

## **Invasive Plant Management from a Water Resources Perspective**

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John Clement  
City of Austin  
Watershed Protection Department  
Environmental Resource Management Division

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### **Abstract**

*The Austin Invasive Management (AIM) program is a multi-departmental effort within the City of Austin to implement the City's Invasive Species Management Plan (ISMP) and reduce the environmental, recreational and economic impacts of non-native, invasive plants on city land. The Watershed Protection Department (WPD) is engaged in several aspects of ISMP implementation. This includes evaluation of distribution and impacts, control of invasive populations, public education and volunteer engagement, and restoration of riparian and littoral environments. Prioritization and planning of invasive management activities in the department acknowledge the novelty of urban ecosystems while striving to develop methods of invasives management that are sustainable and enhance the services provided by these systems.*

*Currently most work sponsored by WPD is performed in parkland riparian areas by volunteers using a management template and guidelines developed by WPD, with a focus on increased diversity and abundance of native vegetation. The department is also directly responsible for management of several parcels of land. These lands would benefit from development of clear management objectives, including invasives control, that would enhance the ecosystem and recreational services they provide.*

*This report also reviews the most common Central Texas invasives and prioritizes them for management based on WPD and citywide goals. *Hydrilla verticillata* (hydrilla), *Arundo donax* (giant reed), *Ligustrum lucidum* (glossy privet), *L. sinense* (Chinese privet) and *L. quihoui* (waxyleaf privet) are identified as high priority for management based on their ongoing or potential impacts to waterbodies or riparian areas.*

### **Background**

The City of Austin Invasive Species Management Plan (ISMP) outlines the economic and environmental importance of managing non-native, invasive plant species in Central Texas (City of Austin, 2015b). The Austin Invasive Management (AIM) program forms the basis for achieving the invasive management goals identified in the ISMP. Within the AIM framework the Watershed Protection Department (WPD) focuses on non-native species that impact City

waterways and riparian areas. The purpose of the present document is to evaluate WPD's invasive plant management needs and capabilities in terms of departmental and citywide master planning goals and to provide a framework for implementation of the AIM program within WPD.

The planning documents that currently guide WPD invasive plant management objectives are the WPD Master Plan (City of Austin, 2015c) and the citywide Imagine Austin plan (City of Austin, 2012). The recently adopted Urban Forest Plan (City of Austin, 2013a) also presents goals that pertain to management of invasive plants. Two other documents, the Community Wildfire Protection Plan (Travis County and the City of Austin, 2014) and Lake Austin Taskforce Report (City of Austin, 2013b) provide recommendations regarding invasive plant management.

The relevant goals and recommendations articulated in each document are presented in Appendix A. Each of these goals can be linked to invasive plant management through one or more impacts non-native invasives can have on water resources. These impacts include (Charles & Dukes, 2007; Simberloff, Schmitz, & Brown, 1997):

- Reduction of stream baseflow
- Reduction of channel conveyance
- Alteration of channel dynamics
- Increased susceptibility to erosion
- Clogging of water treatment and energy generation facility intakes
- Reduction of cover and diversity of native plant species
- Reduction or impairment of habitat for other organisms, including endangered species
- Alteration of nutrient cycling in lacustrine, riverine and riparian environments
- Alteration of wildfire frequency and intensity, which can impact water resources through post-fire effects (e.g. exposed soil and unstable slopes leading to increased suspended sediment)

Invasive plants can also affect the recreational and cultural value of reservoirs, streams and riparian greenbelt corridors.

Many of these impacts can be described as causing impairment of ecosystem services (Funk, Matzek, Bernhardt, & Johnson, 2013; Pejchar & Mooney, 2009). Ecosystem services are those benefits provided to society by the environment through natural processes. These services extend from basic sustaining functions such as nutrient cycling, primary production and soil formation; to provisioning of water, lumber and other natural resources; to broader regulating functions such as water and air quality maintenance, climate stability and carbon sequestration, as well as cultural services.

One challenge to preserving or restoring ecosystem services is the fact that many ecosystems have been so extensively modified by human intervention that it is unlikely that all of the functions originally provided by these systems can be restored to anything approaching pre-development levels (Hobbs et al., 2014). In many cases these novel ecosystems represent new environmental states that, while noticeably modified in many ways, may still perform a variety of valuable functions (Davis et al., 2011; Hobbs, Higgs, & Harris, 2009; Tredici, 2010). The goal

therefore should be to identify and maximize the services that can be provided by these systems, rather than attempting to restore all features of the pre-development systems. Management of non-native, invasive species can play a significant role in sustaining and enhancing the delivery of ecosystem services even in highly modified habitats, but should not be an end goal in itself.

Another complicating factor is that many anthropogenic changes to these systems may themselves facilitate invasion by non-native plants (Richardson et al., 2007), which can then lead to further impacts to water resources. An example of this is provided by the chain of reservoirs along the Colorado River that compose the Highland Lakes. Reservoirs such as these represent a significant and permanent alteration of the riverine ecosystem where original flow patterns are dramatically modified. The establishment of the Highland Lakes reservoirs has in turn facilitated invasion of a portion of the system (Lake Austin) by the non-native, aquatic plant *Hydrilla verticillata*. The functions provided by the reservoir – flood control, hydroelectric generation potential and recreational opportunities – have all been impacted by hydrilla. Excessive growth of this plant has reduced conveyance and contributed to localized flooding of residential structures along Lake Austin, clogged water intakes for electrical generation and severely hampered boating, fishing and swimming activities (City of Austin, 2000; Gilroy, 2005). Due to the permanently altered flow regime in this segment of the Colorado River, Lake Austin will continue to provide ideal habitat for hydrilla and this plant will remain an on-going management challenge for the foreseeable future.

As invasive species both exploit altered ecosystems and play a major role in forming novel ones, the focus of invasive management efforts should be on those species that most significantly impact valued services. Additionally, those efforts should be specifically tailored to desired management outcomes on impacted lands and water bodies. Thus, while there are invasive plants that “everyone loves to hate”, land managers and others guiding invasive plant management activities should consider whether their efforts are sustainable and will lead to desired outcomes (such as long-term support of valued services).

Volunteers are considered an essential part of many invasive plant management programs, due to both their value as a workforce and the potential for outreach opportunities and community engagement. However, coordinating volunteer efforts comes with its own set of challenges. Perhaps the most popular target of volunteer invasive management efforts in Central Texas is glossy privet (*Ligustrum lucidum*). As discussed below, this plant has extensively invaded woodland habitats throughout the area. These evergreen plants are highly tolerant of low-light conditions, produce abundant seed and readily re-sprout from cut stumps. Weed-wrenching of saplings in City parks and preserves is a popular activity. Volunteers sometimes also fell small (2”- 4”) diameter trees and occasionally even use chainsaws without the knowledge or approval of City staff. As these efforts are not always well-coordinated with staff, some workdays have resulted in excessive clearing of land that may delay achievement of broader restoration goals. Additionally, accumulation of slash material generated by volunteers in locations or amounts that are not easily removed may contribute to wildfire fuel loads if left in place.

A lack of coordination between the City and volunteer groups can also lead to somewhat of a piecemeal approach to invasives management. Work is sometimes performed without consideration of whether significant, sustainable progress is practical on a given tract. For many

invasive species, management will only be successful if it is applied consistently over an extended period of time and across a suitable geographic extent. Volunteers should be guided to perform work that is effective and sustainable within a long term restoration framework. Invasive species control should be considered only one of the components of the broader ecological restoration approach. This would help to meet land management goals and also help ensure that volunteers remain engaged in the work they do and the ecological context in which it takes place. This in turn will help to sustain their interest in and support of ecological restoration work performed on City land.

Given the extent and intensity of plant invasions and the proliferation of novel ecosystems, it is worth asking what level of effort is in fact sustainable and effective (Richardson et al., 2007; Simberloff, 2014). Some scientists have derisively referred to invasives management actions that focus on restricted geographic areas as a form of “gardening” (Tredici, 2007). Clearly, though, there are circumstances where a very low tolerance for plant invasion over a given set of parcels would be appropriate. This would be the case, for example, on lands that are managed for endangered species habitat, such as the Balcones Canyonlands Preserve system (City of Austin, 2007). It would also be true for park preserves where a management goal is to re-create, to whatever extent practical, ecosystems that were in place prior to the impacts of modern development. While these lands will likely always be subject to invasion pressure from surrounding areas, this does not mean that they should be wholly abandoned to invasion.

### **Invasive Species and Vegetation Management in an Urban Watershed Context**

Within the City of Austin, WPD is responsible for management of terrestrial and aquatic vegetation on a variety of different types of land. This includes land solely managed by WPD, land co-managed for recreation with the City of Austin Parks and Recreation Department (PAR), and two of the three City reservoirs (Lake Austin and Lady Bird Lake).

- WPD land: WPD manages several parcels that have been purchased by the City to meet the strategic needs of the department through protection of water quality, prevention of erosion, or mitigation of flood impacts. These parcels generally lack the facilities and maintenance programs that would support heavy recreational use but are often open to the public as greenbelt areas and are available for light recreational use. There is currently no systematic approach to invasives management on these tracts. The most frequently encountered invasive is glossy privet. Land management plans that incorporated control of glossy privet and other invasives would contribute to the resilience of the associated riparian areas, provide refugia for native woodland species and improve the recreational value of these lands.
- PAR/WPD co-managed: A second category of properties are those that are co-managed by WPD and PAR. The City’s Grow Zone program is the result of an agreement between the two departments to allow restoration of riparian areas in several City parks. WPD manages restoration within Grow Zones in ways that are compatible with other park uses. Invasives management is generally performed by volunteers under guidance of WPD staff and coordinated with local community organizations such as Keep Austin Beautiful, Austin Parks Foundation and TreeFolks. Staff emphasizes the importance of healthy riparian areas generally and tries to convey that invasive plant management is just one component of this approach.

- **Reservoirs:** WPD collaborates with the Texas Parks and Wildlife department (TPWD) and PARD to manage aquatic vegetation in Lake Austin and Lady Bird Lake. Austin Energy works with TPWD to manage vegetation in Lake Walter E. Long, as this reservoir is used as a source for cooling water for an electrical generation facility. All three reservoirs are considered waters of the state and TPWD makes final determination on any management actions. As discussed previously, hydrilla has been a significant management issue on Lake Austin. The most prominent invasive plant on Lady Bird Lake is giant cane (*Arundo donax*). Hydrilla and giant cane are both considered to be of sufficient impact to water resources as to merit their own capital improvement project (CIP) funding in the WPD budget.
- **Drainage easements:** WPD also manages vegetation in drainage easements as needed to ensure conveyance of stormwater and proper functioning of wet ponds and green stormwater infrastructure. As these easements are generally on private property, the department's ability to implement effective control measures for invasive plants are highly constrained and focused on management of species such as giant cane and golden bamboo (*Phyllostachys aurea*) that have the potential to exacerbate flooding issues by blocking culverts and drainageways.

### **Current WPD Activities Related to Invasives Management**

Management strategies for invasives can be divided into five broad categories – 1) prevention, 2) early detection and rapid response, 3) control and management, 4) restoration and 5) organizational collaboration (National Invasive Species Council, 2012). It is important to note that not all approaches to invasives management are appropriate for implementation at the municipal level. For example, while **prevention** is an important component of an invasives management program, the City of Austin does not have a mechanism to limit invasive plant distribution by preventing their sale or transport, as this is regulated by the state. Similarly, total eradication is often presented as a goal of invasive control activities. While this could potentially be achieved for species that have limited distribution only on public land, the City cannot require removal of specific species from private or other non-City-owned lands.

**Detection** of invasives by WPD is done through periodic review of the Lady Bird Johnson Wildflower Center's Texas Invaders database ([texasinvasives.org/invasives\\_database](http://texasinvasives.org/invasives_database)). The University of Texas Plant Resource Center's Flora of Texas database is also searched regularly for new Travis County collections ([prc-symbiota.tacc.utexas.edu/index.php](http://prc-symbiota.tacc.utexas.edu/index.php)). WPD staff also perform extensive field work related to land management, public education, restoration technique development and wetlands evaluation, which all provide opportunities for detecting populations of potentially invasive plant species. WPD does not currently have a **rapid response** plan in place for dealing with new invasions, as this responsibility would likely need to be addressed at the regional or state level.

Potential approaches to invasives **control and management** cover a wide range, from total eradication, to eradication on priority lands, to maintenance at sufficiently low densities such that impacts are minimized at either broad or local scales. As discussed above, total eradication will rarely be an option for a municipal department unless it is part of a regional or statewide effort. Currently, management of invasive species is implemented at the level of individual land parcels

within WPD and, in many instances, the goal is to enhance parcel-level native species diversity rather than achieving specific levels of invasive species reduction. The assumption is that invasive species can be managed to achieve specific restoration goals or targeted population densities on many parcels, rather than being locally eradicated. Management approaches for particular species are discussed below.

Volunteers are a significant component of WPD's invasives management strategy and the department puts considerable effort into volunteer engagement and training. The framework within which invasive species are discussed, however, has a broader emphasis on ecological restoration. Work days and training events are coordinated through a number of local civic groups, including Keep Austin Beautiful and the Austin Parks Foundation. WPD staff has developed training materials related to riparian restoration and low-impact invasive plant management for volunteers and partner organizations. Volunteer groups have the opportunity to create a management plan that includes strategies for improving the ecological function of the parcel by enhancing soils and native vegetation while concurrently managing invasive species. Staff also coordinates with the Lady Bird Johnson Wildflower Center on providing training on plant identification and mapping of invasive using the Texas Invaders app.

WPD takes an active role conducting studies related to the development of invasive plant management techniques, especially those that can be applied at broad scales by volunteers with minimal inputs. One current study is the evaluation of the impacts of tree girdling on stands of glossy privet. Girdling may prove to be a more appropriate method of control compared to other mechanical and chemical methods in that it allows for gradual opening of canopy gaps, does not generate large amounts of brush in a short timeframe and utilizes tools that are safe and available to minimally-trained volunteers.

Other approaches to invasives control utilized by WPD include:

- Public education and outreach on the negative impacts of invasives and on native plant alternatives for landscaping
- Establishing land development criteria that prohibit installation of invasive plants with new construction
- Developing site restoration specifications for capital improvement and other projects that include invasive plant management.

WPD has also been evaluating the abundance and impacts of invasive plants on City-owned lands. In 2013 WPD performed vegetation sampling in 25 parks across 37 COA-owned parcels, totaling 1,836 acres (Rodriguez et al., 2015). A total of 2,248 10-meter plots were sampled representing an average density of 1.5 plots per acre within the parcels. The study identified a number of parks and greenbelts where invasive species are present in more than 90% of the plots sampled. In addition, results show that the most abundant invasive species are the glossy, Chinese and waxyleaf privets (*Ligustrum lucidum*, *L. sinense* and *L. quihoui*) and chinaberry (*Melia azedarach*). Glossy privet is especially abundant in woodlands, appearing in 44% of all closed-canopy plots throughout the city. The data is currently being analyzed to identify correlations between invasive species abundance and various environmental factors, as well as potential impacts on native species.

**Restoration** of ecological function is the framework that supports most WPD invasive species management actions. Measures taken to reduce or remove invasive plant populations are designed to minimally impact existing native vegetation and enhance the natural recovery process. Minimizing disturbance is especially important in areas subject to high stream velocities, wave action on lakes or other factors that can facilitate erosion. As discussed above, training materials for volunteers emphasize the importance of viewing invasives management within this restoration context.

The Watershed Protection Department engages in **organizational collaboration** on several levels. Within WPD, coordination is often necessary between the riparian restoration team, which develops and implements restoration plans, the Watershed Education section, which performs outreach and engagement related to invasive plants, and the Field Operations division, which manages vegetation contract work in and around water resources.

Watershed Protection Department staff work with a diverse array of citizen organizations to coordinate volunteer invasive management efforts. This includes citywide entities such as Keep Austin Beautiful and the Austin Parks Foundation, as well as more focused groups such as Shoal Creek Conservancy, Pease Park Conservancy, The Trail Foundation and Greenbelt Guardians. This work also involves considerable coordination with PARD, as the vast majority of natural areas in the City are owned and managed by that department.

Regionally, WPD participates in the newly-formed Hill Country Cooperative Invasive Species Management Area, which is currently focused on a coordinated river basin-based approach to giant cane management. Watershed Protection scientists also frequently work with Lady Bird Johnson Wildflower Center staff on invasive species mapping and citizen training. Additionally, all proposed invasives work within public waters of the state is reviewed by TPWD.

### **Recommendations for Prioritization and Management**

In order to make informed management decisions that support the goals of the Watershed Protection Department, invasive plant species should be evaluated and prioritized based on their current and potential impacts on these goals. Previous prioritization methods have utilized more general evaluation criteria (City of Austin, 2015a; Duncan et al., 2012). The prioritization presented here is focused on WPD land and reservoir management goals and is not necessarily applicable to the needs of other departments. However, the general approach outlined above, where land managers focus on sustainable and effective implementation of control strategies, should be broadly applicable.

The 2013 Central Texas Invasive Plants Volunteer Field Guide identifies 31 invasive plants in the Austin region. This list is based on the “Top 24” invasive species identified in the ISMP as well as several other species commonly encountered in the field. Table 1 lists these species along with their ratings from the ISMP Weed Risk Assessments (City of Austin, 2015a) and also from a WPD evaluation of potential ecological impacts of invasive plants (Duncan et al., 2012). Current recommendations regarding the management and monitoring status of each species are also provided.

Plants identified as “High” for Management Status in Table 1 are those that currently impact WPD goals tied to water resource management and require active control. Generally, the high priority species share two significant traits of high-impact invasives – they form dense populations or colonies that transform native habitats and they appear commonly over a broad geographic area. Species can also have high priority status if they do not have a broad distribution, but pose clear threats to specific resources. This is the case with the aquatic species hydrilla, which has produced significant impacts on Lake Austin.

Species identified as “Moderate” in Table 1 do not currently have known impacts to local water resources but should continue to be monitored until a final determination can be made on their invasive potential. These species generally are either widespread but lack the tendency to form dense populations, or form dense populations/colonies but appear less frequently in the landscape. Specific examples of each type are provided below. Further evaluation of “Moderate” status species is needed to determine their potential future impacts.

Both high and moderate status plants are identified as “Yes” for Monitoring Status, to indicate that mapping, evaluation and public education for these plants are a priority. Species identified as “Low” for Management Status are unlikely to be of concern in the near future and do not require monitoring. These plants either 1) are unlikely to impact water resources locally or 2) do not seem to form dense populations/colonies nor appear frequently in the landscape in Central Texas.

Common control measures for all species listed below can be found in Volume 2 of the ISMP (City of Austin, 2014) and a further discussion of the ecological impacts of the plants are presented in Duncan et al. (2012).

### **High Priority Species**

#### *Arundo donax* (giant reed)

Giant reed chokes river and stream channels, outcompetes native plants, interferes with flood control, increases fire potential, and reduces habitat for wildlife. The long, fibrous root mats of giant reed form a framework for debris dams that can cause damage to bridge supports and other structures. Root and stem fragments can float downstream and initiate new infestations. Rapid growth and vegetative reproduction enable it to quickly invade and dominate new areas. Once established, it has the ability to exclude and suppress native vegetation.

In 2011, LBJ Wildflower Center volunteers mapped 3.5 acres of giant reed along the shoreline of Lady Bird Lake. Much of the growth was on steep slopes adjacent to the lake’s popular hike and bike trail. Herbicide treatments were performed in 2011, 2012 and 2013. Stands were not treated in 2014 and 2015 due to concerns over the steepness and height of some banks and their vulnerability to erosion. Treatments will resume once sites requiring shoreline restoration have been identified and prioritized and shoreline stabilization plans have been developed.

Giant reed is also becoming a management issue for Austin’s urban streams. Its dense growth clogs channels at road crossings, creating a flooding risk, and abundant standing dead material is a fire hazard. WPD is currently developing protocols for managing giant reed in these waterways.

### Hydrilla verticillata

Hydrilla has been present in Lake Austin since at least 1999 and poses significant safety concerns as its dense growth has impacted flood flows, water intakes and recreation on the lake (City of Austin, 2000; Gilroy, 2005). Triploid grass carp have been periodically released in the lake since 2003 to control these populations. Stocking rates are determined by TPWD. In years when there has been sufficient storage in upstream reservoirs, lowering of the lake level in the winter has also been used to reduce hydrilla density along the shoreline through the following year. In spite of these approaches, hydrilla reached a historic high level of coverage of over 600 acres in February 2013, due primarily to drought-induced low flows and warmer water temperatures. Since that time, additional releases of triploid grass carp have reduced the hydrilla populations to below detectable levels.

While the hydrilla population is currently under control, it is unlikely to have been fully eradicated. Over time, the grass carp population will decline naturally and plants will continue to re-sprout from underground tubers. Thus, hydrilla will remain an ongoing management need for the foreseeable future.

### Ligustrum lucidum, L. sinense, L. quihoui (glossy, Chinese and waxyleaf privet)

These evergreen shrubs and small trees have heavily invaded low-lying woodland areas in the Austin region. These species were present on nearly all City-managed lands evaluated in the AIM 2013 sampling study and occurred in 100% of wooded plots surveyed on some parcels. The extent and intensity of invasion makes it very unlikely that these species, which are common yard trees throughout Central Texas and produce abundant seed, will ever be fully eradicated. WPD staff are currently evaluating the ecological impacts of these plants and developing low-impact control methods that can be implemented on select parcels. Further work needs to be done to determine how susceptible restored lands will be to re-invasion. The extraordinarily high propagule pressure from developed areas and other invaded lands may make long-term management of these species unsustainable on all but high-priority parcels.

Two other species of *Ligustrum* have been mentioned in various documents as invasive or potentially invasive in Central Texas – *L. japonicum* (Japanese privet) and *L. vulgare* (common privet). Nesom (2009) determined that nearly all Texas specimens identified as one or the other of these species were in fact glossy privet or, in the case of some collections of Japanese privet, were cultivated plants and had not naturalized.

### **Moderate Priority Species**

#### *Colocasia esculenta* (wild taro)

Wild taro (elephant ear) was identified as of moderate concern in the ISMP and received a priority ranking of “none” by WPD in 2012. However, this plant is known to invade wetland areas and freshwater shorelines, forming dense growth which shades out existing vegetation. It is currently found along the shoreline of Lady Bird Lake and small, scattered populations also exist on Lake Austin. Wild taro is a species of growing concern in Texas and management actions have been taken in the Llano River, Comal River and Rio Grande watersheds. Although wild taro does not occur frequently elsewhere in the Austin area, it merits continued monitoring due to its potential for significant impacts to the Lady Bird Lake shoreline.

*Eichhornia crassipes* (water hyacinth)

Water hyacinth's rapid growth and ability to reproduce both sexually and asexually allow it to quickly spread, forming dense mats that float on the water's surface. It has the ability to severely impact hydroelectric and steam electric generation facilities and to significantly alter ecological structure in pond and reservoir systems. To date, it has only appeared sporadically in smaller water bodies in the Austin area and no significant management actions have been taken. However, due to the potential for serious impacts new populations should be monitored and the plant should be included in any rapid response protocols developed for the area.

*Melia azedarach* (chinaberry) and *Nandina domestica* (heavenly bamboo)

A preliminary analysis of the AIM 2013 sampling study indicates that the distribution of chinaberry and nandina on City lands nearly rivals that of broadleaf and Chinese privet. However, the intensity of invasion, in terms of the densities the populations attain, does not appear to reach the same level as found with the privets. Because little is currently known about these species impacts on riparian communities, further monitoring and evaluation is needed.

*Lonicera japonica* (Japanese honeysuckle), *Macfadyena unguis-cati* (catclawvine), *Photinia serratifolia*, *Pistacia chinensis* (Chinese pistache), *Triadica sebifera* (Chinese tallow), *Verbena brasiliensis* (Brazilian vervain)

These species all have patchy distributions relative to the high priority species but appear to thrive in locations where they have established themselves. Further monitoring and evaluation of these species is required to determine their potential impacts.

*Phyllostachys aurea* (golden bamboo)

Golden bamboo is a rapidly growing, long-lived, perennial grass that spreads vegetatively. It behaves similarly to giant reed in that it tends to form dense monocultures along waterways. However, it does not appear to have giant reed's facility for colonizing new sites through dispersal of vegetative fragments. Golden bamboo was only identified in a single plot in the 2013 AIM study.

*Tamarix ramosissima* (salt cedar)

Salt cedar populations have been identified along the Pedernales and Colorado Rivers in Travis and Bastrop counties. Salt cedar is unlikely to become an issue along Lake Austin or Lady Bird Lake due to reservoir management practices. There is, however, the potential for invasion to occur downstream of Longhorn Dam.

The remaining species in Table 1 are identified as having low management needs. While some of these plants are invasive in Central Texas and all of them have been identified as invasive somewhere in the world, none of them are likely to impact lacustrine, riverine or riparian environments in the Austin area. Management of the species by volunteer groups focused on riparian restoration will be supported by WPD staff. Including these species in volunteer restoration plans provides flexibility in the planning and implementation of volunteer events. It also allows volunteers greater leeway in setting their own management priorities and can contribute to broader City goals regarding invasive species management. The Texas Invaders

app and provide additional volunteer engagement opportunities and will allow WPD to track the presence of these species in and near Austin waterways.

**Table 1. Invasive Plant Management Monitoring Prioritization for Water Resources**

2013 Field Guide Name		ISMP Rating	WPD 2012* Rating	Management Status	Monitoring Status
<i>Arundo donax</i>	Giant reed	High	High	High	Yes
<i>Hydrilla verticillata</i>	Hydrilla	High	High	High	Yes
<i>Ligustrum lucidum</i>	Glossy privet	High	N/A	High	Yes
<i>Ligustrum sinense</i>	Chinese privet	N/A	High	High	Yes
<i>Ligustrum quihoui</i>	Waxyleaf privet	N/A	N/A	High	Yes
<i>Colocasia esculenta</i>	Wild taro/Elephant ear	Moderate	None	Moderate	Yes
<i>Eichhornia crassipes</i>	Water hyacinth	High	Low	Moderate	Yes
<i>Lonicera japonica</i>	Japanese honeysuckle	Moderate	Medium	Moderate	Yes
<i>Macfadyena unguis-cati</i>	Catclawvine	Moderate	High	Moderate	Yes
<i>Melia azedarach</i>	Chinaberry	High	High	Moderate	Yes
<i>Nandina domestica</i>	Nandina	Moderate	Medium	Moderate	Yes
<i>Photinia serratifolia</i>	Taiwanese photinia	N/A	None	Moderate	Yes
<i>Phyllostachys aurea</i>	Golden bamboo	High	Medium	Moderate	Yes
<i>Pistacia chinensis</i>	Chinese pistache	Moderate	None	Moderate	Yes
<i>Tamarix ramosissima</i>	Salt cedar	High	Medium	Moderate	Yes
<i>Triadica sebifera</i>	Chinese tallow	Moderate	High	Moderate	Yes
<i>Verbena brasiliensis</i>	Brazilian vervain	N/A	N/A	Moderate	Yes
<i>Ailanthus altissima</i>	Tree of heaven	Moderate	Medium	Low	No
<i>Albizia julibrissin</i>	Mimosa	N/A	Medium	Low	No
<i>Bothriochloa ischaemum</i>	King Ranch bluestem	Unknown	Medium	Low	No
<i>Broussonetia papyrifera</i>	Paper mulberry	Moderate	Low	Low	No
<i>Centaurea melitensis</i>	Malta star-thistle	Moderate	Low	Low	No
<i>Cynodon dactylon</i>	Bermudagrass	Moderate	Medium	Low	No
<i>Cyrtomium falcatum</i>	Holly fern	Low	None	Low	No
<i>Firmiana simplex</i>	Chinese parasol tree	Moderate	Low	Low	No
<i>Ligustrum japonicum</i>	Japanese privet	N/A	High	Low	No
<i>Ligustrum vulgare</i>	Common privet	N/A	High	Low	No
<i>Myriophyllum spicatum</i>	Eurasian watermilfoil	N/A	N/A	Low	No
<i>Photinia x fraseri</i>	Red tip photinia	N/A	None	Low	No
<i>Pueraria montana var. lobata</i>	Kudzu	High	Low	Low	No
<i>Pyracantha coccinea</i>	Scarlet firethorn	Moderate	Low	Low	No
<i>Rapistrum rugosum</i>	Bastard cabbage	High	Low	Low	No
<i>Sorghum halepense</i>	Johnsongrass	High	Medium	Low	No
<i>Vitex agnus-castus</i>	Vitex	N/A	N/A	Low	No
<i>Wisteria sinensis</i>	Wisteria	N/A	N/A	Low	No

\*Duncan et al. (2012)

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## APPENDIX A

### Watershed Planning Goals and Recommendations Related to Invasive Plant Management

#### Watershed Master Plan (2015) goals

- WQ2 In Urban creeks, restore baseflow quantity and quality to the maximum extent possible.
- WQ3 In Non-Urban creeks, preserve the existing baseflow quantity and quality to the maximum extent possible.
- WQ6 Maintain or enhance high quality environmental features (springs, seeps, wetlands, swimming holes, threatened or endangered species habitat) to the maximum extent possible.
- FC1 Reduce the depth and frequency of flooding for all structures in the 100-year floodplain.
- FC2 Reduce the depth and frequency of flooding on all roads in the 100-year floodplain.
- FC5 Prevent the creation of future flood hazards to human life and property.
- FC6 Reduce the depth and frequency of localized flooding for buildings.
- FC7 Reduce the depth and frequency of localized flooding for yards.
- CG1 Maximize the use of waterways and drainage facilities for public recreation.
- CG2 Maximize areas for public use within floodplains.
- CG3 Maintain natural and traditional character of floodplains to the maximum extent possible.
- CG4 For all state designated stream segments... maintain or improve the Designated Use Support status.
- CG6 Minimize the risk to structures in the 100-year floodplain as required by the National Flood Insurance Program.

#### Imagine Austin (2011) goals

- CE P4 Maintain and increase Austin's urban forest as a key component of the green infrastructure network.
- CE P7 Protect and improve the water quality of the city's creeks, lakes, and aquifers for use and the support of aquatic life.
- CE P8 Improve the urban environment by fostering safe use of waterways for public recreation, such as swimming and boating, that maintains the natural and traditional character of waterways and floodplains.
- CE P12 Adopt innovative programs, practices, and technologies to increase environmental quality and sustainability and reduce Austin's carbon footprint through the conservation of natural resources.

- CE P14 Establish policies that consider the benefits provided by natural ecosystems, such as ecological processes or functions in wetlands and riparian areas, that have value to individuals or society.
- CFS P1 Deliver potable water to Austin’s residents as the population grows and maintain an efficient and sustainable water and drainage system in support of the Growth Concept Map.
- CFS P7 Reduce the threats flooding poses to public safety and private property.
- CFS P10 Protect and improve the health of Austin’s streams, lakes, and aquifers for sustainable uses and the support of aquatic life.
- CFS P11 Protect the health of creeks and prevent public and private property damage by minimizing erosion.
- CFS P46 Foster the use of creeks and lakes for public recreation and enjoyment in a manner that maintains their natural character.

**Urban Forest Plan (2014) goals**

- S-6 Invasive Species Management - Identify and suppress non-native invasive species according to the Invasive Species Management Plan. Provide public education about the detriment of non-native invasive species to the urban forest, particularly when related to other management policies.
- EO-1 Education - Provide appropriate resources (e.g., staff, technical, and educational materials) to communicate with the public about the vision, goals, objectives, policies, incentives, standards, and regulations related to the management of Austin’s urban forest. Increase awareness of urban forest ecosystem issues and support citywide urban forest education efforts.
- EO-2 Promote Stewardship - Develop programming that utilizes the commitment of citizen volunteers to engage in stewardship of Austin’s urban forest. Promote events for mulching and watering for young and mature trees.
- EO-7 Public Demonstration Projects - Develop and support publicly accessible demonstration projects of sound urban forest management; examples include innovative design, mulching, watering and pruning of young and mature trees. Document and promote effective strategies.

**Community Wildfire Protection Plan (2014) recommendations**

- 6.2.3 Develop a coordinated fuel reduction plan - “Noxious weeds and invasive species should be managed to prevent their introduction or spread.” (p. 296)

**Lake Austin Taskforce Report (2014) recommendations**

- H1 Update the Lake Austin Hydrilla Management Plan to be consistent with the current state of science regarding aquatic macrophyte management, the specific process for determining Asian Grass Carp stocking rates, and applicability with current state and federal water quality standards.
- H2 Document in the Hydrilla Management Plan and continue the iterative, proactive, adaptive process for determining Asian Grass Carp stocking rates.

Increase the current stocking rate to 55.5%. Also improve the purchasing process to allow staff to react more quickly and be more nimble when spikes in Hydrilla growth occur.

H3 Ask all agency partners (LCRA, Travis County, Texas Parks & Wildlife) to budget funds for grass carp purchase.