	0
68	1
69	0
70	1

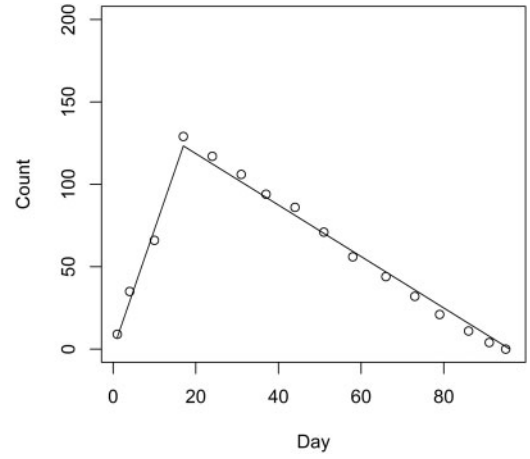

Fig. 2. Results of field data. The open circles ∘ denote the observed counts of adult *T. infantilis* over the 2000 flight season. The fitted model for $\eta\mu(t)$ is given by the solid line.

Table 6. Parameter estimates for fit of model to the data of *T. infantilis*

Parameter	Estimate	Standard error	Percentage error
α	0.046	0.001	2.2
η	5,920	172	2.9
ϕ	0.53	0.13	24.5
ζ	17.0	0.28	1.6

Note: percentage error = standard error/estimate for each parameter.

example, with decline in a food plant, a new MRR study may be warranted to obtain a revised, pertinent estimate of α. That said, because α is shared between the count and MRR terms of $\mathcal{L}$, the current count data may pull the estimate of α more toward the current true value than if α were estimated using the MRR data alone. Also, being a shared parameter, estimates of α should be especially stable, and we observed this stability in the examples provided in the Results.

In a landmark paper, Zonneveld (1991) introduced a technique for estimating generation population size based purely on transect counts derived as the solution to a population-dynamic differential equation, but the maximum likelihood estimator appears to generate unstable estimates, provide confidence intervals of inadequate coverage, and numerical algorithms can fail to converge in small samples (Gross et al. 2007, Haddad et al. 2008, Soulsby and Thomas 2012). We experienced similar difficulties with Zonneveld's technique while trying to analyze our two exemplar data sets.

To aid convergence of fitting algorithms, we recommend 1) choosing a mass function $\mu(t)$ that is well-matched to the sample, possibly employing a kernel smoother as we illustrated in the Results; 2) appropriately re-scaling $\widehat{\eta}$ for fitting purposes; 3) carefully deriving effective starting values for the estimates of the parameters; and 4) using a particle swarm algorithm for numerical optimization. In addition, in application to other

species with very small samples of counts, we have appropriately supplemented the data set by adding counts of zero to the day prior to the first nonzero count and the day after τ, shifting the day index by adding 1. Each obtained fit should always be plotted for visual inspection, as illustrated for our field data in Figs. 1 and 2.

Zonneveld's model is in four parameters. The model presented may be in as few as three parameters, depending upon the specific choice of $\mu(t)$ and yet ours allows for more flexible and realistic modeling of the count process. Specifically, Zonneveld's model assumes subsequent counts are independently Poisson distributed, conditional on day, whereas we allow for autocorrelation via α, due to carryover of individuals between successive counts, and overdispersion seen in real populations (Gross et al. 2007) via ϕ. When we fit our model to real data, we obtained one-day autocorrelation estimates, via $\sqrt{\frac{e^{\hat{\alpha}}-1}{e^{2\hat{\alpha}}-1}}$, of $\hat{\rho} \approx 0.65$ for *E. battoides allyni* and $\widehat{\rho} \approx 0.70$ for *T. infantilis*. These estimated correlations are quite strong because the upper bound is given by

$$\lim_{\alpha \to 0} \left\{ \sqrt{\frac{e^{\alpha}-1}{e^{2\alpha}-1}} \right\} = \frac{1}{\sqrt{2}} \approx 0.707.$$

For *E. battoides allyni*, an approximate 95% confidence interval on ϕ is [18, 94], which falls entirely above 1 and indicates that overdispersion was strong. Interestingly, the 95% confidence interval derived from the estimate of ϕ for *T. infantilis* was [0.24, 0.82], providing evidence of underdispersion. We were able to minimize the quantity of parameters by recognizing that 1) autocorrelation among counts can be expressed as a function of the parameter α (shared with the model for the MRR data), 2) the bandwidth h of the kernel smoother estimator is fixed by the sampling design and 3) length of the flight season τ is known because it is readily observed through minimal field work. A large literature exists on choice of optimal bandwidths for kernel smoothers. The bandwidth that we recommend here is that which yields low bias in estimates of n. If smoother fits are desired, we found that varying the bandwidth from h to $2h$ tended to increase bias in estimates of n. Estimation error for the trajectory of generation counts is efficiently captured by $Var[\hat{\eta}]$.

More recently, Soulsby and Thomas (2012) slightly extended the Zonneveld (1991) model. Like Zonneveld (1991), they assumed that the sequence of counts over the flight season could be modeled as independent Poisson random variables, without allowance for autocorrelation or overdispersion. They treat duration of the flight season τ as a parameter to be estimated, whereas we treat τ as a known parameter based on our population monitoring. As we did, Soulsby and Thomas (2012) assume no migration. Like us, Soulsby and Thomas (2012) base the model for counts on a function that Lebesgue integrates to 1 over the flight season. For this they employ a sine-cubed function. We take a much more flexible approach, allowing $\mu(t)$ to be modeled by any proper mass function with an upper bound, which we illustrate in the above examples and simulations. Their method appears to produce comparatively larger standard errors (ranging from 11.3 to 57.1% for different annual estimates of *Hesperia comma*) than our method (2.8 to 12.1% for *T. infantilis* and *E. battoides allyni*), but a fair comparison would require analysis of the same data sets. It is also quite possible that smaller standard errors will be obtained with our method because two separate samples (count and MRR), and thus two independent sources of information, are employed for each estimate of n, an approach also adopted by Gross et al. (2007) and more informally by Schultz and Dlugosch (1999). Moreover, our estimate of n is a function of shared parameter α, which should further stabilize $\hat{n}$. Soulsby and Thomas (2012) estimate population size for the site through multiplication by a factor that scales between the area sampled and the total area of the site. We take a more rigorous and comprehensive approach, providing two separate variants of our basic estimator—the lower-bias and higher-variance version employs sampling unit-specific estimates and the higher-bias and lower-variance version employ empirical Bayes shrinkage. We account for a finite population size of sampling units.

Matechou et al. (2014) model arrival probabilities, retention probabilities, detection probabilities and (super)population size. These three probabilities are each modeled as functions of other parameters. Arrival probabilities are modeled via finite mixtures of normal distributions and a mixing parameter. Retention probabilities are modeled variously as functions of time-varying environmental parameters, age, etc. Time-varying parameterizations of detection probabilities are also suggested. Exceptionally large data sets, such as the example given by these authors, may be needed to permit estimation of this extremely parameter-dense modeling approach. Application to the much smaller samples generated by annual surveys of rare species will be especially challenging, although, as an underdetermined system, parameter estimation may be possible within a generalized maximum entropy framework (Golan et al. 1996). Another option would be to replace portions of the fully fixed parameter formulation of Matechou et al. (2014) with random effects and apply either empirical Bayes or fully Bayesian estimation. Parsimoniously parameterized models, such as we present in our Methods, are scaled to the information content of annual surveys of rare species. Parameter redundancy (Matechou et al. 2014) may be mitigated through more integrated reformulation of model components, as we demonstrate at the end of the description of our revised estimator.

To our knowledge, other than Gross et al. (2007) and Matechou et al. (2014), we are the only other authors to employ simulations to examine the bias of our estimator, which appears to be quite modest. In 52 of 58 simulations, our average percent bias was 2.7 or less, with a maximum observed average percent bias of 14.7 (Table 2). Doubling of the bandwidth resulted in a smoother population curve but increases the bias and total error. The small-sample Bayesian approach of Gross et al. (2007) and the large-sample frequentist

approach of Matechou et al. (2014) appear to have bias that is comparable to or larger than our method's bias. As an additional measure, because maximum likelihood estimates are often biased in small samples, Firth's (1993) corrective could be applied to our estimators. We also appear to be the first authors to develop a generalized framework for fitting the trajectory of expected mean counts over the flight season and to incorporate detectability in a completely generalized way into the estimator of population size based on counts made over the flight season, although, regarding the latter, Soulsby and Thomas (2012) do provide a helpful and general discussion of detectability in terms of "search efficiency."

Population parameter estimates using MRR along should be compared with estimates from transect count methods, using data sets collected simultaneously during the same generation of a population. However, due to the aforementioned concerns about potentially adverse effects of repeated handling of endangered insects, these comparisons may need to be undertaken with localized, but nonendangered, insects.

Lastly, even though we only present two examples, we have further tested our estimator with other rare or federally listed, endangered insects for which we possess both MRR and transect count data sets (data not shown). These include five lycaenid butterflies (Lepidoptera) *Plebejus icarioides missionensis* Hovanitz, *Euphilotes enoptes smithi* (Mattoni), *Lycaeides melissa samuelis* Nabokov, *Callophrys mossii bayensis* (Brown), and *Apodemia mormo langei* Comstock; two nymphalid butterflies (Lepidoptera) *Speyeria callippe callippe* (Boisduval) and *Speyeria idalia* (Drury); a beetle (Coleoptera) *Cicindela ohlone* Freitag and Kavanaugh; and a dragonfly (Odonata) *Somatochlora hineana* Williamson. These insects live in different habitats, have different life history strategies, exhibit different adult life spans, and their population numbers vary considerably at remaining locations. Despite these differences, preliminary analyses of data sets for these additional insects indicate that our estimator performed well. Thus, it should be possible to adopt our method not only to monitor populations of these taxa, but also other rare or endangered insects. Our method can also be applied to local populations of more common or widespread insects as well as insects tracked by citizen science monitoring programs, such as the UK Butterfly Monitoring Scheme sponsored by Butterfly Conservation and the Long-Term Monitoring of Butterflies sponsored by The Ohio Lepidopterists' Society.

Supplementary Data

Supplementary data are available at *Annals of the Entomological Society of America* online.

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Appendix 1

The derivation of $Var[\frac{\Lambda}{l}\sum_{i=1}^{l}\overline{\eta}_i]$ is as follows. Using indicator-variable notation as in Thompson (1992), where $Z_i = 1$ when the unit is included in the sample and $Z_i = 0$ otherwise,

$$Var\left[\frac{\Lambda}{l}\sum_{i=1}^{l}\overline{\eta}_i\right] = \left(\frac{\Lambda}{l}\right)^2 Var\left[\sum_{i=1}^{\Lambda}\overline{\eta}_i Z_i\right] = \left(\frac{\Lambda}{l}\right)^2 \left(\begin{array}{l}\sum_{i=1}^{\Lambda} Var[\overline{\eta}_i Z_i] \\ \\ \quad + 2\sum_{i=1}^{\Lambda}\sum_{i<j} Cov[\overline{\eta}_i Z_i, \overline{\eta}_j Z_j]\end{array}\right). \quad \text{(A1)}$$

Now, $Var[\overline{\eta}_i Z_i] = \frac{l}{\Lambda}(E[\overline{\eta}_i]^2 + Var[\overline{\eta}_i]) - \left(\frac{l}{\Lambda}\right)^2 E[\overline{\eta}_i]^2$. Assuming that $\overline{\eta}_i$ is approximately unbiased gives two results:

$$\sum_{i=1}^{\Lambda} Var[\overline{\eta}_i Z_i] \approx \frac{l}{\Lambda}\sum_{i=1}^{\Lambda}\left(\left(1-\frac{l}{\Lambda}\right)\eta_i^2 + \sigma^2_{\overline{\eta}_i}\right); \quad \text{(A2)}$$

and

$$Cov[\overline{\eta}_i Z_i, \overline{\eta}_j Z_j] \approx E[\overline{\eta}_i\overline{\eta}_j]\frac{l(l-1)}{\Lambda(\Lambda-1)} - \left(\frac{l}{\Lambda}\right)^2 \eta_i\eta_j. \quad \text{(A3)}$$

As count vectors are mutually independent across sampling units,

$$Cov[\overline{\eta}_i Z_i, \overline{\eta}_j Z_j] \approx \eta_i\eta_j\left(\frac{l}{\Lambda}\frac{(l-1)}{(\Lambda-1)} - \left(\frac{l}{\Lambda}\right)^2\right). \quad \text{(A4)}$$

Substituting results A2 and A3 into Equation 14 gives

$$Var\left[\frac{\Lambda}{l}\sum_{i=1}^{l}\overline{\eta}_i\right] \approx \frac{\Lambda}{l}\sum_{i=1}^{\Lambda}\left(\left(1-\frac{l}{\Lambda}\right)\eta_i^2 + \sigma^2_{\overline{\eta}_i}\right) + 2\left(\frac{\Lambda(l-1)}{l(\Lambda-1)} - 1\right)\sum_{i=1}^{\Lambda}\sum_{i<j}\eta_i\eta_j \stackrel{\text{def}}{=} \sigma^2_{\overline{\eta}}. \quad \text{(A5)}$$